MANAGEMENT INFORMATION SYSTEMS REMIX

Candice Nance
Cañada College

LibreTexts™

Management Information Systems

The LibreTexts libraries are Powered by NICE CXOne and are supported by the Department of Education Open Textbook Pilot Project, the UC Davis Office of the Provost, the UC Davis Library, the California State University Affordable Learning Solutions Program, and Merlot. This material is based upon work supported by the National Science Foundation under Grant No. 1246120, 1525057, and 1413739.

This text was compiled on 03/07/2025

TABLE OF CONTENTS

Licensing

A detailed breakdown of this resource's licensing can be found in ***Back Matter/Detailed Licensing***.

CHAPTER OVERVIEW

1: What an Information System is

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Define what an information system is by identifying is major components;
- Describe the basic history of information;
- Discuss the role and the purpose of information; and
- Explain why IT matters

This chapter provides an overview of information systems and their components, including the history of how we got where are today.

1.1: Introduction

During a given day, think of activities that you do to entertain yourself, deliver a work product, purchase something, or interact with your family, friends, or co-workers. How often do you snap a picture, post a text, or email your friends? Can you even remember the number of times you used a search engine in a day? Consider what you are using to do these activities. Most likely, many, if not all, of these activities involve using technologies such as a smartphone, a laptop, a website, or an app. These activities are also enabled by Wi-Fi networks that surround us everywhere, be it on the school's campus, workplace, airport, or even in cars. You are already a user of one or more information systems, using one or more electronic devices, different software, or apps, and connect globally through various networks. Welcome to the world of information systems!

Information systems affect our personal life, careers, society, and the global economy by evolving to change businesses and how we live. To prepare to participate in developing or using information, building a business, or advancing your career, you must be familiar with an information system's fundamental concepts.

1.1.1: Defining Information Systems (IS)

Students from diverse disciplines, including business, are often required to take a course to learn about information systems. Let's start with the term Information System (IS). What comes to your mind? Computers? Devices? Apps? Here are a few definitions from a few sources:

Definition: Information Systems

- " Information Systems is an academic study of systems with a specific reference to information and the complementary networks of hardware and software that people and organizations use to collect, filter, process, create, and distribute data." (Wikipedia Information Systems, 2022)
- "An information system is a set of interrelated components that work together to collect, process, store, and disseminate information." (Stairs et al., 2018)
- "Information systems are interrelated components working together to collect, process, store, and disseminate information to support an organization's decision making, coordination, control, analysis, and visualization." (Laudon et al., 2012)

They sound similar, yet there is something different in each as well. These authors define the terms from these perspectives:

- What are the components that make up an information system? How do they work together?
- What is the role of IS in providing value to businesses and individuals as their need evolves?
- Can businesses use IS to develop competitive advantages?

Let's examine each perspective.

1.1.2: References

Information System. Retrieved October 28, 2022, from [en.Wikipedia.org]

Stair, R. et al. (2018). Principles of Information Systems, 14th edition. Cengage Learning, Inc.

Laudon, K.C. and Laudon, J. P. (2012). *Management Information Systems*, twelfth edition. Upper Saddle River, New Jersey: Prentice-Hall

1.2: Identifying the Components of Information Systems

Let's use your experience as a user to understand the above definitions. For example, let's say you work for a small business, and your manager asks you to track the business's expenses and send her the list to see where the money has gone. You use a spreadsheet application on your laptop to enter the list of costs you have collected and then email the spreadsheet to her once you are done. You will need a device (i.e., laptop) based on an operating system (i.e., iOS, Windows), a spreadsheet app running, an email app (i.e., Outlook), and an internet connection. All these components must work together perfectly! In essence, you are using the interrelated components in an IS to allow it to collect, process, store, and disseminate information. The role of this IS system is to enable you to create new value (i.e., expense tracker) and for your manager to use the information you disseminate "to support decision making, coordination, control, analysis, and visualization in an organization." (Laudon et al., 2011) You and your manager have obtained your goals through the processes you have created to capture the data, calculate it, check it, and how and when your manager receives the new information to make her decision to manage her company.

Hence, information systems have six major components: hardware, software, network communications, data, people, and processes, as shown in Figure 1.2.1, going clockwise. Each has a specific role, and all parts must work together for a working information system.

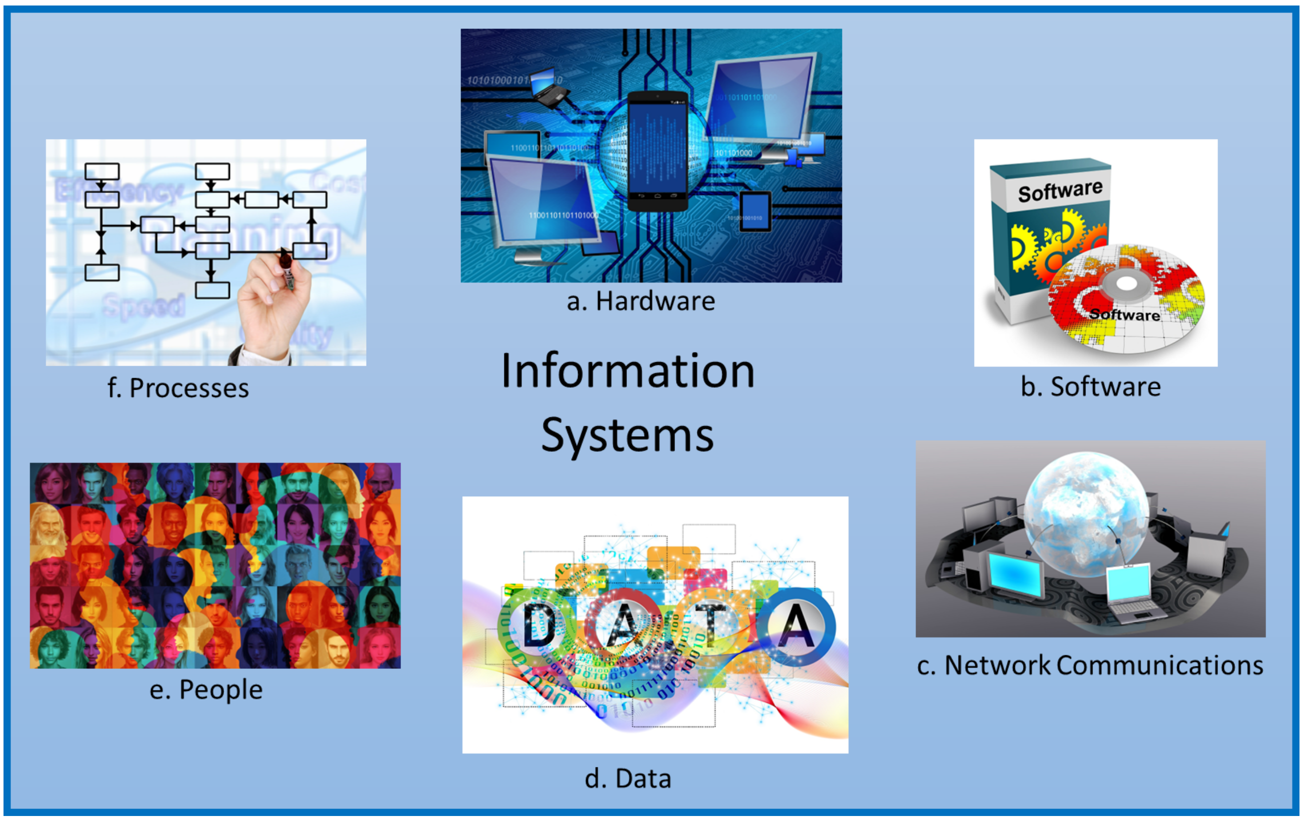
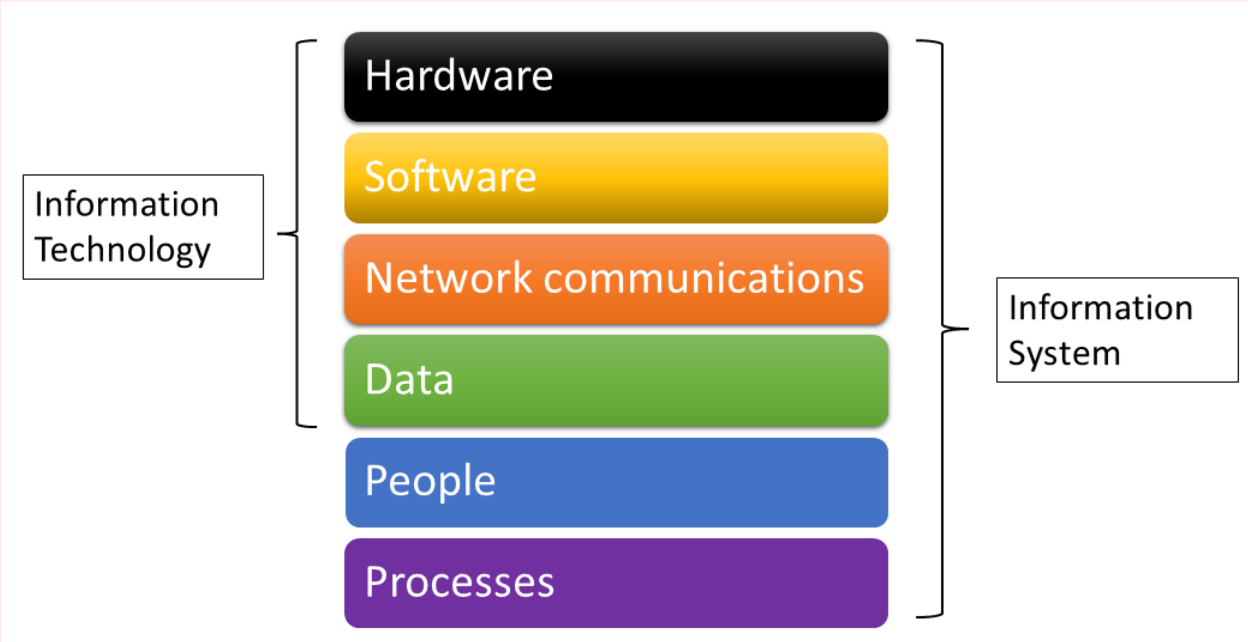


Figure 1.2.1: Components of Information Systems. Image by Ly-Huong Pham is licensed under CC BY NC, comprises of images clockwise a) Hardware, b) Software, d) Data, e) People, and f) Processes by Gerd Altmann from Pixabay, CC-BY; image c) Network Communications by Dimitris Christou from Pixabay , CC-BY

> **Caution**
>
> Information Technology (IT) and Information Systems (IS) are sometimes used interchangeably. However, there is a difference between the two terms. The first four components, hardware, software, network communications, and data, are considered essential elements of IT infrastructure. An IS includes the four components of IT and the remaining two components, People and Process, that deliver value to organizations in setting up and using IT to meet specific organizations' goals (Figure 1.2.2)
>
> 
>
>
> Figure 1.2.2 IT vs. IS Image by Ly-Huong Pham is licensed under CC BY NC.

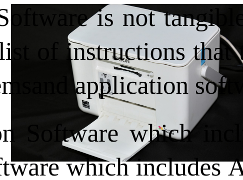
Each of these will get its chapter and a much lengthier discussion, but we will take a moment to introduce them to give you a big picture of each component and how they work together.

1.2.1: Hardware

Hardware represents the physical components of an information system. Some can be seen or touched easily, while others reside inside a device that can only be seen by opening up the device's case. Keyboards, mice, pens, disk drives, iPads, printers, and flash drives are all visible examples. Computer chips, motherboards, and internal memory chips are the hardware that resides inside a computer case and is not usually visible from the outside. Chapter 2 will go into more detail to discuss how they function and work together. For example, users use a keyboard to enter data or a pen to draw pictures.

Figure 1.2.3 Keyboard and iPad by Openclipart-Vectors from Pixabay, Laptop and a mobile, image by rupixen from Pixabay,Printer, image by Harinath R from Pixabay, Apple Watch,image by StockSnap from Pixabay. All images are licensed under CC BY 2.0

1.2.2: Software



Software is a set of instructions that tell the hardware what to do. Software is not tangible – it cannot be touched. Programmers create software programs by following a specific process to enter a list of instructions that tell the hardware what to do. There are several software categories, the two main types being operating system and application software.

Figure 1.2.4 is a diagram showing: Users to and from Application Software which includes word processing, form designer, spreadsheet, email, and calculator to and from Operating System Software which includes Apple iOS, Microsoft Windows, Google Android, Linus based OS to and from Hardware which includes computer chip, keyboard, phone, etc.

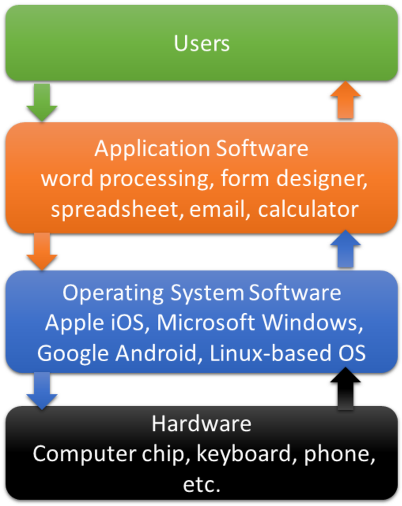


Figure 1.2.4 "Hardware, Software, Users - Interrelated" by Ly-Huong Pham, is licensed under CC BY-NC. It is a derivative of the image by Shaarc from Pixabay, is licensed under CC BY 2.0.

Operating system software provides an interface between the hardware components or devices and applications to protect the programmers from learning about the underlying hardware's specifics. Chapter 3 will discuss software more thoroughly. Here are a few examples:

Examples of Operating Systems and Applications by Devices

Devices	Operating Systems	Applications
Desktop	Apple MacOS, Microsoft Windows	Adobe Photoshop, Microsoft Excel, Google Map
Mobile	Google Android, Apple iOS	Texting, Google Map

1.2.3: Data

The third component of an IS is data. You can think of data as a collection of non-disputable raw facts. Your first name, driver's license number, city in which you live, a picture of your pet, a clip of your voice, and phone number are examples of raw data. You can see or hear your data, but by themselves, they don't give you any additional meanings beyond the data itself. For example, if you can read a person's driver's license number, you may recognize it as a driver's license number, but you know nothing else. They are examples of what IS would need to collect from you or other sources. However, once these raw data are aggregated, indexed, and organized together into a logical fashion using software such as a spreadsheet, or a database, the collection of these organized data will present new information and insights that a single raw fact can't convey. The example of collecting all expenses (i.e., raw data) to create an expense tracker by category (new information derived) discussed earlier is also a good example. All of the definitions presented at the beginning of this chapter focused on how information systems manage data.

Organizations collect all kinds of data, processed and organized them in some fashion, and use it to make decisions. These decisions can then be analyzed for effectiveness, and the organization can improve. The value of data goes beyond the internal use of data, it becomes assets that can produce revenues. For example, some social media sites collect their users' data and make money selling them to advertisers. Chapter 4 will focus on data and databases and their uses in organizations.

1.2.4: Networking Communication

The components of hardware, software, and data have long been considered the core technology of information systems. However, networking communication is another component of an IS that some people believe should be in its own category. An information system can exist without the ability to communicate. For instance, the first personal computers were stand-alone machines that did not have access to the Internet. Information Systems, however, have evolved since they were developed. For example, we used to have only desktop operating system software or hardware. However, in today's environment, the operating system software now includes mobile OS, and hardware comprises other hardware devices besides desktops. It is extremely rare for a computer device that does not connect to another device or a network. Chapter 5 will go into this topic in greater detail.

Figure 1.2.5 Network by Gerd Altmann from Pixabay is licensed under CC BY-SA 2.0

1.2.5: People

People built computers for people to use. It means that there are many different categories in the development and management of information systems to help organizations to create value and improve productivity, such as:

- **Users** are those who use an IS to perform a job function or task. Examples include a student using a spreadsheet or a word-processing software program.
- **Technical Developers** are the people who create the technologies used to build an information system. Examples include a computer chip engineer, a software programmer, and an application programmer.
- **IT Support**: These specialized professionals are trained to keep the information systems running smoothly to support the business and keep it safe from illegal attacks. Examples include network analysts, data center support, and help desk support.
- **Business Professionals:** these are the CEOs, owners, managers, entrepreneurs, and employees who use IS to start or expand their businesses to perform their job functions such as accounting, marketing, sales, human resources, and supporting customers, among others. Famous CEOs representing the components of IS include Reshma Saujani, founder of Girls Who Code, Steve Jobs of Apple, Lisa Tzwu-Fang Su of AMD, Safra Catz of Oracle (Figure 1.2.6), Marc Benioff of Salesforce, Ursula Burns of Xero, Satya Nadella of Microsoft, and Jeff Bezos of Amazon (Figure 1.2.7). These are only some key people whose companies have contributed to the advances of the components of information systems; more details will be covered in Chapters 9 and 10.

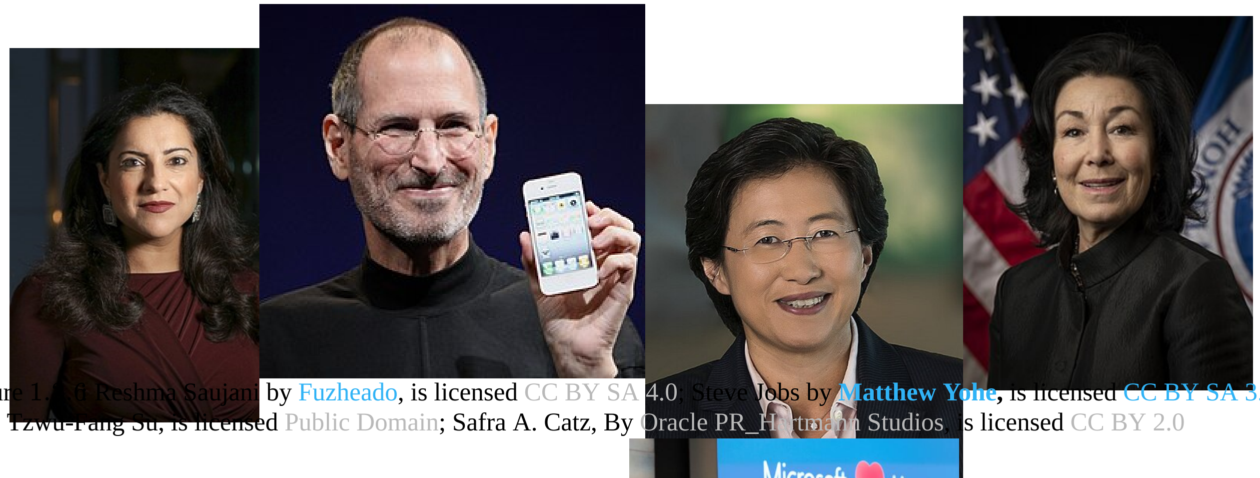


Figure 1.2.6: Reshma Saujani by Fuzheado, is licensed CC BY SA 4.0; Steve Jobs by Matthew Yohe, is licensed CC BY SA 3.0; Lisa Tzwu-Fang Su, is licensed Public Domain; Safra A. Catz, By Oracle PR_Hartmann Studios, is licensed CC BY 2.0

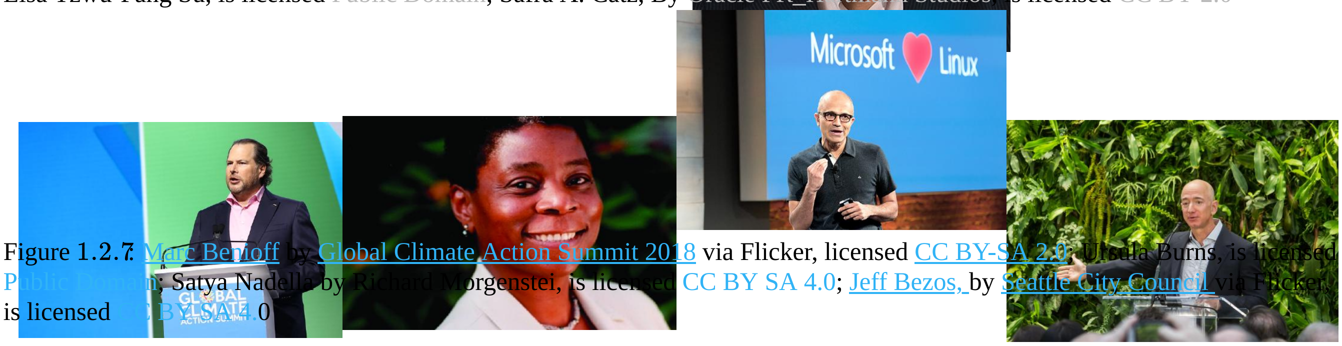


Figure 1.2.7: Marc Benioff by Global Climate Action Summit 2018 via Flicker, licensed CC BY-SA 2.0; Ursula Burns, is licensed Public Domain; Satya Nadella by Richard Morgenstei, is licensed CC BY SA 4.0; Jeff Bezos, by Seattle City Council via Flicker, is licensed CC BY SA 4.0

1.2.6: Process

The last component of information systems is *Process*. A business process is a series of steps to achieve a desired outcome or goal. Businesses must continually innovate to create more revenues through new products and services that fulfill customers' needs or find cost-saving opportunities in running their companies. Simply automating activities using technology is not enough. Information systems are becoming increasingly integrated with organizational processes to deliver value in revenue-generating and cost-saving activities that can give companies competitive advantages over their competitors. Technical standards or procedures such as "business process reengineering," "business process management," "enterprise resource planning," and "customer relationship management" all have to do with the continued improvement of these business procedures and the integration of technology with them to improve internal efficiencies and to gain a deeper understanding of customers' needs. Businesses hoping to gain an advantage over their competitors are highly focused on this component of information systems. We will discuss processes in Chapter 8.

Figure 1.2.8 is an example of a business process to illustrate the steps a customer goes through to purchase a book (Susi, L, 2021). It shows: The customer goes to the bookstore and searches the shelves. If the book is available, customers purchase it and take it home. If it is not available, then ask the clerk to search. If the clerk finds it, the customer buys it and takes it home. If the clerk does not find it, the customer inquires about if they can order it. If not, then customers go to another store. If yes, then the clerk places the order. When it arrives, the clerk notifies the customer, who returns to the store, purchases it, and takes it home.

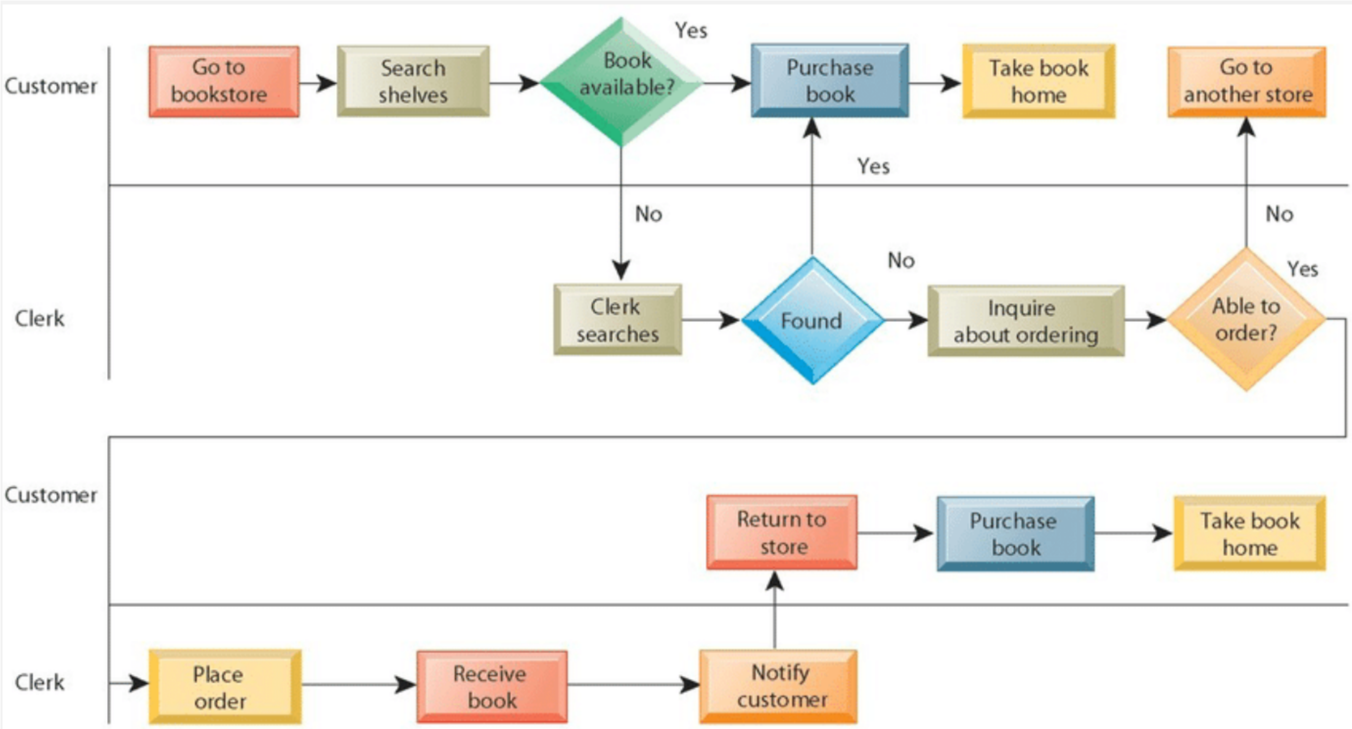


Figure 1.2.8 Figure 13-2 As-Is Business Process For Purchasing a Book From A customer, by Susi Lowati (2021), from Scientific Figure on ResearchGate

1.2.7: References

Laudon, K. C., & Laudon, J. P. (2011). Management information systems. Upper Saddle River, NJ: Prentice-Hall.

Lowati, Susi. (2021). Membangun Sistem Informasi Untuk Perubahan Model Bisnis Dan Digitalisasi Perusahaan Pada PT. Quantum Globalindo. Retrieved from Researchgate.net, October 29, 2022.

1.3: The Evolution and Role of Information Systems

Now that we have explored the different components of information systems (IS), we need to focus on IS's role in an organization and how computer information systems have evolved throughout the years to deliver value to organizations continuously.

From the first part of the definition of an information system, we see that these components collect, store, organize, and distribute data throughout the organization. We can now ask what these components do for an organization to address the second part of the definition of an IS "What is the role of IS in providing value to businesses and individuals as their needs evolve?"

Earlier, we discussed how IS collects raw data to organize them to create new information to aid in running a business. Information Systems (IS) must transform data into organizational knowledge to assist management in making informed decisions. IS plays a crucial role in converting data into useful information that can be used to gain a competitive advantage in today's data-driven business world. Over the years, IS has evolved from running an organization efficiently to becoming a strategic tool for gaining a competitive edge. To fully understand the importance of IS, it is essential to view how it has changed over time to create new opportunities for businesses and meet evolving human needs.

Today's smartphones result from earlier technological advances in making computers smarter, smaller, and lighter. Even though research and experiments happened before 1936, it was not until 1936 that there was concrete proof that the 'Boolean logic", the ability to add two binary digits together, could be implemented in a machine. Computers would not be possible without the ability to calculate in a machine. Since then, we have seen the first computer, Univac I, going from 29000 pounds and costing about $1M each to today's devices, such as Apple's iPhone 14, weighing about 200g and costing about $1500, and with significantly more computing power than the Univac I. It has only taken 71 years since Univac I was delivered! (Figure 1.3.1)

Figure 1.3.1 shows the advances from the 1930s to 1950s, 1970s, 2010s, and 2020s: in the 1930s, Model K Adder demonstrated the proof of Boolean logic (1936), the ability to add two binary digits; in 1950s, first computer, Univac I (1951,) going from 29000 pounds and cost about $1M, in 1970s, Xerox Alto, the first system (1973)to have all of the contemporary graphic User Interface Components and cost $32000 each, in 2010s, the Google Fitbit Ionic (2017) weights ~30gr and cost ~$300, and by 2020s, Microsoft Surface Pro 9 (2022) weight 1.94lb (879gr) and cost ~price0 to $2700, and Apple iPhone 14 (2022) weight 172 to 240g, and cost ~ $1000 to $1500.

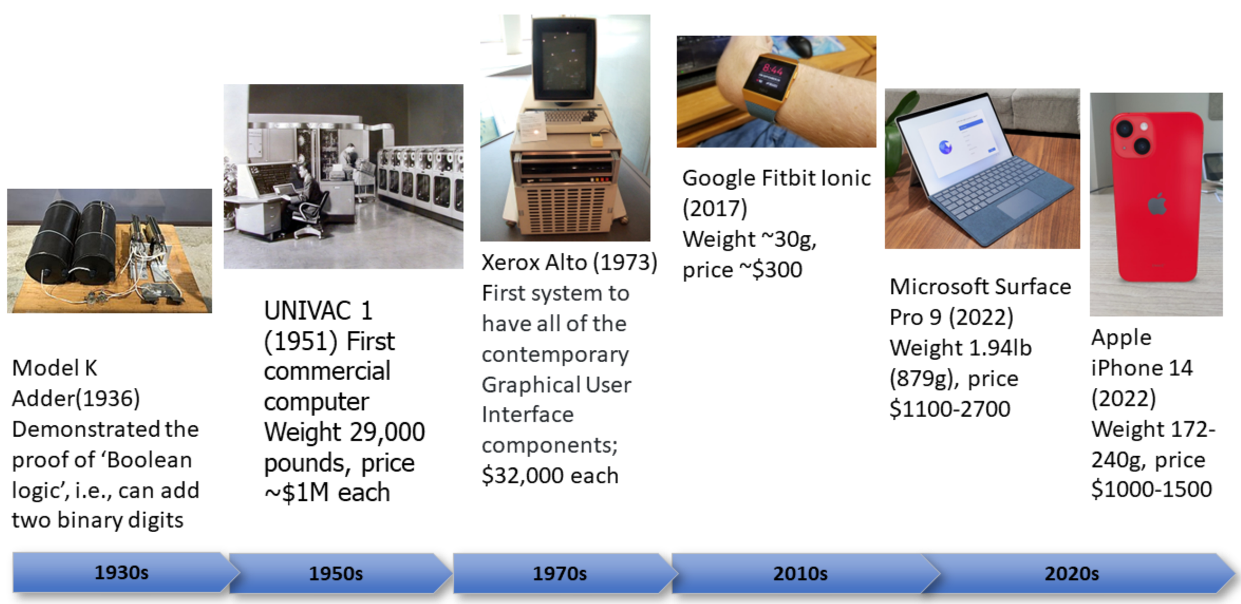


Figure 1.3.1: Model K Adder,Image by Arnold Reinhold is licensed under CC BY 4.0; UNIVAC 1, Image By US Bureau of Census is licensed under CC-PD ; Xerox Alto, Image by Joho345, is licensed under CC-PD ; Fitit Ionic, image is licensed under CC BY

4.0 via Wikimedia; Microsoft Surface 9, photo by Kyler Chin, is licensed under CC BY 4.0' Apple iPhone 14, image by Hajoon0102 is licensed under CC BY 4.0

As you go through each chapter of the book, keep in mind how each of the components of an IS has evolved to accommodate the significant decrease in size of a computing device, the increase in computing power of the hardware, the complexities of programming the software developers to make these devices powerful, yet still intuitive to use, and to collect and process an enormous amount of data.

1.3.1: The Early Years (the 1930s-1950s)

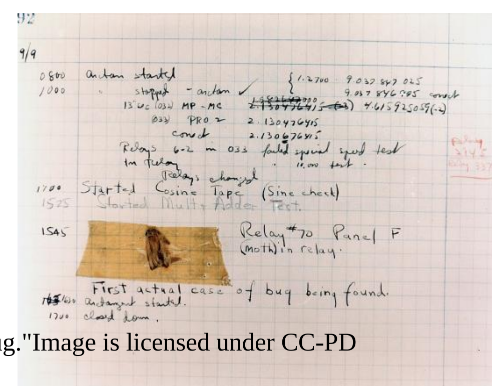
We may say that computer history came to public view in the 1930s when George Stibitz developed the "Model K" Adder (Figure 1.3.1) on his kitchen table using telephone company relays and proved the viability of the concept of 'Boolean logic,' a fundamental concept in the design of computers. From 1939, we saw the evolution of special-purpose equipment to general-purpose computers by companies now iconic in the computing industry; Hewlett-Packard with their first product HP200A Audio Oscillator that Disney's Fantasia used. The 1940s gave us the first computer program running a computer through the work of John Von Newmann, Frederic Williams, Tom Kilburn, and Geoff Toothill. The 1950s gave us the first commercial computer, the UNIVAC 1, made by Remington Rand and delivered to the US Census Bureau; it weighed 29,000 pounds and cost more than $1,000,000 each. (Computer History Museum, n.d.) (Figure 1.3.1)

Software evolved along with hardware evolution. Rear Admiral Grace Hopper invented a compiler program allowing programmers to enter hardware instructions with English-like words on the UNIVAC 1 Figure 1.3.2. Hopper's invention enables the creation of what we now know as computer programming languages. With the arrival of general and commercial computers, we entered what is now called the mainframe era. (Computer History Museum, n.d.)

Figure 1.3.2: Rear Admiral Grace M. Hopper.

Image by James S. Davis is licensed under CC-PD

Figure 1.3.3



: The First "Computer Bug."Image is licensed under CC-PD

Fun Fact: Do you know how the word "bug" becomes the term to describe a malfunction in an information system?

The story goes like this: When Rear Admiral Hopper worked on the Mark II, an error was traced to a moth trapped in a relay, coining the term bug. Figure 1.3.3 showed the bug removed and taped to a log book. Here is her biography for more about her life and contribution to information systems.

1.3.2: The Mainframe Era (the 1950s-1960s)

From the late 1950s through the 1960s, computers were seen to do calculations more efficiently. These first business computers were room-sized monsters, with several refrigerator-sized machines linked together. These devices' primary work was to organize and store large volumes of information that were tedious to manage by hand. More companies, such as Digital Equipment Corporation (DEC), RCA, and IBM, were founded to expand the computer hardware and software industry. Only large businesses, universities, and government agencies could afford them, and they took a crew of specialized personnel and facilities to install them.

IBM introduced System/360 with five models. It was hailed as a significant milestone in computing history for it targeted businesses besides the existing scientific customers. Equally important, all models could run the same software (Computer History, n.d.). These models could serve hundreds of users simultaneously through the time-sharing technique. Typical functions included scientific calculations and accounting under the broader umbrella of "data processing."

Figure 1.3.4 IBM System/360 Model 30 central processor unit (CPU). Image by Arnold Reinhold is licensed CC BY-SA 3.0(opens in new window)

In the late 1960s, the Manufacturing Resources Planning (MRP) systems were introduced. This software, running on a mainframe computer, allowed companies to manage the manufacturing process, making it more efficient. From tracking inventory to creating bills of materials to scheduling production, the MRP systems (and later the MRP II systems) gave more businesses a reason to integrate computing into their processes. IBM became the dominant mainframe company. Nicknamed "Big Blue," the company became synonymous with business computing. Continued software improvement and the availability of cheaper hardware eventually brought mainframe computers (and their little sibling, the minicomputer) into the most prominent businesses.

1.3.3: The PC Revolution (the 1970s-1980s)

The 1970s ushered in the growth era by making computers smaller- microcomputers- and faster big machines- supercomputers. In 1975, the first microcomputer was announced on the cover of Popular Mechanics: the Altair 8800, invented by Ed Roberts, who coined the term "personal computer." The Altair was sold for $297-$395, came with 256 bytes of memory, and licensed Bill Gates and Paul Allen's BASIC programming language. Its immediate popularity sparked entrepreneurs' imagination everywhere, and dozens of companies quickly made these "personal computers." Though at first just a niche product for computer hobbyists, improvements in usability and practical software availability led to growing sales. The most prominent of these early personal computer makers was a little company known as Apple Computer, headed by Steve Jobs and Steve Wozniak, with the hugely successful "Apple II ." (Computer History Museum, n.d.)

Figure 1.3.5 Altair 8800 Computer 8-inch floppy disk system - Image by Swtpc6800 is licensed under CC-PD. (right) Apple II Computer - Image by Rama is licensed under CC BY-SA 2.0(opens in new window)

Hardware companies such as Intel and Motorola continued introducing faster microprocessors (i.e., computer chips). Not wanting to be left out of the revolution, in 1981, IBM (teaming with a little company called Microsoft for their operating system software) released their version of the personal computer, called the "PC." Businesses, which had used IBM mainframes for years to run their businesses, finally had the permission they needed to bring personal computers into their companies, and the IBM PC took off. The IBM PC was named Time magazine's "Man of the Year" in 1982.

Because of the IBM PC's open architecture, it was easy for other companies to copy or "clone" it. During the 1980s, many new computers sprang up, offering less expensive PC versions. This drove prices down and spurred innovation. Microsoft developed its Windows operating system and made the PC easier to use. During this period, common uses for the PC included word processing, spreadsheets, and databases. These early PCs were not connected to any network; for the most part, they stood alone as islands of innovation within the larger organization. The price of PCs has become more and more affordable with new companies such as Dell.

Today, we continue to see PCs' miniaturization into a new range of hardware devices such as laptops, Apple iPhone, Amazon Kindle, Google Nest, and the Apple Watch. Not only did the computers become smaller, but they also became faster and more powerful; the big computers, in turn, evolved into supercomputers, with IBM Inc. and Cray Inc. among the leading vendors.

1.3.4: Networks, Internet, and World Wide Web (The 1980s - Present)

1.3.4.1: Client-Server

By the mid-1980s, businesses began to see the need to connect their computers to collaborate and share resources. This networking architecture was referred to as "client-server" because users would log in to the local area network (LAN) from their PC (the "client") by connecting to a powerful computer called a "server," which would then grant them rights to different resources on the network (such as shared file areas and a printer). Software companies began developing applications that allowed multiple users to access the same data simultaneously. This evolved into software applications for communicating, with the first prevalent use of electronic mail appearing at this time.

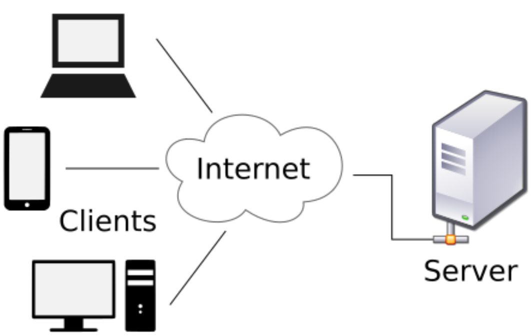


Figure 1.3.6: A computer network diagram of clients communicating with a server via the Internet (GNU Lesser General Public License; Gnome-fs-client. by David Vignoni via Wikipedia)

This networking and data sharing all stayed within the confines of each business for the most part. Electronic data was shared data between companies; this was a very specialized function. Computers were now seen as tools to collaborate internally within an organization. These computers' networks were becoming so powerful that they replaced many of the functions previously performed by the larger mainframe computers at a fraction of the cost.

During this era, the first Enterprise Resource Planning (ERP) systems were developed and run on the client-server architecture. An ERP system is a software application with a centralized database that can be used to run a company's entire business. With separate modules for accounting, finance, inventory, human resources, and many more, ERP systems, with Germany's SAP leading the way, represent state of the art in information systems integration. We will discuss ERP systems as part of the chapter on Processes (Chapter 9).

Figure 1.3.7: Registered trademark of SAP

Networking communication, along with software technologies, evolve through all periods: the modem in the 1940s, the clickable link in the 1950s, the email as the "killer app' and now iconic "@" the mobile networks in the 1970s, and the early rise of online communities through companies such as AOL in the early 1980s. First invented in 1969 as part of a US-government-funded project called ARPA, the Internet was confined to use by universities, government agencies, and researchers for many years. However, the complicated way of using the Internet made it unsuitable for mainstream use in business.

One exception to this was the ability to expand electronic mail outside the confines of a single organization. While the first email messages on the Internet were sent in the early 1970s, companies who wanted to expand their LAN-based email started hooking up to the Internet in the 1980s. Companies began connecting their internal networks to the Internet to communicate between their employees and employees at other companies. With these early Internet connections, the computer began starteding from a computational device to a communications device.

1.3.4.2: Web 1.0 and the Browser

In 1989, Tim Berners-Lee from the CERN laboratory developed an application (CERN, n.d.), a browser, to give a more straightforward and more intuitive graphical user interface to existing technologies, such as clickable links, to make the ability to share and locate vast amounts of information readily available to the mass in addition to the researchers. We call this the World Wide Web (or Web 1.0). This invention became the launching point of the growth of the Internet as a way for businesses to share information about themselves and for consumers to find them easily.

As web browsers and Internet connections became the norm, companies worldwide rushed to grab domain names and create websites. Even individuals would create personal websites to post pictures to share with friends and family. Users could create content on their own and join the global economy for the first time, a significant event that changed the role of IS for both businesses and consumers.

In 1991, the National Science Foundation, which governed how the Internet was used, lifted restrictions to allow its commercialization. These policy changes ushered in new companies establishing new e-commerce industries, such as eBay and Amazon.com. The fast expansion of the digital marketplace led to the dot-com boom through the late 1990s and then the dot-com bust in 2000. An essential outcome of the Internet boom period was that network and Internet connections were implemented worldwide and ushering in the era of globalization, which we will discuss in Chapter 11.

The digital world became more dangerous as more companies and users connected globally. Once slowly propagated through the sharing of computer disks, computer viruses, and worms could now grow with tremendous speed via the Internet and the proliferation of new hardware devices for personal or home use. Operating and application software had to evolve to defend against this threat. A whole new computer and Internet security industry arose as the threats increased and became more sophisticated. We will study information security in Chapter 6.

Fun Fact: Do you know the first "internet" users?

In 1969, The University of California, Los Angeles, the Stanford Research Institute, the University of California, Santa Barbara, and the University of Utah were connected on the ARPANET, the technical infrastructure for the Internet (Computer History Museum, n.d.)

1.3.5: Web 2.0 and e-Commerce

Perhaps, you noticed that in the Web 1.0 period, users and companies could create content but could not interact directly on a website. Despite the Internet's bust, technologies continue to evolve due to increased customer needs to personalize their experience and engage directly with businesses.

Websites become interactive; instead of just visiting a site to find out about a business and purchase its products, customers can now interact with companies directly, and most profoundly, customers can also interact with each other to share their experience without undue influence from companies or even buy things directinstantlyeach other. This new type of interactive website, where users did not have to know how to create a web page or do any programming to put information online, became known as Web 2.0.

Web 2.0 is exemplified by blogging, social networking, bartering, purchasing, and posting interactive comments on many websites. This new web-2.0 world, where online interaction became expected, significantly impacted many businesses and even whole industries. Some industries, such as bookstores, found themselves relegated to niche status. Others, such as video rental chains and travel agencies, began going out of business as online technologies replaced them. This process of technology replacing an intermediary in a transaction is called disintermediation. One such successful company is Amazon which has disintermediated many intermediaries in many industries and is one of the leading e-commerce websites.

Fun Fact: How Amazon leverages the Internet opportunity

Figure 1.3.8 Amazon Technologies, Inc Registered trademark.

When Jeff Bezos, the founder of Amazon.com, learned that the future of the Internet would grow by 2300%, he created a small list of five products that could be marketed online: compact discs, computer hardware, computer software, videos, and books. He decided to go with the idea of selling books online because he believed there was a strong worldwide demand for books, the price of books was low, and then an ample large supply of books and titles to choose from. He wanted to build the largest bookstore online and named the company 'Amazon,' as in the Amazon River, the biggest river in the world. The company opened for business online on July 16, 1995. The company continues to grow beyond selling books into many new industries, such as web services, autonomous vehicles, gaming, and groceries (Wikipedia, 2022.) Amazon went public on May 15, 1997, and the IPO price was $18.00, or $0.075, adjusted for the multiple stock splits between June 2, 1998, through June 3, 2022 (Amazon.com, 2022). As of October 31, 2022, Amazon has a market cap of $1.045T and $102.44 per share (Yahoo Finance, 2022.)

1.3.6: The Post PC and Web 2.0 World

After thirty years as the primary computing device used in most businesses, PC sales are beginning to decline as tablets and smartphones take off. Like the mainframe before it, the PC will continue to play a key role in business but will no longer be the primary way people interact or do business. The limited storage and processing power of these mobile devices is being offset by a move to "cloud" computing, which allows for storage, sharing, and backup of information on a massive scale.

As the world became more connected, new questions arose. Should access to the Internet be considered a right? What is legal to copy or share on the Internet? How can companies protect private data (kept or given by the users)? Are there laws that must be updated or created to protect people's data, including children's data? Policymakers are still catching up with technological advances even though many laws have been updated or created. Ethical issues surrounding information systems will be covered in Chapter 12.

Users continue to push for faster and smaller computing devices. Historically, we saw that microcomputers displaced mainframes, and laptops displaced (almost) desktops. We now see that smartphones and tablets are replacing desktops in many situations. Will hardware vendors hit the physical limitations due to the small size of devices? Is this the beginning of a new era of invention of new computing paradigms such as Quantum computing, a trendy topic we will cover in more detail in Chapter 13?

Tons of content have been generated by users in the web 2.0 world, and businesses have been monetizing this user-generated content without sharing any of their profits. How will the role of users change in this new world? Will the users want a share of this profit? Will the users finally have ownership of their data? What new knowledge can be created from the massive user-generated and business-generated content?

Below is a chart showing the evolution of some of the advances in information systems to date.

The Eras of Business Computing

Era	Hardware	Operating System Software	Applications

Era	Hardware	Operating System Software	Applications
Early years (1930s)	Model K, HP's test equipment, Calculator, UNIVAC 1	The first computer program was written to run and store on a computer.	
Mainframe (1970s)	Terminals connected to a mainframe computer, IBM System 360 Ethernet networking	Time-sharing (TSO) on MVS	Custom-written MRP software Email became 'the killer app'
Personal Computer (mid-1980s)	IBM PC or compatible. Sometimes connected to the mainframe computer via an expansion card. Intel microprocessor	MS-DOS	Email became 'the killer app' WordPerfect, Lotus 1-2-3
Client-Server (the late 80s to early 90s)	IBM PC "clone" on a Novell Network. Apple's Apple-1	Windows for Workgroups, MacOS	Microsoft Word, Microsoft Excel,
World Wide Web (the mid-90s to early 2000s)	IBM PC "clone" connected to the company intranet.	Windows XP, MacOS	Microsoft Office, Internet Explorer, Chrome
Web 2.0 (mid-2000s to present)	Laptop connected to company Wi-Fi. Smartphones	Windows 7, Linux, MacOS	Microsoft Office, Firefox, social media platforms, blogging, search, texting
Web 3.0 (today and beyond)	Apple iPad, iWatch, robots, Fitbit, watch, Kindle, Nest, semi/autonomous cars, drones, virtual reality goggles Artificial Intelligence bots, language models	iOS, Android, Windows 11	Mobile-friendly websites, more mobile apps eCommerce Metaverse Siri Open AI, chatGPT, etc.

We seem to be at a tipping point of many technological advances that have come of age. The miniaturization of devices such as cameras, sensors, faster and smaller processors, software advances in fields such as artificial intelligence, combined with the availability of massive data, have begun to bring in new types of computing devices, small and big, that can do things that were unheard in the last four decades. A robot the size of a fly is already in limited use, a driverless car is in the 'test-drive' phase in a few cities, among other new advances to meet customers' needs today and anticipate new ones for the future. "Where do we go from here?" is a question that you are now part of the conversation as you go through the rest of the chapters. We may not know exactly what the future will look like, but we can reasonably assume that information systems will touch almost every aspect of our personal, work-life, local and global social norms. Are you prepared to be an even more sophisticated user? Are you preparing yourself to be competitive in your chosen field? Are there new norms to be embraced?

1.3.7: References

Amazon.com, Inc. (AMZN). Retrieved October 31, 2022, from finance.yahoo.com

CERN. (n.d.) The Birth of the Web. Retrieved from public.web.cern.ch

Timeline of Computer History: Computer History Museum. (n.d.). Retrieved July 10, 2020, from www.computerhistory.org

1.4: Can Information Systems Bring Competitive Advantage?

It has always been the assumption that the implementation of information systems will, in and of itself, bring a business competitive advantage, especially in the cost-saving or improve efficiency. The more investment in information systems, the more efficiencies are expected by management.

In 2003, Nicholas Carr wrote an article, "IT Doesn't Matter," in the Harvard Business Review (Carr, 2003) and raised the idea that information technology has become just a commodity. Instead of viewing technology as an investment that will make a company stand out, it should be seen as something like electricity: It should be managed to reduce costs, ensure that it is always running, and be as risk-free as possible.

This article was both hailed and scorned at the time. While it is true that IT should be managed to reduce cost, improve efficiencies, history has shown us that many companies have leveraged information systems to build wildly successful businesses, such as Amazon, Apple, Walmart. Recent companies such as Airbnb, Uber have made the use of IS, a central element of their business model.

Use Case: Walmart Uses Information Systems to Become the World's Leading Retailer

Walmart is the world's largest retailer, with total revenue of $611.29B and a market of $424.984B in the fiscal year that ended on January 31, 2023 (source: Yahoo finance on 8/27/2023). Walmart currently has approximately, 2.1M full time employees,10,500 stores and e-commerce websites in 20 countries, serving nearly 240 million customers every week worldwide (Walmart, 2023).

How did Walmart Use Information System?

Figure 1.4.1: Registered Trademark of Walmart, Inc.

Walmart's rise to prominence is due in no small part to its use of information systems.

- One of the keys to this success was the implementation of Retail Link, a supply-chain management system. This system, unique when initially implemented in the mid-1980s, allowed Walmart's suppliers to directly access the inventory levels and sales information of their products at any of Walmart's more than ten thousand stores. Suppliers can use Retail Link to analyze how well their products are selling at one or more Walmart stores, with a range of reporting options. Further, Walmart requires the suppliers to use Retail Link to manage their own inventory levels. If a supplier feels that their products are selling out too quickly, they can use Retail Link to petition Walmart to raise their inventory levels. This has essentially allowed Walmart to "hire" thousands of product managers, all of whom have a vested interest in managing products. This revolutionary approach to managing inventory has allowed Walmart to continue driving prices down and responding to market forces quickly.
- Walmart's continuous replenishment system uses predictive analytics to forecast demand and automate purchase orders based on real-time sales and inventory data. This ensures that the products customers want are in stock.
- Using its massive data warehouses, Walmart analyzes transaction data to derive insights on customer preferences and shopping patterns. This informs everything from shelf layouts to new store locations.
- By using advanced technologies such as RFID tags, Walmart is able to keep a close eye on its inventory in real-time across its distribution network. This helps to prevent theft and minimize stockouts.
- Walmart relies on its information systems to implement its EDLP (Every Day Low Prices) strategy. These systems provide data-driven efficiencies that allow Walmart to offer prices that its competitors find difficult to match.

However, Amazon's fast rise as the leader in eCommerce has given Walmart a new formidable competitor. Walmart continues to innovate with information technology combined with their physical stores to compete with Amazon, locking the two in a fierce battle to retain the largest retailer's title. Using its tremendous market presence, any technology that Walmart requires its suppliers to implement immediately becomes a business standard.

1.4.1: References

Carr, Nicholas (2003). Retrieved from hbr.org it-doesn't-matter

Yahoo Finance - Stock Market Live, Quotes, Business & Finance News. (2023). Retrieved August 27, 2023, from finance.yahoo.com

About Walmart (2023). Retrieved August 27, 2023, from corporate.walmart.com

---

1.5: Summary

In this chapter, you have been introduced to information systems. We have reviewed several definitions, focusing on information systems components: technology (hardware, software, data, networking communication), people, and process. Information systems (IS) have evolved over time from early computers like the Model K adder in the 1930s to today's smartphones and tablets. Key developments include mainframe computers in the 1950s-60s, personal computers in the 1970s-80s, networking and the Internet in the 1980s-90s, Web 2.0 and mobile computing in the 2000s, and emerging technologies like AI and the metaverse today.

As each phase progressed, technological advancements enabled companies and individuals to incorporate technology more extensively. Hardware has become progressively smaller, faster, and cheaper over time. Software has also advanced from early programming languages to today's complex operating systems and applications.

It is a foregone conclusion that almost all if not all, companies are using information systems. Yet, history also has shown us that some companies are very successful and some are failures. By completing this book, you should understand the role of IS has shifted from mainly organizational efficiency to strategic advantage. Companies like Walmart and Amazon have used IS innovations to transform industries. Networking capabilities converted computers from computation devices to communications tools. The Internet, web browsers, and interactive sites like Web 2.0 changed how individuals and companies operate. Information systems continue to evolve. Emerging trends include cloud computing, big data analytics, Internet of Things, and artificial intelligence.

In just 71 years, we have seen the first computer, Univac I, going from 29000 pounds and cost about $1M each to today's devices such as Apple's iPhone, weighing about 200g and costing about $1500, and with significantly more computing power than the Univac I Figure $1.5.1$. Can you imagine what advances we will see in the next 70 years?

1.6: Study Questions

Study Question 1.6.1

What are the components that make up an information system?

Answer

Information systems comprise six major components: hardware, software, network communications, data, people, and processes.

Study Question 1.6.2

List three examples of information system hardware.

Answer

There are many. Some examples can be seen or touched easily, while others reside inside a device that can only be seen by opening up the device's case. Keyboards, mice, pens, disk drives, iPads, printers, and flash drives are all visible examples. Computer chips, motherboards, and internal memory chips are the hardware that resides inside a computer case and are not usually visible from the outside.

Study Question 1.6.3

Identify which component of information systems includes Microsoft Windows.

Answer

Operating System software.

Study Question 1.6.4

What is software? What is application software?

Answer

Software is a program that comprises a set of computer instructions that direct a computer or device on how to perform specific tasks. Application software is one or more programs designed to interact with end-users to perform particular tasks or functions on a computer or device.

Study Question 1.6.5

Describe the different roles people play in information systems

Answer

Examples from the chapter include programmer, IT support, and helpdesk support.

Study Question 1.6.6

Describe what a process is and its purpose.

Answer

A process is a series of steps to achieve a desired outcome or goal.

? Study Question 1.6.7

What was invented first, the personal computer or the Internet?

Answer

The Internet was activated in 1969, and the personal computer was introduced in 1975.

? Study Question 1.6.8

Which comes first, the Internet or the world wide web?

Answer

The Internet was activated in 1969, and the browser was introduced in 1989.

? Study Question 1.6.9

What helps make the Internet usable for the masses, not just researchers?

Answer

Personal computers got cheaper, an email killer app was introduced, and restrictions were lifted in 1991 to allow the commercialization of the Internet.

? Study Question 1.6.10

What does it mean to say we are in a "post-PC and Web 2.0 world"?

Answer

People can interact anytime, anywhere, and on any device. Individuals and companies can leverage IS to generate income.

? Study Question 1.6.11

What is Carr's main argument about information technology? Is it true then, and is it true now?

Answer

Information systems were just a cost-saving tool and could not be used to gain competitive advantages. The text mentions examples of companies achieving both.

Exercises

1. Suppose you had to explain to a member of your family or closest friends the concept of an information system. How would you define it? Write a one-paragraph description in your own words that you feel would best describe an information system to your friends or family.
2. Which of the six components of an information system (hardware, software, data, network communications, people, process) is the most important to a business organization's success? Write a one-paragraph answer to this question that includes an example from your personal experience to support your answer.
3. We all interact with various information systems daily: at the grocery store, at work, at school, and even in our cars (at least some of us). Make a list of the different information systems you interact with every day. See if you can identify the technologies, people, and processes in making these systems work.
4. Do you agree that we are in a post-Web 2.0 stage in the evolution of information systems? Some argue that we will always need a personal computer, but it will not be the primary device to manipulate information. Others think a new era of mobile, biological, or even neurological computing is coming. Do some original research and predict what business computing will look like in the next three to five years.

5. The Walmart case study introduced how that company used information systems to become the world's leading retailer. Walmart has continued to innovate and is still looked to as a leader in the use of technology. Do some original research and write a one-page report detailing a new technology that Walmart has recently implemented or is pioneering to stay competitive.
6. Research and write a report on how Amazon uses Information System to create competitive advantage and relate your personal experience as an Amazon customer.

CHAPTER OVERVIEW

2: Hardware

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe the element hardware of information systems.
- Identify the primary components of a computer and the functions they perform.
- Explain the effect of the commoditization of the personal computer.

This chapter discusses the element hardware and how it works. We will look at different types of computing devices, computer components, learn how they interact and the impact of their commoditization.

2.1: Introduction

Information systems comprise six components: hardware, software, data, communication, people, and process. In this chapter, we will review hardware. Hardware is the tangible or physical parts of computing devices to function. We will review the hardware components of information systems, learn how it work, and discuss some current trends.

Computer hardware encompasses digital devices you can physically touch. This includes devices such as the following:

- desktop computers
- e-readers
- input devices, such as keyboards, mice, and scanners
- laptop computers
- mobile phones
- output devices such as 3d printers and speakers
- smartphones
- smartwatches
- Smart home devices
- storage devices, such as flash drives
- tablet computers
- virtual Reality headsets

Besides these more traditional computer hardware devices, many items that were once not considered digital devices are now becoming computerized. Digital technologies are now being integrated into many everyday objects, so the days of a device being labeled computer hardware may end. Examples of digital devices include automobiles, refrigerators, doorbells, and even soft-drink dispensers. Let's begin with some key metrics and terminologies used in describing units in devices before we get to look at each device in detail.

2.1.1: Digital Devices

A digital device is any physical equipment containing a computer or microcontroller; examples include smartphones, watches, and tablets. A digital device processes electronic signals that represent either a one ("on") or a zero ("off"). The presence of an electronic signal represents the "on" state; the absence of an electronic signal represents the "off" state.

Each one or zero is referred to as a bit (a contraction of a binary digit); a group of eight bits is a byte. The first personal computers could process 8 bits of data simultaneously; modern PCs can now process thousands of bits simultaneously. The larger the number of bits, the faster information can be processed simultaneously.

For the inquiring mind: Understanding Decimal and Binary number systems

The system of numbering we are most familiar with is the decimal numeral system, also known as base-ten numbering. The decimal digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9. In base-ten numbering, each position in the number represents a power of ten, going from right to left, with the far-right position representing 10^0 (ones), the next position from the right representing 10^1 (tens), then 10^2 (hundreds), then 10^3 (thousands), etc. The '10' means the base ten.

Example: How do we express the number 2053 or "two thousand and fifty-three" in base-ten format?

Going from left to right, the number 2053 in decimal represents: (2 x 1000) + (0 x 100) + (5 x 10) + (3 x 1) = 2000 + 0 + 50 + 3 = 2050, as shown in the table below:

Example: Based-ten system for decimal number 2053

Position Exponent (note the '10' is the base ten)	10^4 (read ten to the power of 4)	10^3	10^2	10^1	10^0
Answer	2050 =	2000	+0	+50	+ 3

Decimal Number		2	0	5	3
Decimal Representation		(2 *1000 (position value))	+ (0 *100)	+ (5 * 10)	+ (3 * 1)
Position Value in decimal	10 to the power of 4 =10,000	1000	100	10	1

However, computers use the base-two number system, also known as binary. The binary digits are 0 and 1. Information is expressed by combinations of 'on' or 'off' electrical signals. The digit 0 represents 'off,' and 1 represents 'on.' Each position in a binary number represents a power of 2, going from right to left, with the far-right position representing 2^0 (ones), the next position from the right representing 2^1 (tens), then 2^2 (hundreds), then 2^3 (thousands), etc.

Example: What is the decimal value of the binary number 1010? (i.e., convert binary 1010 to a decimal value)

Going from left to right, the number 1010 in the binary represents: (1 * 8) + (0 * 4) + (1 * 2) + (0 * 1) =8 + 0 + 2 + 0 =10 in decimal, as shown in the table below:

Converting a binary number to a decimal example: Binary number 1010 is the decimal number 10

Position Exponent (note the '2' is the base two)	2(read 2 to the power of 4)	2^3	2^2	2^1	2^0
Position Value in decimal	2 to the power of 4 = 16	8	4	2	1
Binary Number		1	0	1	0
Convert to base ten decision		(1 * 8 (position value in decimal))	+ (0 *4)	+ (1 * 2)	+ (0 * 1)
Answer	10 =	8	+0	+2	+0

As digital devices' capacities grew, new terms were developed to identify the capabilities of processors, memory, and disk storage space.

Let's get familiar with the terminologies to express the different sizes in bytes.

Definition: Terms for different magnitudes expressed in bytes

We discussed that computer systems operate using a binary number of systems with two digits: 0 and 1. Each digit is also called a bit. It takes 8 bits to describe a letter in the alphabet, such as the letter A. Eight bits is also called a byte. Prefixes were applied to the word byte to represent different orders of magnitude. The prefixes were initially meant to represent multiples of 1024 but have more recently been rounded to mean multiples of 1000.

Prefixes to express different magnitude in bytes

To Say	Use Prefix	Complete Expression
1 byte	No prefix needed	1 byte
One thousand bytes	kilo	1 kilobyte

To Say	Use Prefix	Complete Expression
One million bytes	mega	1 megabyte
One billion bytes	giga	1 gigabyte
One trillion bytes	tera	1 terabyte
One quadrillion bytes	peta	1 petabyte
One quintillion bytes	exa	1 exabyte
One sextillion bytes	zetta	1 zettabyte
One septillion bytes	yotta	1 yottabyte

2.2: Tour of a Digital Device

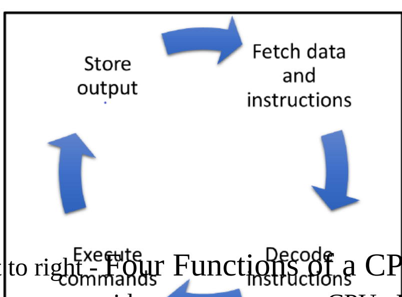
We will begin with personal computers, which consist of these essential basic components:

- Central Processing Unit (CPU)
- Motherboard (circuit board)
- Random Access Memory (RAM)
- Video Card
- Power Supply
- Hard Drive (HDD)
- Solid-State Drive (SSD)
- Optical Drive (DVD/CD drive)
- Card Reader (SD/SDHC, CF, etc.)

It also turns out that almost every digital device uses three of components, so examining the personal computer will give us insight into the structure of various digital devices. So let's take a "tour" of a personal computer and see what makes them function.

2.2.1: Central Processing Unit: The CPU

As stated in the previous section, most computing devices have a similar architecture. The core of this architecture is the central processing unit or CPU. The CPU can be thought of as the "brain" of the device or main processor. Its main functions are to fetch data and instructions, decode the instructions, execute, and store the output. The CPU was made up of hundreds of wires that carried information. These wires carried out the commands sent to them by the software and returned results to be acted upon. The earliest CPUs were large circuit boards with limited functionality. Today, a CPU is generally on one chip and can perform a large variety of functions. There are two primary manufacturers of CPUs for personal computers: Intel and Advanced Micro Devices (AMD).



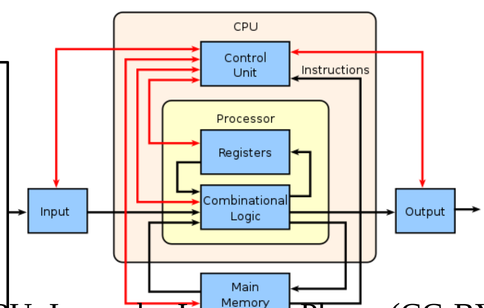


Figure 2.2.1: From left to right - Four Functions of a CPU, Image by Ly-Huong Pham, (CC-BY-NC, 2022); Block diagram of a basic computer with one processor CPU. Black lines indicate data flow, whereas red lines indicate control flow. Arrows indicate the direction of flow, by Surachit is licensed under CC BY-SA 4.0.

A CPU's speed ("clock time") regulates the instruction rate and executes and synchronizes the various computer components. The faster the clock, the quicker the CPU can execute instructions per second. The clock is measured in hertz. A hertz is defined as one cycle per second. Using the binary prefixes mentioned above, we can see that a kilohertz (abbreviated kHz) is one thousand cycles per second, a megahertz (MHz) is one million cycles per second, and a gigahertz (GHz) is one billion cycles per second. The CPU's processing power increases amazingly (see the sidebar about Moore's Law). Besides a faster clock time, many CPU chips now contain multiple processors per chip.A multi-core processor is a single integrated circuit that contains multiple chips. These chips are commonly known as cores. The multi-core runs and reads instructions simultaneously, increasing the speed. A computer with two processors is known as dual-core, or quad-core (four processors), increasing the processing power of a computer by providing multiple CPUs' capability.

When computers run with multiple cores, additional heat is generated and why companies add fans on top of the CPU. Macs have built-in a fail-safe that the computer will shut down to avoid damage when the temperature builds too rapidly. Smartphones may warn users if the temperatures get too hot. As our devices get smaller, we have many parts placed in a compact area, and in turn, devices will generate more heat. Running many apps on your phone simultaneously is another way to increase the phone's heat; this is why it is essential to close applications after use.

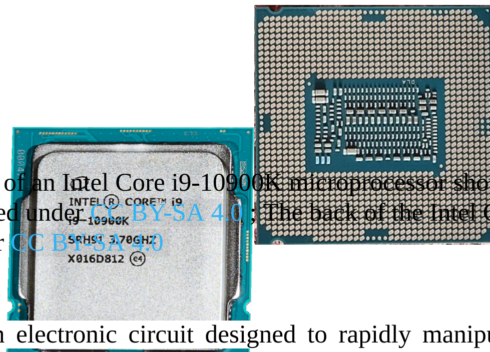


Figure 2.2.2 Left to right: Processor side of an Intel Core i9-10900K microprocessor showing the lid and markings for the processor. Image by Locke Cole is licensed under CC BY-SA 4.0; The back of the Intel Core i9-9900K. Image by PantheraLeo1359531 is licensed under CC BY-SA 4.0

A graphics processing unit (GPU) is an electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of images in a frame buffer for output. Devices that use GPUs are personal computers, smartphones, and game consoles. Nvidia is one of the powerhouse companies that manufacture HD graphics cards. Nvidia has been a leader in GPU's chips, one of the most popular chips is the NvidiaGeForce, which is integrated with laptops, PCs, and virtual reality processors. Nvidia has also worked with many companies expanding its GPU chip market. Some notable companies that Nvidia works with are Tesla, Quadro, and GRID.

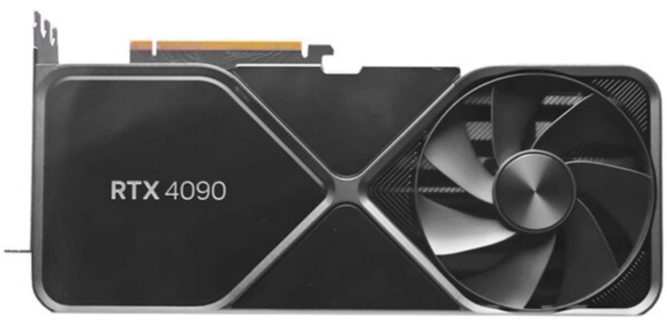


Figure 2.2.3 NVIDIA GeForce 40 series Image by GalaxyNite is licensed under CC-BY-3.0

2.3: Moore’s Law

Technology is advancing, and computers are getting faster every year. Consumers often are unsure of buying today’s smartphone, tablet, or PC model because a more advanced model will be out shortly, leaving them with regret that it won’t be the most advanced anymore. Gordon Moore, the co-founder of Fairchild and one of Intel's founders, recognized this phenomenon in 1965, noting that microprocessor transistor counts had been doubling yearly. His insight eventually evolved into Moore’s Law, which states that the number of transistors on a chip will double every two years. (Moore, 1965). This has been generalized into the concept that computing power will double every two years for the same price point. Another way of looking at this is to think that the same computing power price will be cut in half every two years. Though many have predicted its demise, Moore’s Law has held for over fifty-five years. Technology is changing with innovation in design and Artificial Intelligence (AI) support. Experts now believe,

> *“The name of the game now is the technology may not be traditional silicon transistors; now it may be quantum computing, which is a different structure and nano-biotechnology, which consists of proteins and enzymes that are organic."*

Therefore it is likely in the next few years, the emphasis of Moore’s Law will change. Experts believe that Moore’s law will not be able to go on indefinitely because of physical limits on continually shrinking the size of components on a chip. The billions of transistors on chips are not visible to the naked eye. It is thought that if Moore’s law were to continue through 2050, engineers would have to design transistors from components smaller than a single hydrogen atom.

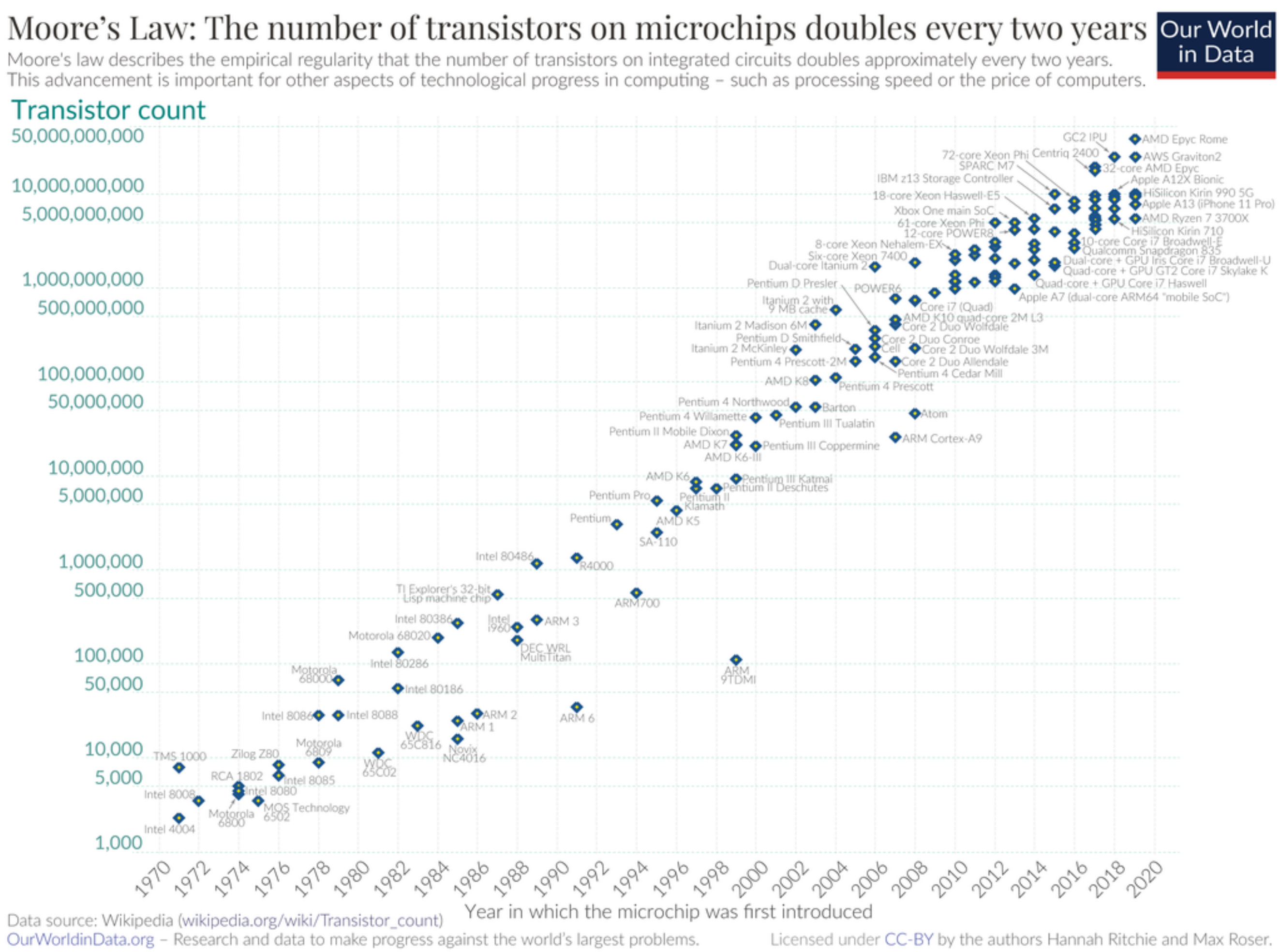


Figure 2.3.1: Moore's Law 1970-2020. (CC-BY-SA 4.0; Max Roser and Hannah Ritchie via Wikipedia)

> **Fun Fact**
>
> Do you know we go from 1000 transistors in 1970, in an Intel 4004 chip, to 114 billion transistors in 2022 in an ARM-based dual die M1 Ultra system on a chip?

Figure 2.3.1 represents Moore's law empirical relationship linked to transistors' number in a dense integrated circuit that doubles about every two years.

There will be a point, someday, where we hit the apex of processing technology as challenges occur to move forward to shrink circuits at the time of exponential growth will get more expensive. Moore's Law will then be outdated due to technological innovation. Engineers will continue to strive for new ways to increase performance (Moore, 1965).

2.3.1: Motherboard

The motherboard is the main circuit board hub of the computer. The motherboard is the largest board inside a computer that allows communication between all the critical components that make the computer function. Some vital components attached directly to the motherboard include the central processing unit (CPU), graphics processing unit (GPU), main system memory (RAM), and expansion slots that provide connectivity and upgradeability. Also integrated onto modern motherboards are components like sound cards, network interfaces, USB ports, power regulators and controllers.

Motherboards come in different shapes and sizes; the prices of motherboards also vary depending on complexity. Complexity depends on how compact or expandable the computer is designed to be. Most modern motherboards have many integrated components, such as video and sound processing, requiring separate components.

The key role of the motherboard is to act as the central nervous system for the computer, passing power and data between components, and coordinating activities so that the system works in unison. It provides the critical links and communication that allows the other components such as processor, memory, storage, expansion cards, peripherals etc. to work together as an integrated system. It is a hub that holds and connects crucial computer components together through electronic circuitry etched onto it to coordinate data traffic.

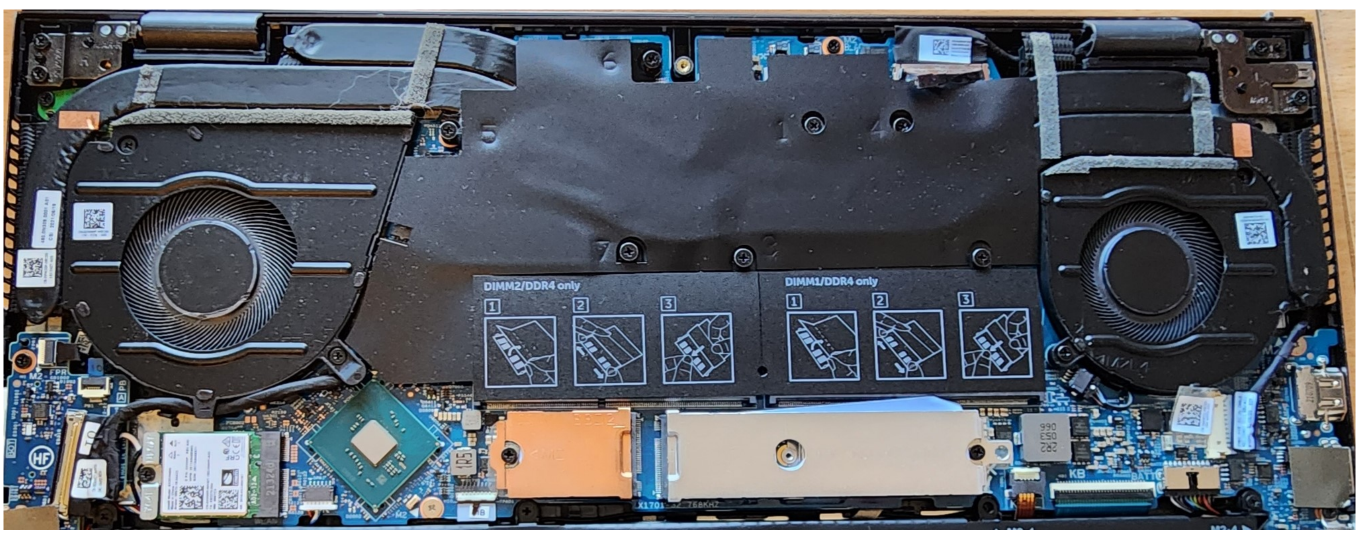


Figure 2.3.2 A 2021 Dell Laptop Motherboard. Image by Ly-Huong Pham, is licensed under CC BY SA

Figure 2.3.1 shows an overall view of a motherboard, once the bottom cover is opened. Some of the motherboard, color blue, is visible while other portion is covered by two fans (right and left), or some black protective cover

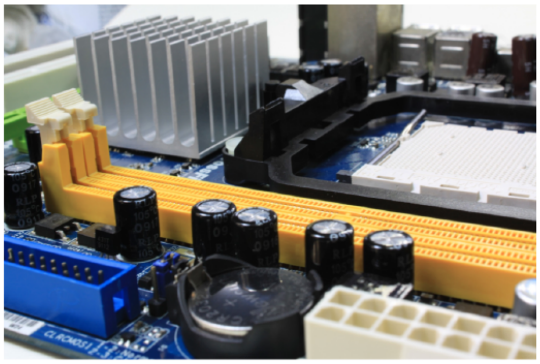


Figure 2.3.3 Computer Motherboard of a Desktop circa 2000 by MH Rhee is licensed under CC BY-SA 2.0

2.3.2: Random-Access Memory

When a computer starts up, it begins to load information from the hard disk into its working or temporary memory. Your computer's short-term memory is called random-access memory (RAM), which transfers data much faster than the hard disk. Any program that you are running on the computer is loaded into RAM for processing. RAM is a high-speed component that stores all the information the computer needs for current and near-future use. Accessing RAM is much quicker than retrieving it from the hard drive. Fora computer to work effectively, a minimal amount of RAM must be installed. In most cases, adding more RAM will allow the computer to run faster. Increasing the RAM size, the number of times this access operation is carried out is reduced, making the computer run faster. Another characteristic of RAM is that it is a volatile or temporary memory. This means that it can store data as long as it receives power; when the computer is turned off, any data stored in RAM is lost. This is why we need hard drives and SSDs that hold the information when we shut off the system.

RAM is generally installed in a personal computer by using a dual-inline memory module (DIMM). The type of DIMM accepted into a computer is dependent upon the motherboard. As described by Moore's Law, the amount of memory and speeds of DIMMs have increased dramatically over the years.

Definition: Term

A **DIMM** (Dual In-line Memory Module), commonly called a **RAM stick**, contains one or several random access memory (RAM) chips on a small circuit board with pins that connect it to the computer motherboard. DIMMs are typically used in desktop PCs, laptops, printers and other devices. They are the predominant method for adding memory into a computer system.

Figure 2.3.4 Two types of DIMMs on a desktop: a 168-pin SDRAM module (top) and a 184-pin DDR SDRAM module (bottom). The SDRAM module has two notches (rectangular cuts or incisions) on the bottom edge, while the DDR1 SDRAM module has one. Also, each module has eight RAM chips, but the lower one has an unoccupied space for the ninth chip; this space is occupied in ECC DIMMs. Image by Grendelkhan is licensed under CC BY-SA 3.0(opens in new window)

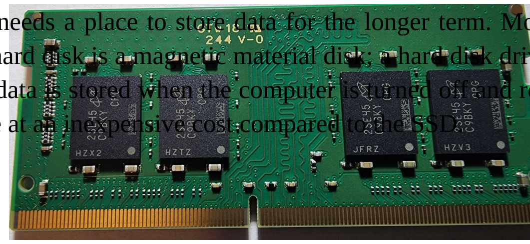


Figure 2.3.5: Left image is a 8GB SO-DIMM for a Dell 2021 Laptop. Right image is 16GB SO-DIMM for a Dell 2021 Laptop. Images by Ly-Huong Pham, is licensed CC BY-NC-SA

2.3.3: Hard Disk Drive (HDD)

While the RAM is used as working memory, the computer also needs a place to store data for the longer term. Most of today's personal computers use a hard disk for long-term data storage. A hard disk is a magnetic material disk; a hard disk drive or HDD is the device for storing the data into a hard disk. The disk is where data is stored when the computer is turned off and retrieved from when the computer is turned on. The HDD provides lots of storage at an inexpensive cost compared to the SSD.

Figure 2.3.6: Open Hard Drive. Image by Welcome to All via Pixabay, is licensed under CC-BY

2.3.4: Solid-State Drive (SSD)

SSD is a new generation device replacing hard disks. They are much faster, and they utilize flash-based memory. Semiconductor chips are used to store data, not magnetic media. An embedded processor (or brain) reads and writes data. The brain, called a controller, is an important factor in determining the read and write speed. SSD's are decreasing in price, but they are expensive. SSD's have no moving parts, unlike the HDD, which deals with wear and tear of spinning and break down.

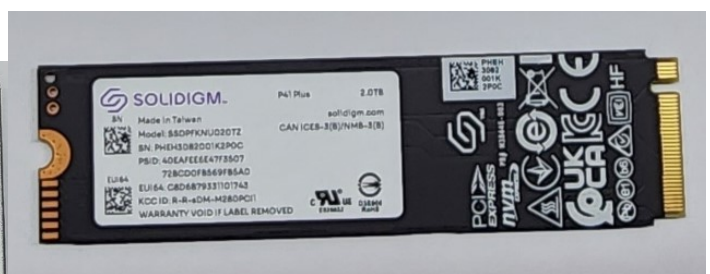


Figure 2.3.7: Left image is 2.5in SSD 1TB, circa 2015; Right image is NVME SSD 2TB, in 2023. Image by Ly-Huong Pham, is licensed under CC BY-NC-SA

2.3.4.1: Comparison of SSD vs. HDD

The * represents the best selection in the category.

Comparison of Solid State Drives and Hard Disk Drives

Attribute	SSD (Solid State Drive)	HDD (Hard Disk Drive)
Power Draw / Battery Life	* Less power draw, averages 2 – 3 watts, resulting in 30+ minute battery boost.	More power draw-- averages 6 – 7 watts and therefore uses more battery.
Cost	Expensive, roughly $0.20 per gigabyte (based on buying a 1TB drive).	* Only around $0.03 per gigabyte, very cheap (buying a 4TB model)
Capacity	Typically not larger than 1TB for notebook size drives; 4TB max for desktops.	* Typically around 500GB and 2TB maximum for notebook size drives; 10TB max for desktops.
Operating System Boot-Time	* Around 10-13 seconds average bootup time.	Around 30-40 seconds average bootup time.
Noise	* There are no moving parts and, as such, no sound.	Audible clicks and spinning can be heard.
Vibration	* No vibration as there are no moving parts.	The spinning of the platters can sometimes result in vibration.
Heat Produced	* Lower power draw and no moving parts, so little heat is produced.	HDD doesn't produce much heat, but it will have a measurable amount more heat than an SSD due to moving parts and higher power draw.
Failure Rate	* Mean time between failure rate of 2.0 million hours.	Mean time between failure rate of 1.5 million hours.
File Copy / Write Speed	* Generally above 200 MB/s and up to 550 MB/s for cutting-edge drives.	The range can be anywhere from 50 – 120 MB/s.
Encryption	Full Disk Encryption (FDE) Supported on some models.	* Full Disk Encryption (FDE) Supported on some models.
File Opening Speed	* Up to 30% faster than HDD.	Slower than SSD.
Magnetism Affected?	* An SSD is safe from any effects of magnetism.	Magnets can erase data.

2.3.5: Reference

Moore, Gordon E. (1965). "Cramming more components onto integrated circuits" (PDF). *Electronics Magazine*. p. 4. Retrieved 2012-10-18.

2.4: Removable Media

2.4.1: Removable Media

Removable storage has changed greatly over the four decades of PCs. CD-ROM drives have replaced floppy disks, and then they were replaced by USB (Universal Serial Bus) drives. USB (Universal Serial Bus) drives are now standard on all PCs with capacities approaching 512 gigabytes. Speeds have also increased from 480 Megabits in USB 2.0 to 10 Gigabits in USB 3.1. USB devices also use EEPROM technology. Since the USB is a cross-platform technology, it is supported by most operating systems. This helps connect to other devices such as printers, tv's external hard drives, and the list goes on. "There are now by one count six billion USB devices in the world." (Johnson, 2019)

Figure 2.4.1: Left image is an inside view of an USB.Image by Silke from Pixabay, is licensed CC BY; The right image is USB Connections. Image by Bruno /Germany is licensed CC BY-SA 2.0

Network Connection

When personal computers were first developed, they were stand-alone units, which meant that data was brought into the computer or removed from the computer via removable media, such as the floppy disk. As early as 1965, engineers saw merit in connecting and sharing information with other computers. The term used was networking as the connections increased to multiple users, it grew to inter-networking. The abbreviated version is now called the Internet. In the mid-1980s, organizations began to see the value in connecting computers together via a digital network. Because of this, personal computers needed the ability to connect to these networks. Initially, this was done by adding an expansion card to the computer that enabled the network connection. By the mid-1990s, network ports were standard on most personal computers. The configuration of these ports has evolved over the years, becoming more standardized over time. Today, almost all devices plug into a computer using a USB port. This port type, first introduced in 1996, has increased in its capabilities, data transfer rate and power supply.

For a personal computer to be useful, it must have channels for receiving input from the user and channels for delivering output to the user. These input and output devices connect to the computer via various connection ports, generally part of the motherboard and accessible outside the computer case. In early personal computers, specific ports were designed for each type of output device. The configuration of these ports has evolved over the years, becoming more and more standardized.

2.4.2: Input Devices

All personal computers need components that allow the user to input data. Early computers used simply a keyboard to allow the user to enter data or select an item from a menu to run a program. With the advent of the graphical user interface, the mouse became a standard component of a computer. These two components are still the primary input devices to a personal computer, though variations of each have been introduced with varying levels of success over the years. For example, many new devices now use a touch screen as the primary way of entering data. Besides the keyboard and mouse, additional input devices are becoming more common. Scanners allow users to input documents into a computer, either as images or as text. Microphones can be used to record audio or give voice commands. Webcams and other video cameras can be used to record video or participate in a video chat session. The list continues to grow, such as joysticks used for gaming, digital cameras, and touch screens. Smartwatches are wearable compact computers on the wrist. The watch's functionality is similar to the smartphone offering mobile apps and WiFi/Bluetooth connectivity. Specialized watches for health and sports enthusiasts have also emerged, offering counts of steps taken, heart rate, and blood pressure monitoring; a popular brand is Fitbit.

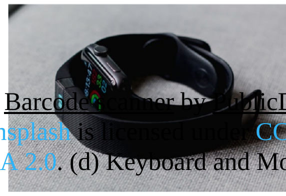
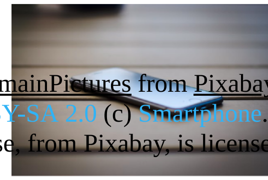




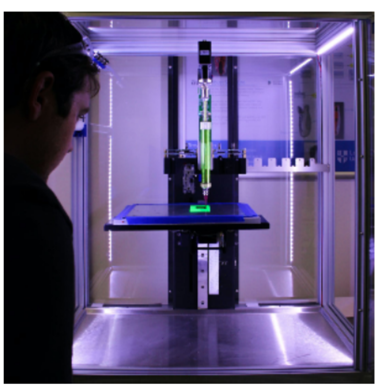

Figure 2.4.3 From Left to Right: (a) Barcode Scanner by PublicDomainPictures from Pixabay is licensed under CC BY-SA 2.0 (b) Fitbit. Image by Andres Urena on Unsplash is licensed under CC BY-SA 2.0 (c) Smartphone. Image by Selwyn van Haaren on Unsplash is licensed under CC BY-SA 2.0. (d) Keyboard and Mouse, from Pixabay, is licensed under CC BY-NC

2.4.3: Output Devices

Output devices are essential as well. The most obvious output device is a display, visually representing the state of the computer. In some cases, a personal computer can support multiple displays or be connected to larger-format displays such as a projector or large-screen television. Besides displays, other output devices include speakers for audio output and printers for printed output. 3D printers have changed the way we build toys, tools, homes, and even body parts. The process of 3D printing that differentiates itself from a regular printer is called additive manufacturing.

Figure 2.4.4 HP Office Printer. Image by WangXuefei via Pixabay, is licensed CC BY-NC

Figure 2.4.5 3D Printer. Image by Rob Wingate on Unsplash CC BY-SA 2.0



Additive manufacturing breaks down an object and builds it layer by layer, making three-dimensional objects.

Plastic is The most popular material, but other materials, such as gold and bio-material, can be used to make human parts such as a nose or ear. The 3D printers have proven themselves in many industries and offered an inexpensive prototyping route.

2.4.4: Bluetooth

Besides USB, some input and output devices connect to the computer via a wireless technology standard called Bluetooth. Bluetooth was first invented in the 1990s and exchanges data over short distances using radio waves.

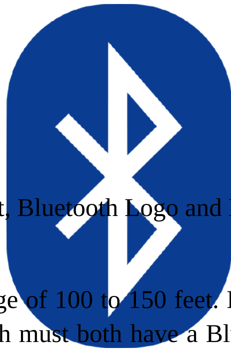


Figure 2.4.6 From left to right, Bluetooth Logo and Bluetooth Earphones. Images by Michael from Pixabay

Bluetooth generally has a range of 100 to 150 feet. It was not until 1999 that it reached its first general public users. Two devices communicating with Bluetooth must both have a Bluetooth communication chip installed. Bluetooth devices include pairing your phone to your car, computer keyboards, speakers, headsets, and home security, to name just a few.

Note: What Hardware Components Contribute to the Speed of A Computer?

Many elements determine a computer's speed, some related to hardware and software. In hardware, speed is improved by giving the electrons shorter distances to traverse to complete a circuit. Since the first CPU was created in the early 1970s, engineers have constantly worked to figure out how to shrink these circuits and put more and more circuits onto the same chip. And this work has paid off – the speed of computing devices has been continuously improving ever since.

The hardware components contributing to a personal computer's speed are the CPU, the motherboard, RAM, and the hard disk. Usually, these items can be replaced with newer, faster components. In the case of RAM, simply adding more RAM can also speed up the computer.

The table below shows how each of these components contributes to the speed of a computer. Besides upgrading hardware, many changes can be made to the software to enhance the computer's speed.

How Components Impact the Speed of a Computer

Component	Speed measured by	Units	Description
CPU	Clock speed	GHz	The time it takes to complete a circuit. Memory does affect computer speed. The CPU moves information from the memory while retrieving information from running applications.

Component	Speed measured by	Units	Description
Motherboard	Bus speed	MHz	How much data can move across the bus simultaneously. The motherboard bus architecture, supported components/slots, available bandwidth, and overall stability all impact the potential speed that a system can attain.
RAM	Data transfer rate	MB/s	The time it takes for data to be transferred from the memory to the system. More RAM capacity/speed results in faster program execution and data access by the CPU.
Hard Disk	Access time	ms	The time it takes before the disk can transfer data. Factors like RPM speed, interface bandwidth, seek times, density, caching, and fragmentation all contribute to HDD performance.
Router	Data transfer rate	MBit/s	The time it takes for data to be transferred from disk to system. Faster routers improve network throughput and response times

2.4.5: Reference

Johnson, J. (2019). *The unlikely origins of USB, the port that changed everything*. FastCompany. Retrieved August 6, 2020.

2.5: Other Computing Devices

A personal computer is designed to be a general-purpose device. It can be used to solve many different types of problems. As the technologies of the personal computer have become more commonplace, many of the components have been integrated into other devices that previously were purely mechanical. We have also seen an evolution in what defines a computer. Ever since the invention of the personal computer, users have clamored for a way to carry them around. Here we will examine several types of devices that represent the latest trends in personal computing.

2.5.1: Portable Computers

In 1983, Compaq Computer Corporation developed the first commercially successful portable personal computer. By today's standards, the Compaq PC was not very portable: weighing in at 28 pounds, this computer was portable only in the most literal sense – it could be carried around. But this was no laptop; the computer was designed like a suitcase to be lugged around and laid on its side to be used. Besides portability, the Compaq was successful because it was fully compatible with the software run by the IBM PC, which was the standard for business.

In the years that followed, portable computing improved, giving us laptop and notebook computers. The "luggable" computer has given way to a much lighter clamshell computer weighing 4 to 6 pounds and running on batteries. The most recent technological advances give us a new class of laptops that is quickly becoming the standard: these laptops are incredibly light and portable and use less power than their larger counterparts. The screens are larger, and some can weigh less than three pounds.

The DELL XPS 13 Laptop is a good example of this. Its specification is:

- CPU:12th Gen Intel; Core i7-1250U (12MB cache, 10 cores)
- Graphics: Intel Iris Xe Graphics
- RAM: 8GB - 32GB
- Screen: 13.4-inch Full HD
- Storage: 256GB - 1TB SSD
- Thunderbolt™ 4 (USB Type-C™) with DisplayPort and Power Delivery x2
- Weight: 1.17 kg (2.59 pounds)
- The body is razor thin at 0.55%
- it can recharge in less than an our with ExpressCharge.

This is simply amazing!

Finally, as more and more organizations and individuals are moving much of their computing to the Internet or cloud, laptops are being developed that use "the cloud" for all of their data and application storage. These laptops are also extremely light because they have no need for a hard disk at all! A good example of this type of laptop (sometimes called a netbook) is Samsung's Chromebook.

2.5.2: Smartphones

The first modern-day mobile phone was invented in 1973. Resembling a brick and weighing in at two pounds, it was priced out of reach for most consumers at nearly four thousand dollars. Since then, mobile phones have become smaller and less expensive; today, mobile phones are a modern convenience available to all levels of society. As mobile phones evolved, they became more like small walking computers. These smartphones have many of the same characteristics as a personal computer, such as an operating system and memory. The first smartphone was the IBM Simon, introduced in 1994.

Figure 2.5.1: Smartphone. Image by Syaibatul Hamdi from Pixabay is licensed under CC BY-SA 2.0

In January of 2007, Apple introduced the iPhone. Its ease of use and intuitive interface made it an immediate success and solidified the future of smartphones. Running on an operating system called iOS, the iPhone was a small computer with a touch-screen interface. In 2008, the first Android phone was released, with similar functionality.

Consider the following data regarding mobile computing :

- There are 6.7 billion global mobile Internet users in 2028. (Statista, 2023)
- It is expected by 2024, approximately 187.5 million U.S. users will have made at least one purchase via a web browser or mobile app on their mobile device.(Statista, 2021)
- By 2023, consumer electronics retail sales in the United States will reach 485 billion U.S. dollars. (Statista, 2023)
- The average order value for online orders placed on desktop in the second quarter of 2022 is $155.75, while the average order value for orders placed on cellphones is $112 and Tablets is less than $100.00.(Statista, 2022)
- In 2022, there are 4.9 billion active social media users in the world and it is projected to increase near 6 billion in 2027. (Statista, 2023)
- In the first quarter of 2023, internet users spent six hours and forty minutes online daily (Statista, 2023)
- In 2023, Mobile accounts for about half of the web traffic worldwide. (Statista, 2023)
- The time spent on websites still favors desktop over 50% of the time. (Broadbansearch, 2023)

2.5.3: Tablet Computers

The tablet is larger than a smartphone and smaller than a notebook. A tablet uses a touch screen as its primary input and is small enough and light enough to be easily transported. They generally have no keyboard and are self-contained inside a rectangular case. Apple set the standard for tablet computing with the introduction of the iPad in 2010 using iOS, the operating system of the iPhone. After the success of the iPad, computer manufacturers began to develop new tablets that utilized operating systems that were designed for mobile devices, such as Android.

Global market share for tablets has changed since the early days of Apple's dominance. Apple iPad has about 37%, Samsung at 20.6% as of the second quarter of 2023 (Statista, 2023). The market popularity of the tablet has been steadily declining in recent years.

2.5.4: Integrated Computing and Internet of Things (IoT)

IoT stands for Internet of Things. It refers to the growing network of physical objects embedded with sensors, software, and technologies to connect and exchange data over the internet. IoT enables physical things to be detected and controlled remotely across existing network infrastructure, integrating the physical world and computer systems.

Along with advances in computers themselves, computing technology is being integrated into many everyday products such as security systems, thermostats, refrigerators, airplanes, cars, electronic appliances, lights in the household, alarm clocks, speaker systems, vending machines, and commercial environments, to name a few. Integrated computing technology has enhanced the capabilities of these devices and added capabilities to everyday lives, thanks in part to IoT.

These three short videos highlight some of the latest ways computing technologies are being integrated into everyday products through the Internet of Things (IoT):

- The video gives an explanation of what the Internet of things is and how they are connected.: The Internet of Things [video file: 3:21 minutes] Closed Captioned
- 

- This video is an example how users can update their home to a smart home. How to start a Smart Home in 2023 [video file: 10:04 minutes] Closed Captioned

2.5.5: The Commoditization of the Personal Computer

Since the late 1970’s, the personal computer has gone from a technical marvel to part of our everyday lives; it has also become a commodity. The PC has become a commodity because there is very little differentiation between computers, and the primary factor that controls their sale is their price. Hundreds of manufacturers all over the world now create parts for personal computers. Dozens of companies buy these parts and assemble the computers. As commodities, there are no differences between computers made by these different companies. Profit margins for personal computers are razor-thin, leading hardware developers to find the lowest-cost manufacturing.

Apple has differentiated itself from the pack and achieved a competitive advantage in a challenging market. The cost of their product is significantly higher, but you are buying a high-quality product and design. Apple designs both the hardware as well as its software in-house. The hardware and software design of the Mac works seamlessly with its other products, such as the iPhone and iPad. The engineers at Apple are constantly updating software apps and hardware to remain a leader in the PC world.

Smartphone vendors are highly competitive and release updates or new models annually. Here is an interesting article on what we can expect coming next in Smartphone (Zdnet, 2023). Smartphone shipments peaked at 1.56 billion units between 2011 and 2017 and has decreased to 1.23 millions units in 2022 (Statista, 2023.)

2.5.6: The Problem of Electronic Waste

Personal computers have become a common fixture in households since the early eighties. The average life span of many of these devices is between three to five years. Recycling has become a hot subject for companies who want to be viewed by consumers as Green companies. Consumers are demanding companies make a commitment to the environment. Worldwide, almost 45 million tons of electronics were tossed out in 2016. Out of that staggering amount of electronic waste, only 20% has been recycled in some shape or form. The remaining 80% made its way to a more environmentally damaging end at the landfill. Mobile phones are now available in even the remotest parts of the world and, after a few years of use, they are discarded. Where does this electronic debris end up?

Figure 2.5.2 Electronic Waste. Image by George Hotelling from Flicker is licensed under CC BY-SA 2.0

Many developing nations accept this e-waste. Abroad, these recyclers re-purpose parts and extract minerals, gold, and cobalt from these devices. These dumps have become health hazards for those living near them.

Proper safe practices are ignored, and whatever waste is not usable is dumped improperly. Consumers are trying to change this common practice by demanding companies be transparent about how they address e-waste. Though many manufacturers have made strides in using materials that can be recycled, electronic waste is a problem with which we must all deal.

In 2006 the Green Electronics Council launched the Electronic Product Environmental Assessment Tool (EPEAT). This tool helps purchasers of electronics to evaluate the effect of products on the environment. They rank companies' performance in gold, silver, and bronze levels. When the first began, three PC and electronic equipment manufacturers participated with 60 products. The US government in 2007 then created the U.S. Federal Acquisition Regulations (FAR), requiring federal agencies to make purchases based on EPEAT status. In 2015 EPEAT added in Imaging Equipment and Television categories. Today many large companies are using EPEAT standards such as Amazon and Apple. EPEAT systems are widely accepted, and over 43 countries are participating, and the number continues to grow.

2.5.7: References

Broadband Search (2020). *Mobile Vs. Desktop Internet Usage*. Retrieved September 1, 2020, from Broadbandsearch.net.

Bianchi, T. (2023). Share of Global Mobile Website Traffice 2015-2022. Retrieved August 26, 2023, from Statista.com

Ceci, L. (2023). *Mobile internet users worldwide 2019-20028*. Retrieved August 26, 2023, from Statista.com.

Chevalier, S.. (2022). *U.S. average online shopping order value 2020-2022, by device*. Retrieved August 26, 2023, from Statista.com

Chevalier, S.. (2021). *Number of mobile users in the United States 2020-2024*. Retrieved August 26, 2023, from Statista.com

Coldfusion. (2015). How Tesla'sAuto-pilot Mode Works. Youtube. [video file: 10:04 minutes] Closed Captioned

Dixon, S. (2023). *Number of local social network users 2017-2007*. Retrieved August 26, 2023 from Statisca.com

Edureka! (2020). The Internet of Things. Youtube. [video file: 3:21 minutes] Closed Captioned

Laricchia, F. (2023). *U.S. consumer electronics industry retail revenue 2012-2023.* Retrieved August 26, 2023, from Statista.com

Laricchia, F. (2023). *Global market share held by tablet vendors 2011-2023.* Retrieved August 26, 2023, from Statista.com

Laricchia, F. (2023). *Smartphone shipments worldwide 2011-2022.* Retrieved August 27, 2023, from Statista.com

Mobile vs. Desktop Internet Usage (Latest 2023 data). Retrieved August 26, 2023, from Broadbansearch.net

Petrosyan, A. (2023). Daily Time Spent Online by Users Worldwide 2023. Retrieved August 26, 2023, from Statista.com

Smartphone trends in 2023: Here's what's coming next. Retrieved August 27, 2023, from zdnet.com

Six Months later reviews. (2020). How to start a Smart Home in 2020(opens in new window). Youtube. [video file: 2:01 minutes] Closed Captioned

---

2.6: Summary

2.6.1: Summary

Information systems hardware consists of the components of digital technology that you can touch. The chapter discusses different types of computing hardware devices including desktop PCs, laptops, smartphones, tablets, and integrated devices. A PC consists of components like the motherboard, CPU, RAM, hard disk drives, solid state drives, and various input/output components. CPUs and RAM provide computing power, while storage devices hold data. We also reviewed some personal computer variations, such as the tablet computer, Bluetooth, and the smartphone.

Moore's Law states that computing power doubles every two years. This has largely held true over the past 50+ years. Besides desktops and laptops, computing is now integrated into smartphones, tablets, home appliances, cars, and more through the Internet of Things (IoT). Smartphones have capabilities similar to PCs and have become the primary computing device for many. Tablets are larger than phones but smaller than laptops.

Finally, we discussed two of the consequences of this evolution: the commoditization of the personal computer and the problem of electronic waste. The commoditization of PCs means there is little differentiation anymore between brands. Apple stands out for its proprietary hardware and software. Computing devices generate electronic waste that is environmentally damaging. More recycling and "green" practices are needed.

2.7: Study Questions

? Study Question 2.7.1

Write your own description of what the term information systems hardware means.

Answer

Key ideas that should be in the answer: hardware consists of the physical components that people can see and touch.

? Study Question 2.7.2

Explain why Moore's Law may not be a valid theory in the next five years.

Answer

Compare two similar devices with one is two years older than the other. Discuss that computing doubles in speed every two years while devices get smaller, faster, and cheaper.

? Study Question 2.7.3

What is the CPU and how does it work?.

Answer

The CPU (Central Processing Unit) is the "brain" of a computer. It fetches instructions, decodes them, executes them, and stores results.

? Study Question 2.7.4

Explain why the personal computer is now considered a commodity.

Answer

They are carrying similar options with minor differentiation between computers. The users often choose by brands or price.

? Study Question 2.7.5

List the following in increasing order (slowest to fastest): megahertz, kilohertz, gigahertz

Answer

Kilohertz (kHz) Megahertz (MHz) Gigahertz (GHz). 1 kHz = 1,000 hertz; 1 MHz = 1,000,000 hertz; $1 \text{ GHz} = 1{,}000{,}000{,}000 \text{ hertz}$

So kilohertz is the smallest unit referring to thousands of hertz. Megahertz is larger, referring to millions of hertz. Gigahertz is the largest unit, referring to billions of hertz.

? Study Question 2.7.6

What are the differences between HDD and SSD?

Answer

HDD (Hard Disk Drive) uses spinning disks to read/write data, while SSD (Solid State Drive) uses flash memory, faster performance, and has no moving parts.

? Study Question 2.7.7

Why are desktops declining in popularity?

Answer

Many reasons, including the popularity and increasing power of mobile devices.

? Study Question 2.7.8

What does the acronym RAM stand for?

Answer

Random Access Memory.

? Study Question 2.7.9

List three things that can be considered IoT.

Answer

Cars, machines, home appliances, and wearables to be internet-connected and share data.

2.7.1: Exercises

1. Review the sidebar on the binary number system. How would you represent the number 16 in binary? How about the number 100? Besides decimal and binary, other number bases are used in computing and programming. One of the most used bases is hexadecimal, which is base-16. In base-16, the numerals 0 through 9 are supplemented with the letters A (10) through F (15). How would you represent the decimal number 100 in hexadecimal? Show your work
2. Go to Old-Computer.com - Pick one computer from the listing and write a brief summary. Include the specifications for CPU, memory, and screen size. Now find the specifications of a computer being offered for sale today and compare. Did Moore's Law hold?
3. Under the category of IoT, pick two products and explain how IoT has changed the product. Review the price before and after the technology was introduced. Has this new technology increased popularity for the item?
4. Go on the web and compare and contrast two smartphones on the market. Is one better than the other, and if so, why. Be sure to include the price.
5. Review the e-waste policies in your area. Do you feel they are helping or ignoring this growing crisis?

6. Now find at least two more scholarly articles on this topic. Prepare a PowerPoint of at least 10 slides that summarize the issue and recommend a possible solution based on your research.
7. As with any technology text, there have been advances in technologies since publication. What technology that has been developed recently would you add to this chapter?
8. What is the current state of solid-state drives vs. hard disks? Describe the ideal user for each. Do original research online where you can compare prices on solid-state drives and hard disks. Be sure you note the differences in price, capacity, and speed.
9. What does a motherboard do? Name two important components that connect directly to the motherboard.

CHAPTER OVERVIEW

3: Software

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Define the term software;
- Describe the two primary categories of software;
- Describe the role ERP software plays in an organization;
- Describe the process of writing a computer program;
- Describe cloud computing and its advantages and disadvantages for use in an organization;
- Define the term open-source and identify its primary characteristics;
- Describe Artificial Intelligence generative language models.

Software and hardware cannot function without each other. Without software, hardware is useless. Without hardware, the software has no hardware to run on. This chapter discusses the types of software, their purpose, and how they support different hardware devices, individuals, groups, and organizations.

3.1: Introduction to Software

The second component of an information system is software.

Definition: Software

Software is a collection of computing instructions that direct a computer or device on how to perform specific tasks. A group of instructions is also called a computer or a software program.

For example, when a user presses the letter ‘A” key on the keyboard when using a word processing app, it is the word processing software that tells the hardware that the user pressed the key ‘A’ on the keyboard and fetches the image of the letter A to display on the screen as feedback to the user that the user’s data is received correctly.

Software is created through the process of programming. We will cover software creation in this chapter and more detail in Chapter 10. In essence, hardware is the machine, and software is the intelligence that tells the hardware what to do. Without software, the hardware would be rendered inoperable, and without hardware, the software would have no platform to run on.

The software component can be broadly divided into two categories: system software and application software.

Definition: System Software

System software is a collection of computer programs that provide a software platform for other software programs. It also insulates the hardware's specifics from the applications and users as much as possible by managing the hardware and the networks. It consists of

1. Operating System
2. Utilities

Definition: Application Software

Application software is a computer program that performs a specific user's activity (i.e., create a document, draw a picture). It can be for either:

1. a general-purpose (i.e., Microsoft Word, Google doc) or
2. for a particular purpose (i.e., weather forecast, CAD engineering)

3.2: Types of Software

Figure 3.2.1 illustrates the types of software. The bottom layer of a computer system is composed of hardware components like the CPU, motherboard, and ports. Above this is the Operating System, which facilitates communication between the hardware and other layers. The next layer includes single-purpose utilities like anti-virus software and general-purpose applications like word processors, as well as specialized applications like CAD engineering software. At the top layer, we see the interactions between the users and different types of software.

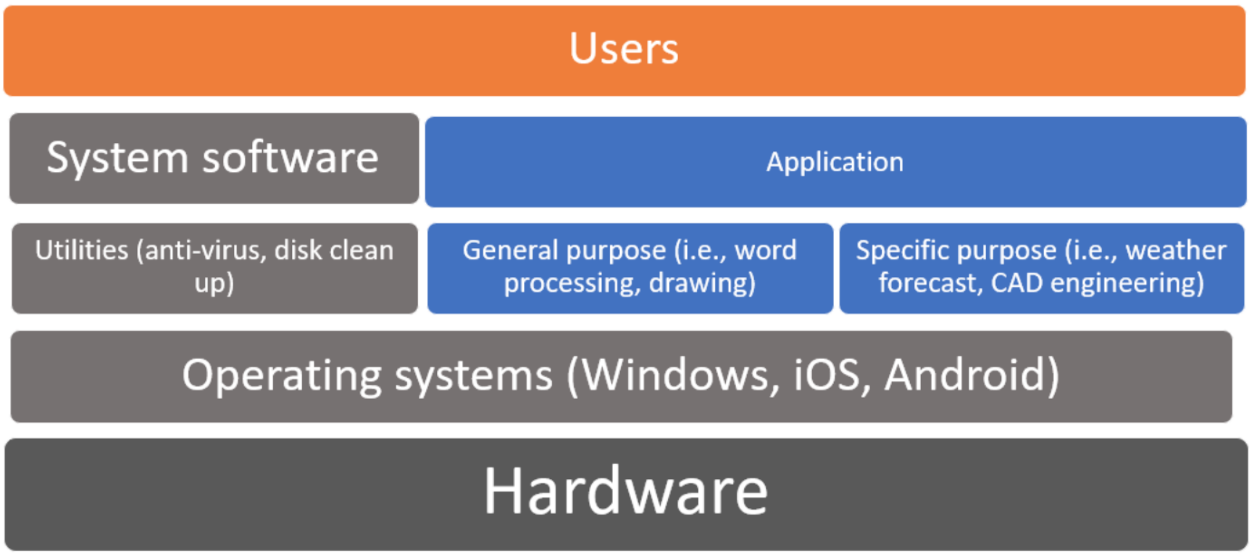


Figure 3.2.1: Overview of software types. Image by Ly-Huong Pham is licensed under CC BY-NC

System Software

System software refers to the group of software called: operating systems and utilities.

Operating Systems

The operating system provides several essential functions, including:

1. Managing the hardware resources of the computer
2. Providing the user-interface components
3. Providing a platform for software developers to write applications.

An operating system (OS) is a key component of the system software. Popular operating systems include Google Android^{TM}, Microsoft Windows^{TM}, and Apple iOS^{TM}.

An OS is a set of programs that coordinate hardware components and other programs and acts as an interface with application software and networks. Some examples include getting input from a keyboard device, displaying output to a screen, and storing or retrieving data from a disk drive.

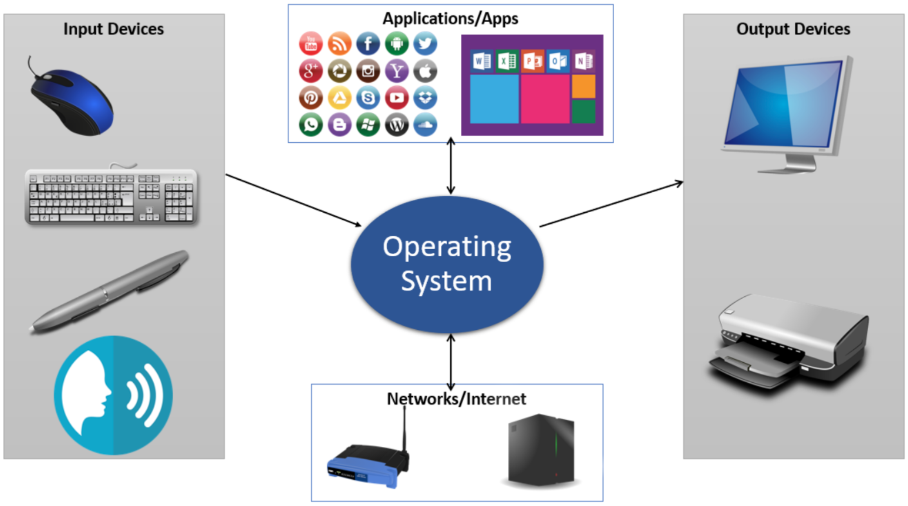


Figure $3.2.2$ Operating System Role. Image by Ly-Huong T. Pham is licensed by CC BY NC

Figure $3.2.2$ shows the operating system at the center; it accepts input from various input devices such as a mouse, a keyboard, a digital pen, or a speech recognition (left panel), outputs to various output devices such as screen monitor or a printer (right panel); acts an intermediary between applications and apps (top middle), and access the internet via network devices such as a router or a web server (bottom middle.)

In 1984, Apple introduced the Macintosh computer, featuring an operating system with a graphical user interface, now known as macOS. Apple has different names for its OS running on different devices such as iOS, iPadOS, watchOS, and tvOS.

In 1986, as a response to Apple, Microsoft introduced the Microsoft Windows Operating Systems, commonly known as Windows, as a new graphical user interface for their then command-based operating system, known as MS-DOS, which was developed for IBM's Disk Operating System or IBM-DOS. By the 1990s, Windows dominated the desktop personal computers market as the top OS and overtaken Apple's OS.

Figure $3.2.3$ Tux, Linux's Mascot. Image by Larry Ewing and The GIMP is licensed Public Domain

A third personal-computer operating system family that has gained popularity is Linux. Linux is a version of the Unix operating system that runs on a personal computer. Unix is an operating system used primarily by scientists and engineers on larger minicomputers. These computers, however, are costly, and software developer Linus Torvalds wanted to find a way to make Unix run on less expensive personal computers: Linux was the result. Linux has many variations and now powers a large percentage of web servers in the world. It is also an example of open-source software, a topic we will cover later in this chapter.

In 2007, Google introduced Android to support mobile devices such as smartphones and tablets specifically. It is based on the Linux kernel, and a consortium of developers developed other open-source software. Android quickly became the top OS for mobile devices, overtook Microsoft, and has created opportunities for new competitors such s Samsung Group.

Operating systems have continuously improved with more and more features to increase speed and performance to process more data at once and access more memory. Features such as multitasking, virtual memory, and voice input have become standard features of both operating systems. Many of these features are enabled by the improved speed and performance of the underlying hardware components.

All computing devices run an operating system, as shown in the below table. The most popular operating systems are Microsoft's Windows, Apple's operating system, and different Linux versions for personal computers. Smartphones and tablets run operating systems as well, such as Apple's iOS and Google's Android.

Computing devices and Operating systems

Operating Systems	Desktop	Mobile
Microsoft Windows	Windows 11	Windows 10
Apple OS	Mac OS	iOS
Various versions of Linux	Ubuntu	Android (Google)

According to Statista.com (2023), Windows still retains the desktop's dominant position with over 74% market share, followed by Apple's OS with %15.33 market share. However, in the mobile industry, Statista.com (2023) reports that Android maintained its position as the leading mobile operating system worldwide with a market share of 70.8 percent and Apple's iOS had a market share of 28.4 percent.

Note: Why Is Microsoft Software So Dominant in the Business World?

As we learned in Chapter 1, almost all businesses used IBM mainframe computers in the 1960s and 1970s. Businesses shied away from personal computers until IBM released the PC in 1981. Initially, business decisions were low-risk decisions since IBM was dominant, a safe choice. Another reason might be that once a business selects an operating system as the standard solution, it will invest in additional software, hardware, and services built for this OS. The switching cost to another OS becomes a financial hurdle and for the workforce to be retrained.

Utility

Utility software includes specific-purposed computer programs and is focused on keeping the computing environment or infrastructure healthy. Examples include antivirus software to scan and stop computer viruses and disk defragmentation software to optimize files' storage. Over time, some of the popular utilities were absorbed as features of an operating system. Here are a few popular utilities:

1. **CCleaner**: Cleans up junk files, repairs registry errors, and offers tools to optimize the startup process.
2. **Defraggler**: Designed to defragment hard drives to optimize the speed of the device
3. **Norton Utilities**: Various tools including disk cleaner, startup manager, and disk defragmenter to optimize and speed up your computer.
4. **Advanced SystemCare**: Optimization tools, malware protection, and a wide range of system maintenance utilities.
5. **Disk Utility (for macOS)**: Apple's built-in tool for disk repair, partitioning, and format management.

Keep in mind that the "top" software can vary based on reviews, specific needs, updates, and new entrants in the market. Always ensure that any utility software you use is compatible with your system and is sourced from reputable providers to avoid potential harm or unwanted software.

Application or App Software

The second major category of software is application software. While system software focuses on running the computers, application software allows the end-user to accomplish some goals or purposes. Examples include word processing, photo editor, spreadsheet, or a browser. Applications software are grouped in many categories, including:

- Killer app
- Productivity
- Enterprise
- Mobile

The "Killer" App

Figure 3.2.4 *VisiCalc. Image by Gortu is licensed under Public Domain*

When a new type of digital device is invented, there are generally a small group of technology enthusiasts who will purchase it just for the joy of figuring out how it works. A "killer" application runs only on one OS platform and becomes so essential that many people will buy a device on that OS platform just to run that application. For the personal computer, the killer application was the spreadsheet. In 1979, VisiCalc, the first personal computer spreadsheet package, was introduced. It was an immediate hit and drove sales of the Apple II. It also solidified the value of the personal computer beyond the relatively small circle of technology geeks. When the IBM PC was released, another spreadsheet program, Lotus 1-2-3, was the killer app for business users. Another killer is the web browser that brings the Internet to the mass. Microsoft Excel dominates as the spreadsheet program, running on all the popular operating systems. Today various Artificial Intelligence (AI) generated text such as ChatGPT appears to be the next killer app. We will discuss AI-generated text in a later chapter.

Productivity Software

Along with the spreadsheet, several other software applications have become standard tools for the workplace. These applications, called productivity software, allow office employees to complete their daily work. Many times, these applications come packaged together, such as in Microsoft's Office suite or 365. Here is a list of these applications and their basic functions:

- Word processing: This class of software provides for the creation of written documents. Functions include the ability to type and edit text, format fonts and paragraphs, and add, move, and delete text throughout the document. Most modern word-processing programs also have the ability to add tables, images, voice, videos, and various layout and formatting features to the document. Word processors save their documents as electronic files in a variety of formats. The most popular word-processing package is Microsoft Word, which saves its files in the Docx format. This format can be read/written by many other word-processor packages or converted to other formats such as Adobe's PDF.

- Spreadsheet: This class of software provides a way to do numeric calculations and analysis. The working area is divided into rows and columns, where users can enter numbers, text, or formulas. The formulas make a spreadsheet powerful, allowing the user to develop complex calculations that can change based on the numbers entered. Most spreadsheets also include the ability to create charts based on the data entered. The most popular spreadsheet package is Microsoft Excel, which saves its files in the XLSX format. Just as with word processors, many other spreadsheet packages can read and write to this file format.
- Presentation: This software class provides for the creation of slideshow presentations that can be shared, printed, or projected on a screen. Users can add text, images, audio, video, and other media elements to the slides. Microsoft's PowerPoint remains the most popular software, saving its files in PPTX format.
- Office Suite: Microsoft popularized the idea of the office-software productivity bundle with their release of Microsoft Office. Some office suites include other types of software. For example, Microsoft Office includes Outlook, its e-mail package, and OneNote, an information-gathering collaboration tool. The professional version of Office also includes Microsoft Access, a database package. (Databases are covered more in chapter 4.) This package continues to dominate the market, and most businesses expect employees to know how to use this software. However, many competitors to Microsoft Office exist and are compatible with Microsoft's file formats (see table below). Microsoft now has a cloud-based version called Microsoft Office 365. Similar to Google Drive, this suite allows users to edit and share documents online utilizing cloud-computing technology. Cloud computing will be discussed later in this chapter.

Popular Software

Category	Word Processing	Spreadsheet	Presentation	Other
Microsoft Office 365 suite	Word	Excel	PowerPoint	Outlook email, Access (database), OneNote (note and share notes), One Drive (cloud storage), ClipChamp, etc. Cloud version works on any platform via a browser
Apple iWork suite	Pages	Numbers	KeyNotes	Integrates with Apple apps such as iTunes, iCloud, and other Apple software. Work only Apple's devices

Category	Word Processing	Spreadsheet	Presentation	Other
Open Office suite Discontinued as of April 2011	Writer	Calc	Impress	Base (database), Draw (drawing), Math (equations) Multiple versions to support different OS, including Linux
Google Drive	Docs	Sheets	Slides	Gmail (email), Forms, Draw, Meet, etc. Work in any browser

Figure 3.2.5: Comparison of office application software suites. Adapted by Ly-Huong Pham from image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

Enterprise Software

As the personal computer proliferated inside organizations, control over the information generated by the organization began splintering. For example, the customer service department creates a customer database to track calls and problem reports. The sales department also creates a database to keep track of customer information. Which one should be used as the master list of customers? As another example, someone in sales might create a spreadsheet to calculate sales revenue, while someone in finance creates a different one that meets their department's needs. However, the two spreadsheets will likely come up with different totals for revenue. Which one is correct? And who is managing all this information? This type of example presents challenges to management to make effective decisions.

Enterprise Resource Planning (ERP)

In the 1990s, the need to bring the organization's information back under centralized control became more apparent. The enterprise resource planning (ERP) system (sometimes just called enterprise software) was developed to bring together an entire organization in one software application. Key characteristics of an ERP include:

- An integrated set of modules: Each module serves different functions in an organization, such as Marketing, Sales, Manufacturing.
- A consistent user interface: An ERP is a software application that provides a common interface across all modules of the ERP and is used by an organization's employees to access information
- A common database: All users of the ERP edit and save their information from the data source. This means that there is only one customer database, there is only one calculation for revenue, etc.
- Integrated business processes: All users must follow the same business rules and process throughout the entire organization": ERP systems include functionality that covers all of the essential components of a business, such as how organizations track cash, invoices, purchases, payroll, product development, supply chain.

Figure 3.2.6 shows that an ERP has many modules, all connected to a central database. Each module support different business processes like, going clockwise, Accounting, Finance, Inventory, Human Resources, Production Planning, Sales and Distribution, Project Management, Quality Management, and Materials Management. ERP integrates business processes across departments onto a single unified system and database. This helps improve efficiency, data access, and decision making.

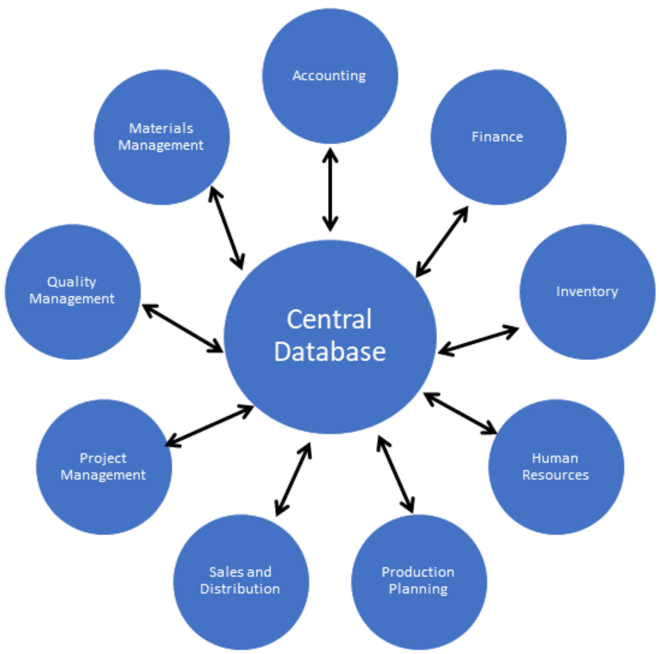


Figure 3.2.6 Enterprese Resource Planning Modules. Image by Ly-Huong Pham, is licensed under CC BY-NC

ERP systems were originally marketed to large corporations, given that they are costly. However, as more and more large companies began installing them, ERP vendors began targeting mid-sized and even smaller businesses. Some of the more well-known ERP systems include those from SAP, Oracle, and Microsoft.

To effectively implement an ERP system in an organization, the organization must be ready to make a full commitment, including the cost to train employees as part of the implementation.

All aspects of the organization are affected as old systems are replaced by the ERP system. In general, implementing an ERP system can take two to three years and several million dollars.

So why implement an ERP system? If done properly, an ERP system can bring an organization a good return on its investment. By consolidating information systems across the enterprise and using the software to enforce best practices, most organizations see an overall improvement after implementing an ERP. Business processes as a form of competitive advantage will be covered in chapter 9.

Customer Relationship Management (CRM)

A customer relationship management (CRM) system is a software application designed to manage customer interactions, including customer service, marketing, and sales. It collects all data about the customers.

CRM (Customer Relationship Management) is not typically a module within an ERP (Enterprise Resource Planning) system. CRM and ERP are separate systems that can complement each other when integrated:

- ERP focuses on internal business processes such as manufacturing, finance, HR, etc.
- CRM focuses on managing customer interactions and data - sales, marketing, customer service, support.

The objectives of a CRM are:

- Personalize customer relationships to increase customer loyalty
- Improve communication
- Anticipate need to retain existing or acquire new customers

Some ERP software systems include CRM modules. An example of a well-known CRM package in Salesforce

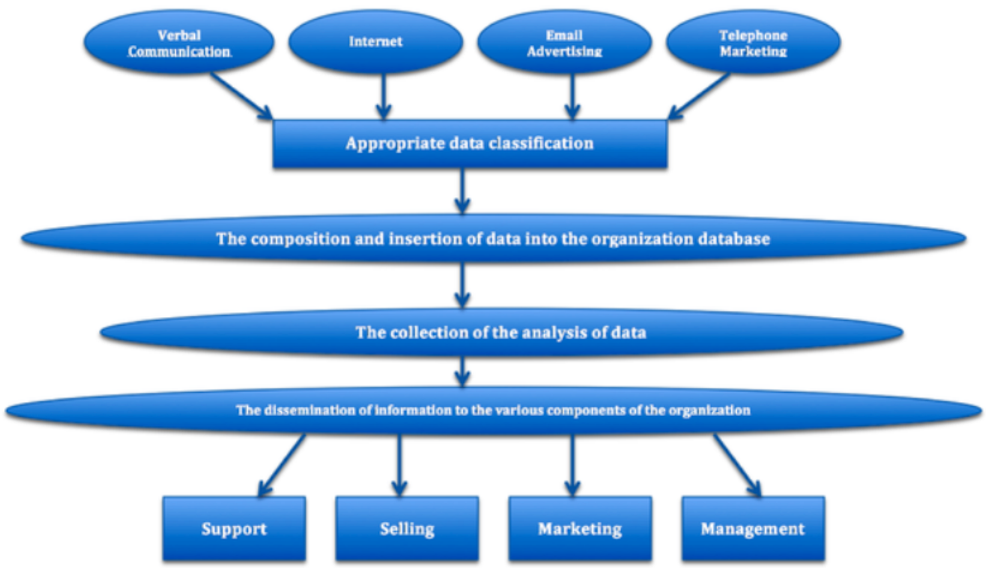


Figure $3.2.7$: Components in the different types of CRM. Image by Bgrigorov is licensed under CC-BY-SA

While they have different focuses, integrating CRM and ERP can be beneficial for companies. Some ways they can work together:

- CRM system provides customer data that helps inform demand forecasts and supply chain in ERP.
- ERP provides product availability and pricing information to the CRM system.
- Integrated reporting and analytics brings together data from both systems.
- Automated workflows between both systems (e.g. order management).

CRM and ERP serve different core purposes, but integration between the two systems allows critical customer and business data to be shared to increase the effectiveness of the decisions made by the organization.

Supply Chain Management (SCM) Software

SCM is a module within an ERP. SCM supports functions like:

- Inventory management - tracking stock levels, setting reorder points, etc.
- Purchasing - managing vendors, purchase orders, payment terms, etc.

- Warehouse management - inventory allocation across locations, stock movement, picking/packing, etc.
- Order management - order entry, shipment/fulfillment, returns/exchanges, etc.
- Manufacturing - production planning, materials requirements, managing manufacturing processes
- Transportation/logistics - optimizing shipment methods, routes, carriers, etc.

Many organizations must deal with the complex task of managing their supply chains. At its simplest, a supply chain is a linkage between an organization's suppliers, its manufacturing facilities, and its products' distributors. Each link in the chain has a multiplying effect on the complexity of the process. For example, if there are two suppliers, one manufacturing facility, and two distributors, then there are 2 x 1 x 2 = 4 links to handle. However, if you add two more suppliers, another manufacturing facility, and two more distributors, then you have 4 x 2 x 4 = 32 links to manage.

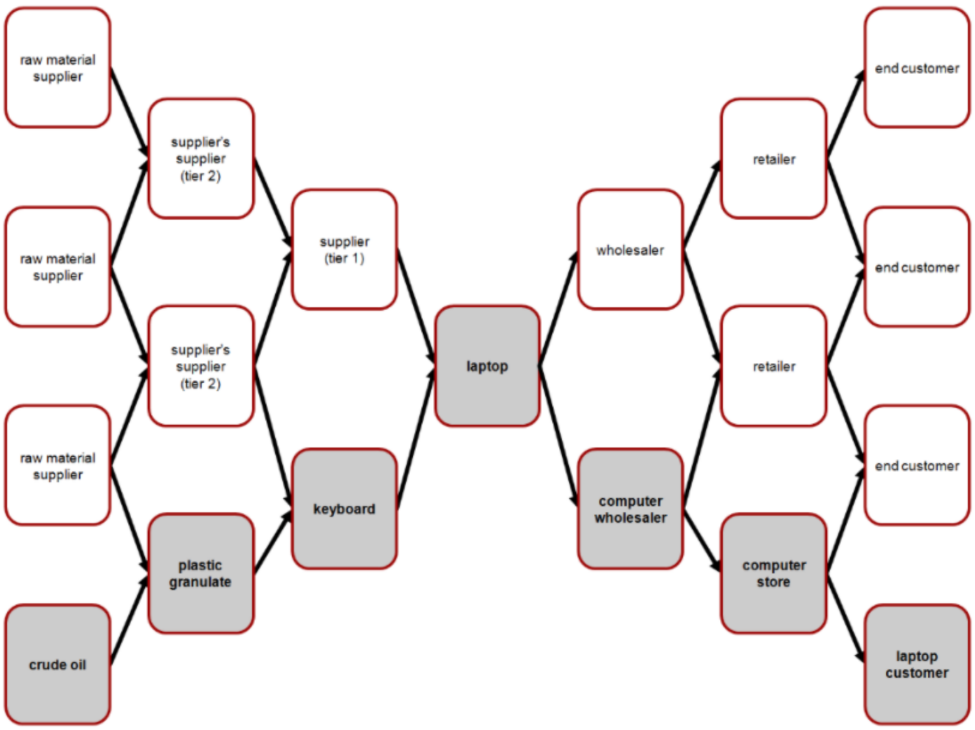


Figure 3.2.8 A supply and demand network. Image by Andreas Wieland is licensed under CC-BY-SA 3.0

A supply chain management (SCM) system manages the interconnection between these links and the products' inventory in their various development stages. The Association provides a full definition of a supply chain management system for Operations Management: "The design, planning, execution, control, and monitoring of supply chain activities to create net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally." Most ERP systems include a supply chain management module to enable optimization and automation of an organization's end-to-end supply chain activities.

Mobile Software

A mobile application, commonly called a mobile app, is a software application programmed to run specifically on a mobile device such as smartphones and tablets.

As we saw in Chapter 2, smartphones and tablets are becoming a dominant form of computing, with many more smartphones sold than personal computers. This means that organizations will have to get smart about developing software on mobile devices to stay relevant. With the rise of mobile devices' adoption, the number of apps is about 9M of mobile apps, 255B app downloads, and it is projected that by 2025, mobile apps are expected to generate more than US$613 billion in app revenue. (bankmycell, 2023). Nowadays, there is an app for just about anything a user is looking to do. Examples include apps such as a flashlight, a step counter, a plant identifier, and games.

We will discuss the question of building a mobile app in Chapter 10.

Artificial Intelligence Software

Definition: Term - Artificial Intelligence

Artificial intelligence (AI) refers to computer systems or software that can perform tasks normally requiring human intelligence, such as visual perception, speech recognition, and decision-making. AI leverages large amounts of data and complex algorithms to mimic human cognitive skills in an automated manner. It is used in applications like digital assistants, image analysis, autonomous vehicles, and fraud detection.

Artificial intelligence (AI) systems called generative models represent a new emerging software category. Instead of focusing on analysis, this new category focuses on generating content and artifacts based on the massive quantity of data it is trained on. In essence, it is the simulation of human intelligence processes by machines. 2023 seems to be the breakout year for many artificial intelligence software, with two popular models, one to generate images and one to generate text.

Generative image models like DALL-E leverage neural networks trained on massive image datasets to generate realistic images and art from a text description. Large language models (LLM) such as ChatGPT are trained on massive online text data to generate coherent written responses. A LLM is only as good and current as the data used to train it. If incorrect data was used in the training, then LMM will give answers using the incorrect data. If a LMM is trained with the data that is only current up to Dec 2021 then it will not know anything beyond 2021. eWeek (2023) has a helpful comparison chart for some AI generative products, what they are best for, and their key attributes.

Here is a 5-min video from IBM explaining how Large Language Models Work.

This relatively new and exciting category comes with various benefits, like assisting students in their studies, improving writing skills, chatting, and providing quick answers. However, as with any disruptive technology, there are potential legal and ethical issues, including licensing problems, plagiarism risks, and incorrect answers generated by these AI bots (commonly known as hallucinations). It's important for users of these new tools to verify the accuracy of the data before using them, just as one cannot always assume the internet search results are 100% correct.

Here is a 9-minute video from IBM explaining why large language models hallucinate.

> **Note: Can AI Help Making Microsoft PowerPoint Presentations Less Boring?**
>
> As presentation software, specifically Microsoft PowerPoint, has gained acceptance as the primary method to present information in a business setting formally, the art of giving an engaging presentation is becoming rare. Many presenters now just read the bullet points in the presentation and immediately bore those in attendance who can already read it for themselves.
>
> The real problem is not with PowerPoint as much as with the person creating and presenting. The book Presentation Zen by Garr Reynolds is highly recommended to anyone who wants to improve their presentation skills.
>
> Some tools have been introduced to make presentation software more effective. One such example is Prezi. Prezi is a presentation tool that uses a single canvas, allowing presenters to place text, images, and other media on the canvas and then navigate between these objects as they present.
>
> What can AI help with this problem?
>
> A more recent example is the integration of artificial intelligence into Microsoft 365, known as Microsoft 365 Copilot that helps users create even more powerful presentations faster.
>
> 
>

References

Best Artificial Intelligence Software 2023. Retrieved August 27, 2023 from eweek.com

How Large Language Models Work by IBM Technology. (2023). Retrieved August 27, 2023 from YouTube.com

How Many Apps are There in the World (Aug 2023.) Retrieved August 27, 2023 from bankmycell.com

Microsoft CoPilot (March, 2023). Retrieved August 10, 2023 from Microsoft Blog

Why Large Language Models Hallucinate IBM Technology. (2023). Retrieved August 27, 2023 from YouTube.com

---

3.3: Cloud Computing

Historically, for software to run on a computer, an individual copy of the software had to be installed on the computer, either from a disk or, more recently, after being downloaded from the Internet. The concept of "cloud" computing changes this model.

"The cloud" refers to applications, services, and data stored in data centers, server farms, and storage servers and accessed by users via the Internet. In most cases, the users don't know where their data is actually stored. Individuals and organizations use cloud computing.

You probably already use cloud computing in some forms. For example, if you access your email via your web browser, you are using a form of cloud computing. If you use Google Drive's applications, you are using cloud computing. Simultaneously, these are free versions of cloud computing, big business in providing applications and data storage over the web. Commercial and large applications can also exist on the cloud, such as the entire suite of CRM from Salesforce is offered via the cloud. Cloud computing is not limited to web applications: it can also be used for phone or video streaming services.

3.3.1: Advantages of Cloud Computing

- No software to install or upgrades to maintain.
- Available from any computer that has access to the Internet.
- Can scale to a large number of users easily.
- New applications can be up and running very quickly.
- Services can be leased for a limited time on an as-needed basis.
- Your information is not lost if your hard disk crashes or your laptop is stolen.
- You are not limited by the available memory or disk space on your computer.

3.3.2: Disadvantages of Cloud Computing

- Your information is stored on someone else's computer
- You must have Internet access to use it. If you do not have access, you're out of luck.
- You are relying on a third party to provide these services.
- You don't know how your data is protected from theft or sold by your own cloud service provider.

Cloud computing can greatly impact how organizations manage technology. For example, why is an IT department needed to purchase, configure, and manage personal computers and software when all that is really needed is an Internet connection?

3.3.3: Using a Private Cloud

Many organizations are understandably nervous about giving up control of their data and applications using cloud computing. But they also see the value in reducing the need for installing software and adding disk storage to local computers. A solution to this problem lies in the concept of a private cloud. While there are various private cloud models, the basic idea is for the cloud service provider to rent a specific portion of their server space exclusive to a specific organization. The organization has full control over that server space while still gaining some of the benefits of cloud computing.

3.3.4: Virtualization

One technology that is utilized extensively as part of cloud computing is "virtualization." Virtualization is a technology that allows a single physical computer hardware system to function as multiple virtual systems. Virtualization creates a layer of abstraction between physical hardware and the software running on it. This provides greater efficiency, flexibility and manageability compared to dedicated physical servers. It enables multiple operating systems and workloads to share the same physical computer's resources on demand.

For example, using virtualization, a single computer that runs Microsoft Windows can host a virtual machine that looks like a computer with a specific Linux-based OS. This ability maximizes the use of available resources on a single machine. Companies such as EMC provide virtualization software that allows cloud service providers to provision web servers to their clients quickly and efficiently. Organizations are also implementing virtualization to reduce the number of servers needed to provide the necessary services. For more detail on how virtualization works, see this informational page from VMWare.

✔ Use Case Example 3.3.1

Here is an example use case for virtual machines (VMs) and virtualization:

A software development company needs to test a web application they are building across multiple operating systems and browser combinations. What are their options:

1) Purchase separate physical computers for each OS and browser.

2) A cost-effective solution is to use virtualization to create VMs for different testing environments.

Which option should they take?

Solution

Option 1 would work, but it would be extremely expensive and time-consuming to manage.

Option 2 is the most cost effective. Using virtualization, on a **single powerful physical server,** the company can create:

- A VM running Windows 11 and Internet Explorer
- A VM running OSX and Safari
- A VM running Ubuntu and Firefox
- A VM running Android and Chrome
- etc.

It is as if they have 4 (or more) different machines, but they did not have to buy 4 (or more) machines. They all run on one physical server. The web application can then be tested across these VMs to ensure compatibility. The VMs share resources from the physical server like CPU, memory, and disk.

When testing is complete, these VMs can be deleted easily and new ones provisioned quickly for the next round of testing. The development team can scale up and down VMs rapidly as needed.

3.4: Software Creation

We just discussed different types of software and now can ask: How is software created? If the software is the set of instructions that tells the hardware what to do, how are these instructions written? If a computer reads everything as one and zero, do we have to learn how to write software that way? Thankfully, another software type is written, especially for software developers to write system software and applications - called programming languages. The people who can program are called computer programmers or software developers.

Analogous to a human language, a programming language consists of keywords, comments, symbols, and grammatical rules to construct statements as valid instructions understandable by the computer to perform certain tasks. Using this language, a programmer writes a program (called the source code). Another software then processes the source code to convert the programming statements to a machine-readable form, the ones, and zeroes necessary to execute the CPU. This conversion process is often known as compiling, and the software is called the compiler. Most of the time, programming is done inside a programming environment; when you purchase a copy of Visual Studio from Microsoft; It provides the developers with an editor to write the source code, a compiler, and help for many of Microsoft's programming languages. Examples of well-known programming languages today include Java, PHP, and C's various flavors (Visual C, C++, C#.)

Figure 3.4.1: Convert a computer program to an executable. Image by Ly-Huong T. Pham is licensed under CC-BY-NC

Thousands of programming languages have been created since the first programming language in 1883 by a woman named Ada Lovelace. One of the earlier English-like languages called COBOL has been in use since the 1950s to the present time in services that we still use today, such as payroll, reservation systems. The C programming language was introduced in the 1970s and remained a top popular choice. Some new languages such as C#, Swift are gaining momentum as well. Programmers select the best-matched language with the problem to be solved for a particular OS platform. For example, languages such as HTML and JavaScript are used to develop web pages.

It is hard to determine which language is the most popular since it varies. However, according to the TIOBE Index, one of the companies that rank the popularity of the programming languages monthly, the top five in August 2023 are Python, C, C++, Java, and C# with Julia emerging as a language that is faster than Python (Tiobe, 2023). For more information on this methodology, please visit the TIOBE page. For those who wish to learn more about programming, Python is a good first language to learn because not only is it a modern language for web development, it is simple to learn and covers many fundamental concepts of programming that apply to other languages.

One person can write some programs. However, most software programs are written by many developers. For example, it takes hundreds of software engineers to write Microsoft Windows or Excel. To ensure teams can deliver timely and quality software with the least amount of errors, also known as bugs, formal project management methodologies are used, a topic that we will discuss in Chapter 10.

3.4.1: Open-Source vs. Closed-Source Software

When the personal computer was first released, computer enthusiasts immediately banded together to build applications and solve problems. These computer enthusiasts were happy to share any programs they built and solutions to problems they found; this collaboration enabled them to innovate more quickly and fix problems.

However, as software began to become a business, this idea of sharing everything fell out of favor for some. When a software program takes hundreds of hours to develop, it is understandable that the programmers do not want to give it away. This led to a new business model of restrictive software licensing, which required payment for software to the owner, a model that is still dominant today. This model is sometimes called closed source, as the source code remains private property and is not made available to others. Microsoft Windows, Excel, and Apple iOS are examples of closed-source software.

Many, however, feel that software should not be restricted. Like those early hobbyists in the 1970s, they feel that innovation and progress can be made much more rapidly if we share what we learn. In the 1990s, with Internet access connecting more and more people, the open-source movement gained steam.

Open-source software has the source code available for anyone to copy and use. For non-programmers, it won't be of much use unless the compiled format is also made available for users to use. However, for programmers, the open-source movement has led to the development of some of the world's most-used software, including the Firefox browser, the Linux operating system, and the Apache webserver.

Some people are concerned that open-source software can be vulnerable to security risks since the source code is available. Others counter that because the source code is freely available, many programmers have contributed to open-source software projects, making the code less buggy and adding features, and fixing bugs much faster than closed-source software.

Many businesses are wary of open-source software precisely because the code is available for anyone to see. They feel that this increases the risk of an attack. Others counter that this openness decreases the risk because the code is exposed to thousands of programmers who can incorporate code changes to patch vulnerabilities quickly.

In summary, some benefits of the open-source model are:

- The software is available for free.
- The software source code is available; it can be examined and reviewed before it is installed.
- The large community of programmers who work on open-source projects leads to quick bug-fixing and feature additions.

Some benefits of the closed-source model are:

- Providing a financial incentive for software developers or companies
- Technical support from the company that developed the software.

Today there are thousands of open-source software applications available for download. An example of open-source productivity software is Open Office Suite. One good place to search for open-source software is sourceforge.net, where thousands of software applications are available for free download.

3.4.2: Software Licenses

The companies or developers own the software they create. The software is protected by law through patents, copyrights, or licenses. It is up to the software owners to grant their users the right to use the software through the terms of the licenses. In a later chapter, we will discuss the topic of copyright and licenses in more detail.

Paying for software licensing offers several benefits for individuals, businesses, and organizations, such as receiving technical support, regular updates, and legal protection. Companies usually need the comfort of having regular updates and technical support, even if the software is free.

For closed-source vendors, the terms vary depending on the price the users are willing to pay. Examples include single-user, single installation, multi-users, multi-installations, per network, or machine.

They have specific permission levels for open-source vendors to grant using the source code and set the modified version conditions. Examples include free to distribute, remix, and adapt for non-commercial use but with the condition that the newly revised source code must also be licensed under identical terms. While open-source vendors don't make money by charging for their software, they generate revenues through donations or selling technical support or related services. For example, Wikipedia is a widely popular online free-content encyclopedia used by millions of users. Yet, it relies mainly on donations to sustain its staff and infrastructure.

3.4.3: Reference

TIOBE Index for August 2023. Retrieved August 27, 2023, from tiobe.com

---

3.5: Summary

Chapter 3 focuses on software, which provides the intelligence and instructions that enable hardware to function. Software is categorized as system software like operating systems, utility programs, and application software. Operating systems manage hardware resources and provide a platform for applications. Utilities like antivirus software maintain system health. Artificial Intelligence software is an emerging software that can improve people's productivity. Application software is designed to meet a specific goal. Productivity software is a subset of application software that provides basic business functionality to a personal computer: word processing, spreadsheets, and presentations. An ERP system is a software application with a centralized database that is implemented across the entire organization. ERP and CRM systems integrate business processes and data to help run the organization.

The rise of AI-powered large language models has led us into uncharted territory, where new content created by AI is becoming increasingly prevalent. Although these models are imperfect at this early stage, they can still be both useful and harmful. On one hand, they can assist people with faster research and content creation, such as in marketing and education. However, on the other hand, they can also be harmful, as these models can hallucinate and provide incorrect answers.

Another software delivery model is cloud computing, which provides services over the internet rather than installing locally. While convenient, it raises security and privacy concerns. Virtualization software enables providers to allocate resources efficiently in the cloud. Software is created through programming languages that are compiled into executable instructions. Development follows formal methodologies and can be done through open source or closed source models. The software can be an open-source or a closed-source model, and users or developers are granted different licensing terms.

3.6: Study Questions

3.6.1: Study Questions

Study Question 3.6.1

Give your own definition of software.

Answer

Software is a set of instructions or programs that tells the hardware of a computing device how to operate and perform tasks.

Study Question 3.6.2

Identify the key functions of the operating system.

Answer

Key functions of an operating system: manages hardware resources, provides user interface, provides platform for software developers.

Study Question 3.6.3

Match which of the following are operating systems and which are applications: Microsoft Excel, Google Chrome, iTunes, Windows, Android, Angry Birds.

Answer

Operating systems: Windows, Android Applications: Microsoft Excel, Google Chrome, iTunes, Angry Birds.

Study Question 3.6.4

List your favorite software application and explain what tasks it helps you accomplish.

Answer

There are many options. Here is one example: My favorite software is Google Sheets. It allows me to create spreadsheets to track data, run calculations and analyses, create charts, collaborate with others on reports, and more.

Study Question 3.6.5

Explain what is a "killer" app and identify the killer app for the PC.

Answer

A "killer" app is a software application so useful or popular it drives sales of the hardware platform needed to run it. The killer app that helped popularize the PC was the spreadsheet, exemplified by VisiCalc.

Study Question 3.6.6

List at least three basic categories of mobile apps and give an example of each.

Answer

Three categories of mobile apps:

- Productivity - document editors, cloud storage
- Entertainment - games, video/music streaming
- Utilities - maps, banks, airline apps

Study Question 3.6.7

Explain what an ERP system does.

Answer

An ERP integrates business processes across departments onto a unified system. It includes modules for functions like accounting, manufacturing, HR.

Study Question 3.6.8

Explain what AI generative model is

Answer

AI generative models are trained on massive quantities of data such as images to generate new images given a specific description, or massive online texts to generate new text-based answers.

Study Question 3.6.9

What is AI hallucinations?

Answer

Watch the video in the section Artificial Intelligence Software and name two ideas from the video.

Study Question 3.6.10

Explain the difference between open-source software and closed-source software. Give an example of each.

Answer

Open source software has publicly available source code that can be modified. Closed source software keeps source code private. Example open: Linux. Closed: Microsoft Windows.

Study Question 3.6.11

Describe what a software license is.

Answer

A software license dictates the terms of use for a software program. It specifies permissions like number of users and installations.

Study Question 3.6.12

Explain the process of creating a software program.

Answer

To create software:

- Programmers write source code in a programming language
- Source code is compiled into machine-readable instructions
- Programming done in an integrated development environment
- Teams follow methodologies to manage large projects

3.6.2: Exercises

1. Go online and find a case study about the implementation of an ERP system. Was it successful? How long did it take? Does the case study tell you how much money the organization spent?
2. What ERP system does your university or place of employment use? Find out which one they use and see how it compares to other ERP systems.
3. If you were running a small business with limited funds for information technology, would you consider using cloud computing? Find some web-based resources that support your decision.
4. Download and install Open Office. Use it to create a document or spreadsheet. How does it compare to Microsoft Office? Does the fact that you got it for free make it feel less valuable?
5. Go to sourceforge.net and review their most downloaded software applications. Report back on the variety of applications you find. Then pick one that interests you and report back on what it does, the kind of technical support offered, and the user reviews.
6. Go online to research the security risks of open-source software. Write a short analysis giving your opinion on the different risks discussed.
7. What are three examples of programming languages? What makes each of these languages useful to programmers?
8. Ask ChatGPT three questions, rewrite the answer in your own words, and compare the difference. Which one is authentic and why?

CHAPTER OVERVIEW

4: Data and Databases

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Explain the differences between data, information, and knowledge;
- Define the term database and identify the steps to creating one;
- Describe the role of a database management system;
- Describe the characteristics of a data warehouse; and
- Define data mining and describe its role in an organization.

This chapter explores how organizations use information systems to turn data into information and knowledge to be used for competitive advantage. We will discuss how different types of data are captured and managed, different types of databases, and how individuals and organizations use them.

4.1: Introduction to Data and Databases

You've already learned about the first two components of information systems: hardware and software. However, these alone do not make a computer useful. Imagine turning on your computer and typing up a document, but being unable to save it. Or opening your music app, only to find no music available to play. Or opening a web browser, but finding no web pages to browse.

To gain a competitive advantage, companies have two methods of control: increasing efficiency through cost savings or increasing profits by providing new solutions that meet customer needs. To increase efficiency, companies need to allow employees to share relevant data. This facilitates timely decision-making and standardizes the process of submitting time cards for payroll. To meet customer demands, marketing, and manufacturing must have access to real-time inventory levels. To understand customer preferences and buying patterns, companies must keep track of trends and collect data on what customers are buying, when, and how. To achieve these goals, companies must standardize their processes, store data in a common location accessible to appropriate personnel, and collect customer data for analysis.

Businesses need to gather data and information on their procedures, staff, clientele, suppliers, and other relevant data and organize it to maximize efficiency and effectiveness across all employee levels. Without data, hardware and software are not very useful! This chapter will discuss data, the third component of an information system, and how it is organized. Data collection and utilization are crucial to the business models of many modern companies, enabling real-time decision-making and a competitive edge.

Use Case Example 4.1.1

Uber wants to:

1. Predict which areas are of high demand to direct more drivers to those areas
2. Analyze average pickup times to improve processes
3. Adjust surge pricing dynamically based on demand
4. Plan a campaign to recruit drivers
5. Build an Artificial Intelligence model to forecast future demands

What data should Uber collect?

Answer

Uber can collect the following data from the Uber app used by customers and drivers.

- Number of active drivers
- Driver locations
- Request locations and times
- Historical request patters

After gathering the necessary data, Uber can thoroughly analyze and combine it to detect trends and acquire valuable information that can help enhance customer satisfaction, increase driver productivity, adjust the pricing accordingly, and introduce new services.

Data, Information, Knowledge, and Wisdom

In everyday life, we use these terms interchangeably. However, to organize data effectively, we need to clearly differentiate these four terms: data, information, knowledge, and wisdom and how they relate to each other.

Figure 4.1.1 shows four circles; each is larger, encompassing the previous one, labeled from the innermost to the outermost circle: data, information, knowledge, and wisdom. Wisdom sits at the top, enclosing the other foundation of knowledge, information, and raw data. Each layer provides more meaning and capability.

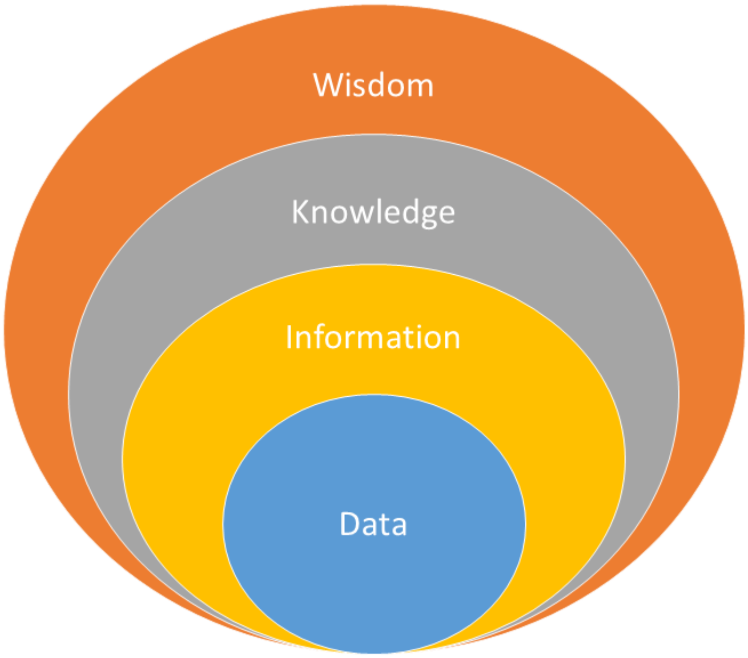


Figure 4.1.1:From Data to Wisdom. Image by Ly-Huong Pham, is licensed under CC BY

Data consists of discrete facts and observations that are not disputable facts. Data leads to information when it is organized in a meaningful way that give more context. Information leads to knowledge when there is a recognized pattern, a cause and effect, or insights from prior experience. Knowledge leads to wisdom when a person exercises good judgment, foresight, and balanced perspective when making a decision.

The two highest levels of data are quantitative or qualitative. To know which to use depends on the question to be answered and the available resources. Quantitative data is numeric, the result of a measurement, count, or some other mathematical calculation. A quantitative example would be how many 5th graders attended music camp this summer. Qualitative data consist of words, descriptions, and narratives. A qualitative example would be a camper wearing a red tee-shirt. A number can be considered qualitative as well. If I tell you my favorite number is 5, that is qualitative data because it is descriptive, not the result of a measurement or mathematical calculation.

When using qualitative data and quantitative data, we need to understand the context of its use. There are advantages and disadvantages to each. This table encapsulates the advantages and disadvantages when gathering data.

Qualitative Data

Advantages	Disadvantages
• Can give a nuanced understanding of the perspectives and needs of program participants • Can help support or explain results indicated in quantitative analysis • Source of detailed or "rich" information that can be used to identify patterns of behavior	• May lend itself to working with smaller populations; may not be representative of larger demographics • Data analysis can be time-consuming • Analysis can be subjective; there is potential for evaluator bias in analysis and collection.

Quantitative Data

Advantages	Disadvantages

Advantages	Disadvantages
• Clear and specific • Accurate and reliable if properly analyzed • It can be easily communicated as graphs and charts • Many large datasets already exist that can be analyzed	• Data collection methods provide respondents with a limited number of response options • Can require complex sampling procedures • May not accurately describe a complex situation • Some expertise with the statistical analysis required

By itself, data is a collection of components waiting to be analyzed. To be useful, it needs to be given context. Users and designers create meaning by collecting, referencing, and organizing the data. Information typically involves manipulating raw data to indicate magnitude, trends, and patterns in the data for a purpose. Returning to the example above, if I told you that "15, 23, 14, and 85″ are the numbers of students that had registered for an upcoming camp, that would be information. By adding the context – that the numbers represent the count of students registering for specific classes – I have added context to data which now is information. Information is data that has been analyzed, processed, structured, and avails itself to be useful.

Once we collect and understand the data, we put it into context, aggregate it, and analyze it. We then have information and can use it to make decisions for the individual and our organization. We can say that this consumption of information produces knowledge. Knowledge can be viewed as information that facilitates action. This knowledge can be used to make decisions, set policies, and spark innovation.

The final step up the information ladder is the step from knowledge (knowing a lot about a topic) to wisdom. Wisdom is experience coupled with understanding and insight. We can say that someone has wisdom when combining their knowledge and experience to produce a deeper understanding of a topic. It often takes many years to develop wisdom on a particular topic and requires patience and expertise.

Use Case Example 4.1.1

Here's an example of the progression from data to wisdom in Alice's daily life context

Solution

Data:

- Alice's car makes loud grinding noise when brakes applied
- Checking account balance is $125
- Alice's paycheck on Friday is $500

Information:

- Brake pads likely need replacement from worn brake sound
- Low checking account balance currently

Knowledge:

- From experience, knows brake jobs cost ~$300 at mechanic
- Paychecks come every 2 weeks so cashflow fluctuates

Wisdom:

- Waits to schedule brake replacement next Friday after paycheck
- Plans ahead for car maintenance by budgeting money each month
- Starts emergency fund for unexpected expenses

In this case, the discrete or raw facts like noises and balances become meaningful when organized as information. Alice used prior knowledge to interpret the costs of repairs. Wisdom was applied to make financial decisions, aligning short-term needs with long-term planning.

4.2: Examples of Data

Data can be anything that are factual and can't be disputed.

Some examples of data are weights, prices, costs, numbers of items sold, names, places, an image, a song. Almost all software programs require data to do something useful. It can be straightforward, as a name of a place, a person, or a number. An example would be editing a document in a word processor such as Microsoft Word, the document you are working on is the data. The word-processing software can manipulate the data: create a new document, duplicate a document, or modify a document. Today we have a new type of data called biometrics, which are physical or behavioral human characteristics that can digitally identify a person. Examples would be facial recognition used for passports. Fingerprint authentication is used to unlock smartphones. Iris recognition uses high-resolution images of the iris. This data is stored for future identification. Many governments and high-security companies use iris recognition because it is considered to be errorless when identifying individuals.

4.2.1: Databases

Definition: Database, DBMS

A **database** is an organized collection of data stored in a computer system. Databases allow for the storage and retrieval of large amounts of information in a structured and interrelated manner through the use of electronic tables, indexes, queries, and other mechanisms.

A **Database management system** (DBMS) is the software used to manage and query a database.

We will give an overview of database fundamentals. Many information systems aim to transform data into information to generate knowledge that can be used for decision-making. To do this, the system must take or read the data, then put the data into context, and provide tools for aggregation and analysis. A database is designed for just such a purpose.

A database is an organized, meaningful collection of related information. It is an organized collection because, in a database, all data is interrelated and associated with other data. All information in a database should be related; separate databases should be created to manage unrelated information. For example, a database that contains information about employees' payroll should not also hold information about the company’s stock prices.

Digital databases include things created by MS Excel, such as tables to more complicated databases used every day by people, from checking your balance at the bank to accessing medical records and online shopping. Databases help us to eliminate redundant information. It ensures more effective ways to access searches. Databases would be a filing cabinet before the arrival of computing. For this text, we will only consider digital databases.

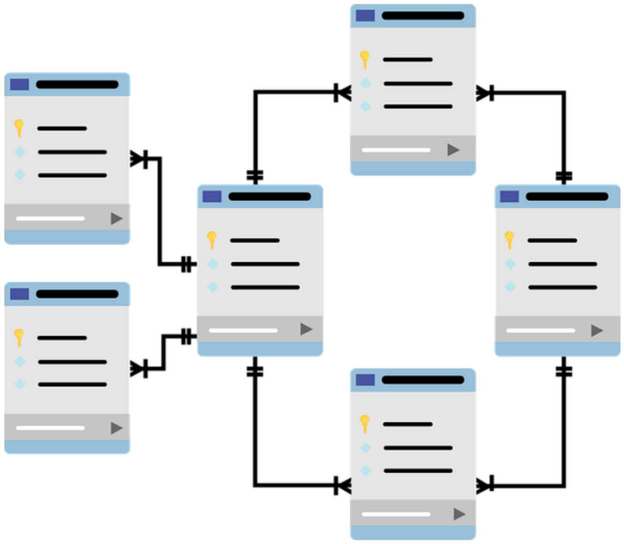


Figure 4.2.1: Relational Database. Image by mcmurry julie from Pixabay is licensed under CC-BY-SA 2.0

4.2.2: Relational Databases

Databases can be organized in many different ways and thus take many forms. DBMS (Database Management System) is software that facilitates the organization and manipulation of data. DBMS functions as an interface between the database and the end-user. The software is designed to store, define, retrieve and manage the data in the database. Other forms of databases today are relational databases.

Definition: Relational Database

A relational database is a type of database that structures its data into relations, which are essentially tables consisting of rows and columns.

- Each row represents a record with a unique ID called the key and has a set of fields to define the nature of the data stored in the table.
- Each column represents fields in the table, stores the attributes for that record

Relational databases establish predefined relationships between their tables through the use of foreign keys, which create connections between rows in different tables, as shown in Figure 4.2.2.

To visualize this, think of an Excel spreadsheet, the records as the rows of the table and the fields as the table columns. In the example below, we have a table of student information, with each row representing a student and each column representing one piece of information about the student.

Relational Database Example

Figure 4.2.2: Relational database table adapted from David Bourgeois, Ph.D. is licensed under CC BY 4.0

	Fields (Columns)			
Records (Rows)	First Name	Last Name	Major	Birthdate
	Ann Marie	Strong	Pre-Law	2/27/1997
	Evan	Right	Business	12/4/1996
	Michelle	Smith	Math	6/27/1995

Relational databases include Oracle (RDBMS), MySQL, SQL, and PostgreSQL.

4.3: Structured Query Language

Once you have a database designed and loaded with data, how will you do something useful with it? The primary way to work with a relational database is to use Structured Query Language, SQL (pronounced “sequel,” or stated as S-Q-L).

Definition: Structured Query Language (SQL)

SQL (structured query language) is a specialized programming language designed for managing and manipulating relational databases. It allows you to access and work with database data in a standard way.

Almost all applications that work with databases (such as database management systems, discussed below) use SQL to analyze and manipulate relational data. SQL allows users to interact and manage tables in a relational database, such as define the structure of the database, insert new data, update existing data, delete data, and, most importantly, query data (i.e., retrieve specific information).

Some common SQL commands are:

SELECT - Retrieve specific columns and rows from a database table. This might be used to look up a customer's purchase history.

INSERT - Add new data, like a new customer record, into a database.

UPDATE - Modify existing data in a database, like changing a product price.

DELETE - Remove data from a database table, like removing discontinued products.

Example 4.3.1

Using the Student Clubs database, form a query to retrieve a list of the first and last names of the club presidents.

Solution

SELECT "First Name," "Last Name" FROM "Students" WHERE "Students.ID" =

Example 4.3.2

Using the Student Clubs database, form a query will create a list of the number of students in each club, listing the club name and then the number of members.

Solution

SELECT "Clubs.Club Name", COUNT("Memberships.Student ID") FROM "Clubs"

SQL is the primary way database administrators and business analysts interact with many databases and a flexible approach to managing company data. Almost every major database system uses SQL. SQL skills allow analysts to enjoy the full potential of databases for key objectives like customer intelligence, streamlined operations, and data-driven strategy.

While SQL has a steeper learning curve than spreadsheets, it is a high-demand skill in the IT job market.

An in-depth description of how SQL works is beyond this introductory text's scope. Still, these examples should give you an idea of the power of using SQL to manipulate relational data. Many database packages, such as Microsoft Access, allow you to visually create the query you want to construct and then generate the SQL query for you. For more learning resources, you can check out free courses from Codecademy, or watch this series of videos SQL Basics from Khan Academy.

4.3.1: Rows and Columns in a Table

In a relational database, all the tables are related by one or more fields, so it is possible to connect all the tables in the database through the field(s) they have in common. For each table, one of the fields is identified as a primary key. This key is the unique identifier for each record in the table. To help you understand these terms further, let's walk through the process of designing the following database.

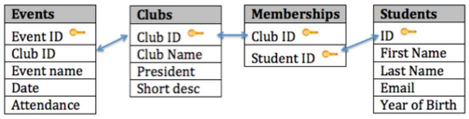


Figure 4.3.1: Data design flow. Image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

4.4: Designing a Database

4.4.1: Designing a Database

Suppose a university wants to create a database to track participation in student clubs. After interviewing several people, the design team learns that implementing the system is to give better insight into how the university funds clubs. This will be accomplished by tracking how many members each club has and how active the clubs are. The team decides that the system must keep track of the clubs, their members, and their events. Using this information, the design team determines that the following tables need to be created:

- Clubs: this will track the club name, the club president, and a short description of the club.
- Students: student name, e-mail, and year of birth.
- Memberships: this table will correlate students with clubs, allowing us to have any given student join multiple clubs.
- Events: this table will track when the clubs meet and how many students showed up.

Now that the design team has determined which tables to create, they need to define the specific information that each table will hold. This requires identifying the fields that will be in each table. For example, Club Name would be one of the fields in the Clubs table. First Name and Last Name would be fields in the Students table. Finally, since this will be a relational database, every table should have a field in common with at least one other table (in other words: they should have a relationship with each other).

To properly create this relationship, a primary key must be selected for each table. This key is a unique identifier for each record in the table. For example, in the Students table, it might be possible to use students' first names to identify them uniquely. However, it is more than likely that some students will share the last name (like Mike, Stefanie, or Chris), so a different field should be selected. A student's email address might be a good choice for a primary key since e-mail addresses are unique. However, a primary key cannot change, so this would mean that if students changed their email addresses, we would have to remove them from the database and then re-insert them – not an attractive proposition. Our solution is to create a value for each student — a user ID — that will act as a primary key. We will also do this for each of the student clubs. This solution is quite common and is the reason you have so many user IDs!

You can see the final database design in the figure below:

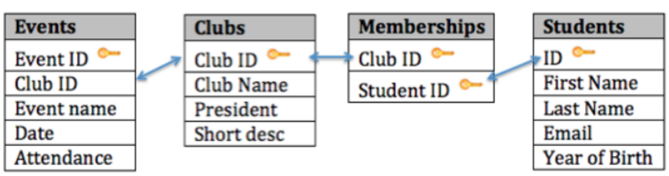


Figure 4.4.1: Data design flow. Image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

With this design, not only do we have a way to organize all of the information we need to meet the requirements, but we have also successfully related all the tables together. Here's what the database tables might look like with some sample data. Note that the Memberships table has the sole purpose of allowing us to relate multiple students to multiple clubs.

Club ID	Club name	President	Short desc
1	Cheese Club	14	To talk about our love of cheese.
2	Chess Club	1	To learn how to become better chess players.
3	Archery Club	6	To compete in archery tournaments.

Table: Clubs

Figure 4.4.2 Table: Clubs. Image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

ID	First Name	Last Name	Email	Year of Birth
1	Peter	Lee	plee@university.edu	1992
2	Jonathan	Edwards	jedwards@university.edu	1994
3	Marilyn	Johnson	mjohnson@university.edu	1993
6	Joe	Kim	jkim@university.edu	1992
12	Haley	Martinez	hmartinez@university.edu	1993
14	John	Mfume	jmfume@university.edu	1991
15	David	Letty	dletty@university.edu	1995

Table: Students

Figure 4.4.3 Table: Students. Image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

Club ID	Student ID
1	1
1	2
1	14
2	1
2	3
2	5
2	6
3	1
3	6
3	12
3	14
3	15

Table: Memberships

Figure 4.4.4 Table: Memberships. Image: by David Bourgeois, Ph.D. is licensed under CC BY 4.0

4.4.2: Normalization

When designing a database, one important concept to understand is normalization. In simple terms, to normalize a database means to design it in a way that:

- Reduces redundancy of data between tables easier mapping
- Takes out inconsistent data.
- Information is stored in one place only.
- Gives the table as much flexibility as possible.

In the Student Clubs database design, the design team worked to achieve these objectives. For example, to track memberships, a simple solution might have been to create a Members field in the Clubs table and then list all of the members' names. However, this design would mean that if a student joined two clubs, then his or her information would have to be entered a second time. Instead, the designers solved this problem by using two tables: Students and Memberships.

In this design, when a student joins their first club, we must add the student to the Students table, where their first name, last name, e-mail address, and birth year are entered. This addition to the Students table will generate a student ID. Now we will add a new entry to denote that the student is a specific club member. This is accomplished by adding a record with the student ID and the club ID in the Memberships table. If this student joins a second club, we do not have to duplicate the student's name, e-mail, and birth year; instead, we only need to make another entry in the Memberships table of the second club's ID and the student's ID.

The Student Clubs database design also makes it simple to change the design without major modifications to the existing structure. For example, if the design team was asked to add functionality to the system to track faculty advisors to the clubs, we could easily accomplish this by adding a Faculty Advisors table (similar to the Students table) and then adding a new field to the Clubs table to hold the Faculty Advisor ID.

4.4.3: Data Types

When defining the fields in a database table, we must give each field a data type. For example, the field Birth Year is a year, so it will be a number, while First Name will be text. Most modern databases allow for several different data types to be stored. Some of the more common data types are listed here:

- Text: for storing non-numeric data that is brief, generally under 256 characters. The database designer can identify the maximum length of the text.
- Number: for storing numbers. There are usually a few different number types selected, depending on how large the largest number will be.
- Yes/No: a special form of the number data type that is (usually) one byte long, with a 0 for “No” or “False” and a 1 for “Yes” or “True.”
- Date/Time: a special form of the number data type can be interpreted as a number or a time.
- Currency: a special form of the number data type that formats all values with a currency indicator and two decimal places.
- Paragraph Text: this data type allows for text longer than 256 characters.
- Object: this data type allows for data storage that cannot be entered via keyboards, such as an image or a music file.

The importance of properly defining data type is to improve the data's integrity and the proper storing location. We must properly define the data type of a field, and a data type tells the database what functions can be performed with the data. For example, if we wish to perform mathematical functions with one of the fields, we must tell the database that the field is a number data type. So if we have a field storing birth year, we can subtract the number stored in that field from the current year to get age.

Allocation of storage space for the defined data must also be identified. For example, if the First Name field is defined as a text(50) data type, fifty characters are allocated for each first name we want to store. However, even if the first name is only five characters long, fifty characters (bytes) will be allocated. While this may not seem like a big deal, if our table ends up holding 50,000 names, we allocate 50 * 50,000 = 2,500,000 bytes for storage of these values. It may be prudent to reduce the field's size, so we do not waste storage space.

In defining a data field in a database, we have to give all specific requirements for computers to know what constitutes a valid entry entered by a user. Data entry errors must be caught immediately to avoid having bad data in the database since it can be replicated by different organizations, which spreads the mistake far and wide.

✓ Example 4.4.1

A first-name field is defined to contain up to 10 letters long from A to Z or a to z. We have to be very specific in denoting upper or lower case letters. A valid entry for a field containing a first name can be any upper or lower letter, up to 10 letters.

Question: Is 'space' or 'hyphen' allowed in the above definition?

Solution

No, since we did not define it. If we wish to have these two characters, we will modify it to say: they can contain up to 10 letters long from A to Z, or a to z, ", "or - (hyphen).

✓ Example 4.4.2

How would you define a date if we want to accept DD/MM/YYYY?

Solution

We would define the date field as follows:

Date field: starting with two digits, where DD can be from 01 to 31, followed by a /, followed by two numbers that can be from 01 to 12, followed by a /, and four digits that can be from 1900 to 9999.

4.5: The Difference between a Database and a Spreadsheet

When introducing the concept of databases to students, they quickly decide that a database is similar to a spreadsheet. There are some similarities, but we will review some big differences. A spreadsheet hopes to grow into a database one day.

Let's start with the spreadsheet. It is easy to create, edit, and format. It is simple to use for beginners. It comprises columns and rows and stores data in an organized fashion, like a database table. The two leading spreadsheet applications are Google Sheets and Microsoft Excel. One of the very convenient things about spreadsheets is shared accessibility with multiple users. This is not the case with a database.

For simple uses, a spreadsheet can substitute for a database quite well. Creating a database is probably overkill if a simple listing of rows and columns (a single table) is all that is needed. In our Student Clubs example, we could get away with a single spreadsheet if we only needed to track a listing of clubs, the number of members, and the president's contact information. However, the need to include a listing of events and members' names would be problematic if tracked with a spreadsheet.

When several types of data must be mixed, or when the relationships between these types of data are complex, then a spreadsheet is not the best solution. A database allows data from several entities (such as students, clubs, memberships, and events) to be related together into one whole. While a spreadsheet does allow you to define what kinds of values can be entered into its cells, a database provides more intuitive and powerful ways to define the types of data that go into each field, reducing possible errors and allowing for easier analysis. Though not good for replacing databases, spreadsheets can be ideal tools for analyzing the data stored in a database. A spreadsheet package can be connected to a specific table or query in a database and used to create charts or analyze that data.

A database has many similarities in looks of a spreadsheet utilizing tables that are made up of columns and rows. The database is a collection of structured raw material. The information is stored on the computer. A spreadsheet is easily editable with its rows and columns; this is not the case of a database. The database is formatted, so the field (column) is pre-configured. The database is also relational in that it has the ability to create relationships between records and tables. Spreadsheets and databases can both be edited by multiple authors. In a database, a log is created as changes are made. This is not the case with a spreadsheet. A spreadsheet is terrific for small projects, but a database would become more useful as the project grows.

✔ Example: Why use Databases? 4.5.1

A company uses a spreadsheet to store every purchase amount from a customer. The spreadsheet would look like this:

Clients Purchases

Date	Client Name	Amount
1/1/2023	Jane Doe	$100
1/5/2023	John Smith	$50
1/7/2023	Jane Doe	$25
1/10/2023	Bob Jones	$200

Each transaction is entered on a separate row, with the client name typed out fully each time. Jane made two purchases on two different days; hence there are two rows for her.

Problem: If Jane Doe changed her name to Jane Johnson, her name would need to be updated in multiple rows. Imagine if you have a spreadsheet that has thousands of rows for Jane Doe (she loves your products and has been a customer for the last 5 years!). It would take a lot of time to update each row for her, and it is error-prone because some rows could be missed.

How would the use of a database be more efficient?

Solution

Here is the structure that we would design for this database.

First, we define a table "Clients" to keep the clients' names, and assign a unique key (client id) for each client.

Clients Table

Client-ID (key)	Client Name
1	Jane Johnson
2	John Smith
3	Bob Jones

Next, we define a table "Transactions" to keep track of money spent per client

Transaction Table

Date	Client-ID	Amount
1/1/2023	1	$100
1/5/2023	2	$50
1/7/2023	1	$25
1/10/2023	3	$200

In the database, the Clients table stores the master list of clients. The Transactions table references the ClientID as a unique key to 'relate' the two tables.

To change Jane Doe's name, only change is made at one place: only the name field in the Clients table needs to be updated. The Transactions table automatically reflects this change via the ClientID key.

The company now has a database structure that maintains data integrity and normalization much more efficiently than the spreadsheet when client data needs to be updated.

4.5.1: Streaming

Streaming is a new easy way to view on-demand audio or video from a remote server. Companies offer audio and video files from their server that can be accessed remotely by the user. The data is transmitted from their server directly and continuously to your device. Streaming can be accessed by any device that connects to the internet. There is no need for large memory or having to wait for a large file to download. Stream technology is becoming very popular because of its convenience and accessibility. An example of some streaming services is Netflix, iTunes, and YouTube.

4.5.2: Other Types of Databases

The relational database model is the most used today. However, many other database models exist that provide different strengths than the relational model. In the 1960s and 1970s, the hierarchical database model connected data in a hierarchy, allowing for a parent/child relationship between data. The document-centric model allowed for more unstructured data storage by placing data into "documents" that could then be manipulated.

However, the relational database model does not scale well. The term scale here refers to a larger and larger database being distributed on a larger number of computers connected via a network.

To support large scale models, Some companies are providing new non-relational databases as shown in the Figure 4.5.2.

Figure 4.5.2: Non-Relational databases, by Ly-Huong Pham, Ph.D., is s licensed under CC BY 4.0

Non-Relational Databases

Closed Source (or hybrid) non-relational databases	Open Source non-relational databases
• MongoDB - MongoDB Inc. (public company)	• Cassandra - Apache Software Foundation
• Redis - Redis Labs (private company)	• HBase - Apache Software Foundation
• Neo4j - Neo4j Inc. (private company)	• Elasticsearch is open source software under the Apache license and managed by the non-profit Elasticsearch BV organization, not owned by them
• DynamoDB is a fully proprietary database service owned and managed by Amazon. But the DynamoDB software itself is not strictly closed source	• Google' solutions: Bigtable, Cloud Datastore, Cloud Firestore, Cloud Memorystore

Definition: NoSQL

NoSQL databases are non-tabular data stores that store and access data in ways other than traditional row-column relations used in relational databases. Definition text

The concept of NoSQL (from the phrase "not only SQL") arose from the need to solve large-scale databases spread over several servers or worldwide. For a relational database to work properly, only one person must be able to manipulate a piece of data at a time, a concept known as record-locking. But this is not possible with today's large-scale databases (think Google and Amazon). A NoSQL database can work with data more loosely, allowing for a more unstructured environment communicating changes to the data over time to all the servers that are part of the database. Many companies collect data for all sorts of reasons, from how many times you visit a site to what you are viewing at the site. Without complex SQL queries, NoSQL databases typically access data through simple APIs and operate in a non-tabular format to allow for efficient handling of semi-structured and unstructured data at very large scale. Their dynamic and distributed nature makes NoSQL databases well-suited for contemporary big data and real-time web applications.

4.6: Big Data

Definition: Big Data

Big data refers to large, complex datasets typically involving : a high **volume**, **velocity,** and **variety** of data that require cost-effective, innovative forms of information processing for enhanced insight and decision making.

Big Data refers to capturing large complex data sets that conventional database tools do not have the processing power to analyze. Storing and analyzing that much data is beyond the power of traditional database management tools. Understanding the best tools and techniques to manage and analyze these large data sets is a problem that governments and businesses alike are trying to solve. Big data comes from many different areas such as text, images, audio, and videos. Businesses use this data and refer to it as predictive analytics or user behavior analytics. Companies such as Walmart and Amazon are now collecting big data, to see what searches their customers are looking at. Think of the number of customers and products these two powerhouses have and the amount of data generated.

Use Case Big Data 4.6.1

Amazon wants to collect and analyze massive amounts of data on customers, from different sources and formats to derive user analytics to help improve the customers' experience. The data includes customers' purchases, browsing history, reviews, other activity on the site. The data sets can be unstructured such as customer reviews, social media conversations, or chat logs. They can also be semi-structured such as purchase history, web server logs, or product catalogs.

What are the insights gained by Amazon to increase sales, marketing outreach, or efficiency?

Solution

- Analyzing purchase history and browsing patterns to provide personalized product recommendations. The insights will allow Amazon to take actions to convert to higher sales.
- Applying machine learning techniques across customer data to segment users based on behaviors. This enables targeted marketing outreach.
- Tracking reviews and other metrics to identify trends and issues with products. This feedback leads to improvements.
- Processing log data to detect fraud in real-time before orders are fulfilled. This reduces risk.
- Indexing text data like product descriptions and customer service transcripts to efficiently handle text searches. This will improve customers' experience in searching and selecting products.

4.7: Data Warehouse

As organizations have begun to utilize databases as the centerpiece of their operations, the need to fully understand and leverage the data they are collecting has become more and more apparent. However, directly analyzing the data needed for day-to-day operations is not a good idea; we do not want to tax the company's operations more than we need to. Further, organizations also want to analyze data in a historical sense: How does the data we have today compare with the same data set this time last month or last year? From these needs arose the concept of the data warehouse.

Definition: Data Warehouse

A data warehouse is a centralized repository of integrated data from multiple sources, organized and optimized for reporting and analysis. Data warehouses consolidate data from different systems and sources, such as transactional systems, relational databases, and other sources into a single site to provide business users fast access to analytical and reporting data.

The data warehouse concept is simple: extract data from one or more of the organization's databases and load it into the data warehouse (which is itself another database) for storage and analysis. However, the execution of this concept is not that simple. A data warehouse should be designed so that it meets the following criteria:

- It uses non-operational data. This means that the data warehouse uses a copy of data from the active databases that the company uses in its day-to-day operations, so the data warehouse must pull data from the existing databases on a regular, scheduled basis.
- The data is time-variant. This means that whenever data is loaded into the data warehouse, it receives a timestamp, which allows for comparisons between different time periods.
- The data is standardized. Because the data in a data warehouse usually comes from several different sources, it is possible that the data does not use the same definitions or units. For example, our Events table in our Student Clubs database lists the event dates using the mm/dd/yyyy format (e.g., 01/10/2013). A table in another database might use the format yy/mm/dd (e.g., 13/01/10) for dates. For the data warehouse to match up the dates, a standard date format would have to be agreed upon, and all data loaded into the data warehouse would have to be converted to use this standard format. This process is called extraction-transformation-load (ETL).

There are two primary schools of thought when designing a data warehouse: bottom-up and top-down. The bottom-up approach starts by creating small data warehouses, called data marts, to solve specific business problems. As these data marts are created, they can be combined into a larger data warehouse. The top-down approach suggests that we should start by creating an enterprise-wide data warehouse and then, as specific business needs are identified, create smaller data marts from the data warehouse.

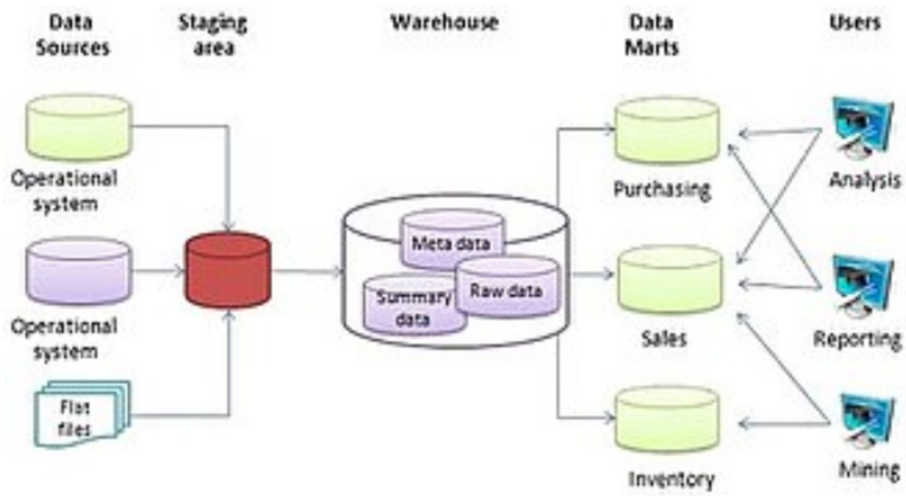


Figure 4.7.1: Data warehouse process (top down). Data warehouse process (top down) by Soha jamil is licensed under CC BY-SA 4.0

4.7.1: Benefits of Data Warehouses

Organizations find data warehouses quite beneficial for many reasons:

- Ability to integrate data from multiple systems formatted with different software and compile it to gain deeper insight.
- The process of developing a data warehouse forces an organization to understand the data better than it is currently collecting and, equally important, what data is not being collected.
- A data warehouse provides a centralized view of all data being collected across the enterprise and provides a means for determining inconsistent data.
- Once all data is identified as consistent, an organization can generate one version of the truth. This is important when the company wants to report consistent statistics about itself, such as revenue or employees' numbers.
- By having a data warehouse, snapshots of data can be taken over time. This creates a historical record of data, which allows for an analysis of trends.
- A data warehouse provides tools to combine data, which can provide new information and analysis.

✓ Use Case Data Warehouse 4.7.1

A retail company sets up a data warehouse to analyze sales performance. The data warehouse pulls in transaction data from all store checkout systems, inventory data from the ERP system, and customer information from loyalty program databases. This disparate data is integrated and transformed into a unified structure optimized for queries.

What do business analysts do to analyze sales performance?

Solution

Business analysts run reports and organize sales data in the data warehouse by time, region, product, customer attributes, and other dimensions. This enables them to spot trends, measure promotional performance, and identify challenges across the retail operation. Having all the data aggregated for reporting in the warehouse is more efficient than trying to query multiple sources and deal with the different types of reports from different systems.

With the sales data warehouse, the business gets a full picture of its performance from high-level indicators to granular details. This allows managers to make strategic decisions around pricing, inventory, promotions, or staffing.

In essence, the sales data warehouse transforms raw transactional data into an analytical asset for driving growth.

4.8: Data Mining

Businesses go from lacking of data to analyze to gain better insights about their company. Databases solved that problem. Now, business has the challenge of too much data to review and analyze which leads to data overload. This becomes an issue because the user needs to evaluate which information is useful and which is not. Data mining helps solve this issue.

Definition: Data Mining

Data mining is the process of discovering patterns and knowledge from large amounts of data using automated methods. It applies statistics, machine learning, and database techniques to parse data and identify useful information to extract actionable insights efficiently from both structured and unstructured data to inform data-driven decision making.

Data mining is the process of sorting through big data (measured in terabytes). Many businesses do mining to get detailed insight on their customers, products and to optimize business decisions. The analysis is executed with sophisticated programs. The programs can combine multiple databases. The end effect is so complex that companies must find a way to store the data. Data warehouses are needed. The data warehouse is where the information is stored and processed from the data mining. The price for a simple warehouse could start at $10 million.

Companies like Google, Netflix, Amazon, and Facebook are big users of data mining. They seek to find out who their consumer is and how best to keep them and sell them more products. They also review their products. The means used are reviewing data and finding trends, patterns, and associations to make decisions. Generally, data mining is accomplished through automated means against extensive data sets, such as a data warehouse.

Examples of data mining include:

- An analysis of sales from a large grocery chain might determine that milk is purchased more frequently the day after it rains in cities with a population of less than 50,000.
- A bank may find that loan applicants whose bank accounts show particular deposit and withdrawal patterns are not good credit risks.
- A baseball team may find those collegiate baseball players with specific statistics in hitting, pitching, and fielding for more successful major league players.

In some cases, a data-mining project is begun with a hypothetical result in mind. For example, a grocery chain may already have some idea that the buying patterns change after it rains and want to get a deeper understanding of exactly what is happening. In other cases, there are no presuppositions, and a data-mining program is run against large data sets to find patterns and associations.

4.9: Database Management Systems

A database looks like one or more files. For the data in the database to be read, changed, added, or removed, a software program must access it. The software creates a database by building tables, forms, reports, and other important variables. Many software applications have this ability: iTunes can read its database to give you a listing of its songs (and play the songs); your mobile-phone software can interact with your list of contacts. Companies of all sizes use this software to enable themselves to streamline the data they have collected to be useful for multiple purposes such as marketing, customer service, and sales. Database management systems help businesses to collect complex data and customize it for their own use. When selecting Database Management Software (DBMS,) the company needs to know what they want to utilize and establish goals. Questions that need to be answered are; What software can you use to create a database, change a database's structure, or analyze? For example, Apache OpenOffice.org Base can create, modify, and analyze databases in open-database (ODB) format. Microsoft's Access DBMS is used to work with databases in its own Microsoft Access Database format. Both Access and Base have the ability to read and write to other database formats as well.

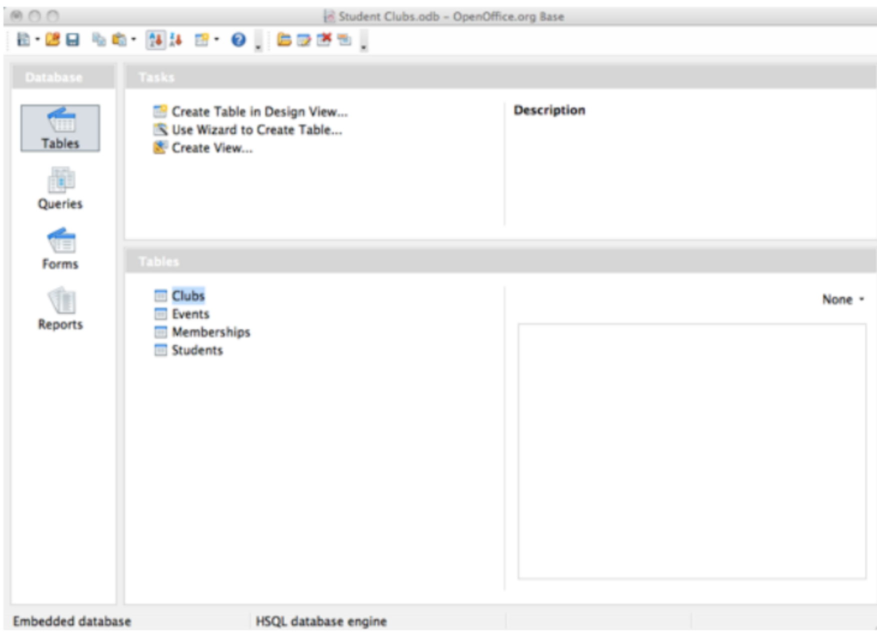


Figure 4.9.1: Open Office database management system. Image by David Bourgeois, Ph.D. is licensed under CC BY 4.0

Microsoft Access and Open Office Base are examples of personal database-management systems. These systems are primarily used to develop and analyze single-user databases. These databases are not meant to be shared across a network or the Internet but are instead installed on a particular device and work with a single user at a time.

4.10: Enterprise Databases

Small and large organizations utilize enterprise databases for managing when collecting large complex data. An enterprise database is robust enough to handle multiple users' queries successfully simultaneously and can handle a range of 100 to 10,000 users at a time. (Technopedia, 2020). Computers have become networked and are now joined worldwide via the Internet, and a class of databases has emerged that can be accessed by two, ten, or even a million people. These databases are sometimes installed on a single computer to be accessed by a group of people at a single location or a small company. They can also be installed over several servers worldwide, meant to be accessed by millions in large companies. These relational enterprise database packages are built and supported by companies such as Oracle, Microsoft, and IBM. The open-source MySQL is also an enterprise database. Open-source databases are free and can be shared, storingvital information in software that the organization can control. An open-source database allows users to create a system based on their unique requirements and business needs. The source code can be customized to match any user preference. Open-source databases address the need to analyze data from a growing number of new applications at a lower cost. The deluge of social media and the Internet of Things (IoT) has ushered an age of massive data that needs to be collected and analyzed. The data only has value if an enterprise can analyze it to find useful patterns or real-time insights. The data contains vast amounts of information that can overload a traditional database. The flexibility and cost-effectiveness of open source database software have revolutionized database management systems. (Omnisci, 2020).

Sidebar: What Is Metadata?

The term metadata can be understood as "data about data." For example, when looking at one of Year of Birth's values in the Students table, the data itself may be "1992″. The metadata about that value would be the field name Year of Birth, the last updated time, and the data type (integer). Another example of metadata could be for an MP3 music file, like the one shown in the image below; information such as the song's length, the artist, the album, the file size, and even the album cover art is classified as metadata. When a database is being designed, a "data dictionary" is created to hold the metadata, defining its fields and structure.

4.10.1: Data Governance

Data governance is the process of taking data and managing the availability, integrity, and usability in enterprise systems. Proper data governance ensures the data is consistent, trustworthy, and secured. We are in a time when organizations must pay close attention to privacy regulations and increasingly need to rely more on data analytics to optimize decision making and optimize operations. Data governance can be used at both the micro and macro levels. When we refer to micro, the focus is on the individual organization to ensure high data quality throughout the lifecycle to achieve optimal business objectives. The macro-level refers to cross-border flows by countries which are called international data governance.

4.10.2: References

Omnisci (2020). *Definition of an Open Source Database*. Retrieved September 1, 2020, from https://www.omnisci.com/technical-glossary/open-source-database#:~:text=An%20open%20source%20database%20has,is%20protected%20to%20prevent%20copying.

Technopedia, (2020) *Definition of Enterprise Database.* Retrieved September 1, 2020, from https://www.techopedia.com/definition/31683

4.11: Knowledge Management

We end the chapter with a discussion on knowledge management (KM) concept.

Definition: Knowledge Management

Knowledge Management (KM) is the systematic process of capturing, organizing, retaining, and disseminating knowledge within an organization to enhance its performance, innovation, and competitive advantage.

All companies accumulate knowledge over the course of their existence. Some of this knowledge is written down or saved, but not in an organized fashion. Much of this knowledge is not written down; it is stored inside its employees' heads. Knowledge management is the process of formalizing the capture, indexing and storing of the company's knowledge to benefit from the experiences and insights it has captured.

Companies have learned this unwritten knowledge is a very valuable asset to to run their businesses and to minimize risks. When employees leave a company, the knowledge goes with them. Years of experience with customers, products, markets, and others just vanishes if they are not written down.

Artificial Intelligence language model is one way to address this issue. Companies can capture, organize knowledge and train an AI model as a tool to disseminate the information to its employees in a more accurate and personalized.

4.11.1: Privacy Concerns

Figure 4.11.1: Cybersecurity. Image by Pete Linforth from Pixabay is licensed under CC BY-SA 2.0

The increasing power of data mining has caused concerns for many, especially in the area of privacy. It is becoming easier in today's digital world than ever to take data from disparate sources and combine them to do new forms of analysis. In fact, a whole industry has sprung up around this technology: data brokers. These firms combine publicly accessible data with information obtained from the government and other sources to create vast warehouses of data about people and companies that they can then sell. This subject will be covered in detail in chapter 12 – the chapter on the ethical concerns of information systems.

4.12: What is data science?

Definition: Data Science

Data science takes structured and unstructured data and uses scientific methods, processes, algorithms, and systems to extract knowledge and insight.

It begins by procuring data from many sources such as web servers, logs, databases, APIs (application program interface), and online repositories. Once the acquisition has happened, the data must be cleaned and pipeline data. This is done by sorting and organizing relevant and usable data; this is the transformation process. Data Modeling is next; the goal is to create the best modeling that suits the company's needs when using the data. This can be done using metrics, algorithms, and analytics. The goal is to progress to AI and deep learning or machine learning. Data science problem solves company issues using data.

- **Structured Data** - Is data that is found in a fixed field within a record or file. It includes data contained in relational databases and spreadsheets. Such as:
  - Date
  - Time
  - Census Data
  - Facebook “Likes”
- **Unstructured Data** - Is information that is not organized and does not have a pre-defined model. Such as:
  - Body of emails
  - Tweets
  - Facebook Status
  - Video Transcripts

4.12.1: What is data analytics?

Data Analytics takes raw data gathered from data mining and analyzes the information to uncover relationships and patterns to find insight into the data when using it. Companies use these analytics to optimize problem-solving and assist in decision-making. The information is helpful to understand who your consumer is as well as marketing your company or product. This is all helpful to create efficiency and streamline operations. Data continuously being collected can then be adjusted as new criteria happen. Today's data analytics are deeper, larger in abundance, and retrieved quicker than yesteryear. The information is more accurate and detailed, which accelerates successful problem-solving.

Figure 4.12.1: Analytic information. Image by xresch from Pixabay is licensed CC BY-SA 2.0

4.12.2: Business Intelligence and Business Analytics

This trend remains a competitive activity for companies. With tools such as data warehousing and data mining at their disposal, businesses learn how to use the information to their advantage. The term business intelligence is used to describe how organizations use to take data they are collecting and analyze it to obtain a competitive advantage. Besides using data from their internal databases, firms often purchase information from data brokers to understand their industries' big-picture understanding. Business analytics is the term used to describe internal company data to improve business processes and practices.

4.12.3: Data-Driving Business Leaders

Data analytics, used correctly, help management make data-driven and timely decisions. Companies like Amazon, Netflix, and Walmart have shown how harnessing rich customer and operational data can create competitive advantages.

The techniques of databases, data warehousing, and data mining are fundamental to building business intelligence. When raw data and information are transformed into valuable assets that provide a deep understanding of customer needs and wants for today and tomorrow, it becomes an essential tool for any company. Integrating business intelligence in day-to-day operations is what sets one company apart from another.

As more data is continually generated and massive volume of data can be analyzed using these techniques, forward-thinking leaders recognize that data mastery opens doors to new ways of understanding customers, streamlining processes, adapting to market changes, and designing winning business models. The story of every major corporate success today inevitably includes how they successfully acquired the right data, organized it in databases built for analytics, and mined it for actionable insights.

4.13: Summary

In this chapter, we learned about the role that data and databases play in the context of information systems. Data is made up of small facts and information without context. If you give data context, then you have information. Knowledge is gained when information is consumed and used for decision-making. A database is an organized collection of related information. Relational databases are the most widely used type of database, where data is structured into tables, and all tables must be related to each other through unique identifiers or keys. A database management system (DBMS) is a software application used to create and manage databases and take the form of a personal DBMS, used by one small business or person versus an enterprise DBMS that multiple users can use.

Big data refers to the large, complex datasets with high volume, velocity, and variety that require advanced techniques to store and analyze. A data warehouse is a special form of database that takes data from other databases in an enterprise and organizes it for analysis. Data mining is the process of looking for patterns and relationships in large data sets. Many businesses use databases, big data, data warehouses, and data-mining techniques to produce business intelligence and gain a competitive advantage.

Proper database design applies principles like normalization to reduce duplication and ensure flexibility. Fields have defined data types and constraints. Spreadsheets are limited compared to relational databases in modeling complex data relationships. As data volumes grow exponentially, non-relational databases provide scalability and flexibility lacking in traditional relational models. Data governance and ethics are becoming crucial with the increasing use of data analytics and personal data collection. Overall, data organized in purpose-built databases enables extraction of meaningful information, knowledge, and ultimately wisdom.

4.14: Study Questions - Data and Databases

Study Questions

Study Question 4.14.1

What is the difference between data, information, and knowledge?

Answer

Data are raw facts and figures. Information is data with context and organization, answering who, what, when, where. Knowledge is the application of information and experience to gain insight for action and decision-making.

Study Question 4.14.2

Explain in your own words the difference between hardware and software components of information systems in your own words.

Answer

Hardware is the physical components of an information system like computers, networks, and devices. Software is the programs and instructions running on the hardware, including operating systems, applications, utilities, etc.

Study Question 4.14.3

What is the difference between quantitative data and qualitative data? In what situations could the number 63 be considered qualitative data?

Answer

Quantitative data are numeric values from measurement or calculation. Qualitative data are descriptive qualities that cannot be measured numerically. The number 63 could be qualitative if it represents a code or identifier, not a measured quantity.

Study Question 4.14.4

What are the characteristics of a relational database?

Answer

Characteristics of a relational database include organized into tables with rows and columns; each row has a unique key, columns have field definitions, tables are related via keys linking rows.

Study Question 4.14.5

When would using a personal DBMS make sense?

Answer

A personal DBMS makes sense for small data management needs for one person or a small workgroup, not enterprise-wide sharing.

Study Question 4.14.6

What is the difference between a spreadsheet and a database? List three differences between them.

Answer

A spreadsheet is a simple data organization tool optimized for basic data manipulation by an individual. A database is designed for complex querying, large data volumes, multi-user access, and ensuring data integrity.

Study Question 4.14.7

Describe what the term normalization means.

Answer

Normalization is designing a database to reduce duplication and redundancy and improve flexibility to change. It involves separating data into multiple tables and establishing relationships.

Study Question 4.14.8

What is Big Data?

Answer

Big data refers to large, complex datasets with high volume, velocity, and variety that require advanced storage, processing, and analyzing techniques.

Study Question 4.14.9

Name a database you interact with frequently. What would some of the field names be?

Answer

A database could be something like contacts on your phone - fields would include name, phone number, email, birthdate, etc.

Study Question 4.14.10

Describe the benefits and what open-source data is.

Answer

Open source data is freely shared data that users can access and modify as needed since the source code is publicly available. Benefits include flexibility, transparency, and cost.

Study Question 4.14.11

Name three advantages of using a data warehouse.

Answer

Data warehouse advantages: Integrates data from disparate sources, provides enterprise-wide analytics, and creates historical records of data over time.

Study Question 4.14.12

What is data mining?

Answer

Data mining is analyzing large datasets to discover patterns and automatically extract meaningful information and insights.

Study Question 4.14.13

What is metadata? Provide one example.

Answer

Metadata is "data about data" - it provides information and context about the actual data in a database. An example is a database column's data type (e.g. text, number, date, etc.), which describes the type of data contained in that column.

Study Question 4.14.14

What are some potential ethical concerns when utilizing personal data for business analytics and data mining?

Answer

Some ethical concerns include:

- Lack of consent from individuals about data collection and use
- Violating privacy expectations by combining various data sources
- Misuse of data profiling to discriminate against groups of people
- Drawing faulty conclusions from incomplete data or incorrect analytics
- Data breaches that expose personal information
- Manipulating consumers through personalized advertising
- Perpetuating existing biases by using biased or unrepresentative data
- Quantitative data are numeric values from measurement or calculation.

Exercises

1. Review the design of the Student Clubs database earlier in this chapter. Reviewing the lists of data types given, what data types would you assign to each of the fields in each of the tables? What lengths would you assign to the text fields?
2. Review structured and unstructured data and list five reasons to use each.
3. Using Microsoft Access, download the database file of comprehensive baseball statistics from the website
4. SeanLahman.com. (If you don't have Microsoft Access, you can download an abridged version of the file here that is compatible with Apache Open Office). Review the structure of the tables included in the database. Identify three different data-mining experiments you would like to try, and explain which fields in which tables would have to be analyzed.
5. Do some original research and find two examples of data mining. Summarize each example and then write about what the two examples have in common.
6. Conduct some independent research on the process of business intelligence. Using at least two scholarly or practitioner sources, write a two-page paper giving examples of how business intelligence is used.
7. Use the Internet to research two software tools or technologies focused on managing knowledge. One tool should be for personal use, and one for business/organizational use. Write a one-page comparison explaining what each tool does, key features, who would use it, and how it facilitates knowledge management. Reflect on how the personal and organizational tools differ in their knowledge management approaches.
8. Install a simple personal DBMS like OpenOffice Base and design a basic database to store information on books, music, or movies. Focus on key fields and data types.

9. Search public data repositories and find 3 datasets of interest. Explain how basic data analysis could provide insights.
10. Interview 2 peers about databases they use and how data is valuable to them. Summarize key learnings in a paragraph.
11. Research a widely used database platform. Explain the key capabilities and a simple use case in 2-3 sentences.
12. Draw an entity relationship diagram for a basic scenario like university enrollment with 5-6 entities.
13. Find an article discussing an ethics case about personal data. Summarize the key issue and perspective in a paragraph.
14. Take a spreadsheet containing duplicated student data and restructure it into a simple, normalized database format.
15. Import a public dataset into a spreadsheet. Make basic charts and graphs to visualize and summarize top-level trends.

CHAPTER OVERVIEW

5: Networking and Communication

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Understand how multiple networks are used in everyday life.
- Define how topologies and devices are connected in a small to medium-sized business network.
- Understand the basic characteristics of a network that supports communication in a small to medium-sized business.
- Describe trends in networking that will affect the use of networks in small to medium-sized businesses.

Today's computing and smart devices are expected to be always-connected devices to support the way we learn, communicate, do business, work, and play, in any place, on any devices, and at any time. In this chapter, we review the history of networking, how the Internet works, and the use of multiple networks in organizations today.

5.1: Introduction

How often do you check Snapchat or Instagram? Multiple times an hour? How about streaming music on Spotify or Apple Music? Binge-watching the latest shows on Netflix? Online shopping on Amazon? These are just some of the apps and services or businesses we use daily, and they are all made possible by the power of computer networks.

Without the ability to connect our devices and share data seamlessly worldwide, concepts like social media, on-demand entertainment, e-commerce, and remote work would not exist. Networks touch every facet of a person's life, from staying in touch with family and friends to ordering food delivery with the tap of a button to collaborate with co-workers globally.

In this chapter, we will explore the history of the Internet and its impact on the information systems that form the backbone of our social and commercial connections. We will also discuss the concepts, trends, and security measures that provide the basis for understanding the challenges faced by network professionals in designing, building, and maintaining modern networks.

5.2: A Brief History of the Internet

Table 5.2.1 is a timeline of a few key Internal milestones to show how fast the development of the internet and communication has come in such a short-term span from 1969 to 2022, a mere 60 years! Think of the impact on our personal and work, the job market, the economic nature of countries, etc. Imagine the daily activities you do today that are possible because of these milestones. How often have you used the email or browser app in the last 24 hours? These two apps are just one of the many key Internet milestones!

Key Internet Milestones 1969-2023

Year	**Internet Milestones**
1969	ARPANET created by the US Department of Defense as the first packet-switched network
1982	TCP/IP becomes the standard Internet protocol allowing internet
1983	Domain name system (DNS) introduced for naming websites
1989	AOL launched commercially providing Internet access to consumers
1991	First website created at CERN by Tim Berners-Lee, notable the hyperlink
1993	Mosaic, the first web browser, released by NCSA
1994	Netscape Navigator, the web browser, helped open the Internet to commercial activity and accelerate Internet adoption Amazon founded as one of the first major online retailers
1996	Hotmail launched as one of the first web-based email services
1997	Netflix introduced DVD rentals ordered online and delivered by mail
1999	Napster pioneered peer-to-peer file sharing over the Internet
2004	Facebook launched to bring social networking to the Internet
2007	Internet of Things (IoT) emerged with internet-connected consumer devices IPhone released and sparked mass mobile Internet adoption
2011	Global Internet users surpassed 2 billion
2016	Internet of Things devices overtook the global population
2020	Next-generation networks emerged, including the 5G rollout and the launch of space-based global satellite internet
2022	SpaceX's Starlink and Amazon's Project Kuiper launch satellites for space-based global internet coverage.

Table 5.2.1 Key Internet Milestones 1996-2023 (CC-BY, by Ly-Huong Pham)

5.2.1: In the Beginning: ARPANET

The origins of the Internet trace back to the Cold War era in the late 1950s. After the Soviet Union launched Sputnik, the US created the Advanced Research Projects Agency (ARPA) to gain technological advantage. Out of ARPA, which later became DARPA, the concept of a decentralized computer network was born. In 1969, the company Bolt, Beranek, and Newman (BBN) won the contract to develop this network for ARPA. That year, the ARPANET was created as the first prototype of the Internet. It connected four university research computers in California and Utah.

Fun Fact

Do you know who the first Internet users were?

They were University of California, Los Angeles (UCLA), Stanford Research Institute (SRI) in Menlo Park, California, University of California, Santa Barbara (UCSB), and University of Utah in Salt Lake City. In 1969, the ARPANET connected one computer at each of these four locations in the first trial of the network.

UCLA, Stanford, and UCSB were in California, while the University of Utah represented another region in the western US. The goal was to demonstrate that computers in different geographies could communicate in real time over the ARPANET, which paved the way for the Internet as we know it today.

5.2.2: The Internet and the World Wide Web

Over the 1970s, ARPANET expanded to connect more organizations. Different organizations were connected to different networks. This led to a problem: the networks could not talk to each other. Each network used its own proprietary language or protocol to send information back and forth. This problem was solved using the transmission control protocol/Internet protocol (TCP/IP). TCP/IP quickly became the standard protocol and allowed networks to communicate with each other. We first got the term Internet from this breakthrough, which means "an interconnected network of networks."

Definition: Communication Protocol

A communication protocol is a system of rules that allows two or more devices to connect, exchange information, and communicate successfully. The protocol defines how data should be formatted, transmitted, received, and processed by the devices on a network. Some key Internet protocols are TCP/IP, HTTP, FTP, SMTP, and POP3. Protocols provide a common language that enables different hardware and software to connect.

Fun Fact: The term "Internet"

We first got the term Internet from the TCP/IP breakthrough, which means "an interconnected network of networks."

Through the 1980s, more government and academic institutions connected to the rapidly growing Internet, mainly utilizing it for email. Using the Internet in these early days was not easy. To access information on another server, you had to know how to type in the commands necessary to access it and know the name of that device. That all changed in 1990 when Tim Berners-Lee introduced his World Wide Web project, which provided an easy way to navigate the Internet through the use of linked text (hypertext). The release of the first web browser Mosaic in 1993 popularized the graphical web. By 1994, the web browser Netscape Navigator helped open the Internet to commercial activity and accelerated Internet adoption. The web browser rapidly improved the user experience beyond the text-based Internet of the 1980s.

By late 1990s and 2000s, mobile and wireless Internet further advanced connectivity among users and devices. Everyone can get online wirelessly via WiFi hotspots. Smartphones brought Internet into the palm of billions of people. Popular mobile apps such as WhatsApp, Instagram made for an almost 24/7 connected lifestyle. Wireless broadband, 3G and then 4G LTE allowed rapid growth of video, social media, and other bandwidth-hungry applications on mobile devices. The evolution to an always-on mobile Internet has profoundly impacted how people learn, play, and work. We will discuss this in more detail wireless technologies in a later section.

Table 5.2.2 shows the growth in internet users globally. According to the International Telecommunications Union (ITU, 2023), the world population reaches 8 billion, about 66% or 5.3 billion people worldwide are using the internet, leaving 2.7 billion people still offline.

Global Internet Users 2005 to 2023

Internet Users	2005	2010	2015	2020	2021	2022	2023
World Population (US Census, 2023)	6.55 billion	6.94 billion	7.35 billion	7.76 billion	7.84 billion	7.90 billion	7.98 billion
Internet Users Worldwide (ITU, 2023)	16%	29%	40%	59%	62%	64%	67%

Table 5.2.2 Global Internet Users 2005 to 2023 (CC-BY-NC, by Ly-Huong Pham)

Exercise - 5.2.1

Email or the web browser, which is the "Killer" App for the Internet?

Answer

When the personal computer was created, it was a great little toy for technology hobbyists and armchair programmers. As soon as the spreadsheet was invented, businesses took notice, and the rest is history. The spreadsheet was the killer app for the personal computer: people bought PCs to run spreadsheets.

Then came the browser that gives the world wide web (www) and email that allows us to connect with each other. They both made a profound impact on the speed of Internet adoption. Email came before the www and browser were invented. Email was the killer app for the Internet and remains a critical app today for both personal and business use.

The browsers made navigating the Internet easier and posting images, articles, etc. Social networks, such as Facebook, and Instagram, usher in Web 2.0 with new business and personal collaboration forms. Web 2.0 gives much more control to consumers to voice their opinions about their experience and changes the nature of how marketers communicate with consumers. These apps and widespread internet adoption have driven explosive growth for information systems globally.

Sidebar: The Internet and the World Wide Web Are Not the Same Things

Many times, the terms "Internet" and "World Wide Web," or even just "the web," are used interchangeably. However, they are not the same thing at all!

The Internet is an interconnected network of networks. Many services run across the Internet: electronic mail, voice and video, file transfers, and, yes, the World Wide Web. The World Wide Web is simply one piece of the Internet. It is made up of web servers with HTML pages being viewed on devices with web browsers.

5.2.3: References

ITU estimate of global population using the internet. Retrieved August 15, 2023, from ITU.int

Roberts, Lawrence G., *The Evolution of Packet Switching, (1978, November)*. Retrieved on September 6, 2020, from www.ismlab.usf.edu/dcom/Ch10_Roberts_EvolutionPacketSwitching_IEEE_1978.pdf

United States Census Bureau, 2023. Retrieved August 15, 2023, from www.census.gov

5.3: Concepts - Networking and Communication

In order for communication to take place, networks rely on a combination of various standard rules and technologies that work together. To understanding of how networks operate, it is necessary to explore some essential concepts and terminology. By doing so, you will be able to identify the components that make up a network, how they are connected and interact, and the services networks provide. Gaining a thorough understanding of these fundamental components will lay a strong foundation for the world of networking.

This chapter contains many technical terms and acronyms due to the nature of the topic of Networking even though the author has kept out the technical details that are unsuitable for the general non-computer science audience.

Sidebar: An Internet Vocabulary Lesson

Understanding networking communication can be simple if you learn the key terms, which will enable you to converse about the Internet.

- **Packet**: The fundamental unit of data transmitted over the Internet. When a device intends to send a message to another device (for example, your PC sends a request to YouTube to open a video), it breaks the message down into smaller pieces, called packets. Each packet has the sender's address, the destination address, a sequence number, and a piece of the overall message to be sent.
- **Hub**: A simple network device connects other devices to the network and sends packets to all the devices connected to it.
- **Bridge**: A network device that connects two networks and only allows packets through that are needed.
- **Switch**: A network device that connects multiple devices and filters packets based on their destination within the connected devices.
- **Router**: A device that receives and analyzes packets and then routes them towards their destination. In some cases, a router will send a packet to another router; it will send it directly to its destination in other cases.
- **IP Address**: Every device that communicates on the Internet, whether it be a personal computer, a tablet, a smartphone, or anything else, is assigned a unique identifying number called an IP (Internet Protocol) address. Historically, the IP-address standard used has been IPv4 (version 4), which has the format of four numbers between 0 and 255 separated by a period. For example, the domain Saylor.org has an IP address of 107.23.196.166. The IPv4 standard has a limit of 4,294,967,296 possible addresses. As the use of the Internet has proliferated, the number of IP addresses needed has grown to the point where IPv4 addresses will be exhausted. This has led to the new IPv6 standard, which is currently being phased in. The IPv6 standard is formatted as eight groups of four hexadecimal digits, such as 2001:0db8:85a3:0042:1000:8a2e:0370:7334. The IPv6 standard has a limit of 3.4×1038 possible addresses. For more detail about the new IPv6 standard, see this Wikipedia article.
- **Domain name**: If you had to try to remember the IP address of every web server you wanted to access, the Internet would not be nearly as easy to use. A domain name is a human-friendly name for a device on the Internet. These names generally consist of a descriptive text followed by the top-level domain (TLD). For example, Wikipedia's domain name is Wikipedia.org; Wikipedia describes the organization, and .org is the top-level domain. In this case, the .org TLD is designed for nonprofit organizations. Other well-known TLDs include .com , .net , and .gov . For a complete list and description of domain names, see this Wikipedia article.
- **DNS**: DNS stands for "domain name system," which acts as the directory on the Internet. A DNS server is queried when a request to access a device with a domain name is given. It returns the IP address of the device requested, allowing for proper routing.
- **Packet-switching**: When a packet is sent from one device out over the Internet, it does not follow a straight path to its destination. Instead, it is passed from one router to another across the Internet until it reaches its destination. In fact, sometimes, two packets from the same message will take different routes! Sometimes, packets will arrive at their destination out of order. When this happens, the receiving device restores them to their proper order. For more details on packet switching, see this interactive web page.
- **Protocol**: In computer networking, a protocol is the set of rules that allow two (or more) devices to exchange information back and forth across the network.

5.3.1: Introduction

Communication is almost as vital to us as air, water, food, and shelter, ranking just below our need to sustain life itself.

Today, networking systems have enabled people to connect from anywhere. Individuals can communicate and collaborate immediately with others. News ideas and discoveries are shared with the world in seconds. People can indeed interface and play with others without the physical barriers of seas and landmasses from wherever they locate.

How long can you go without the Internet and associated networks? What would be the impact of having no Internet on your learning, communicating, and collaborating with others, just to name a few?

Networks Support the Way We Learn

Networks have changed how we learn in profound ways. Students can now take online courses from anywhere, allowing them to learn from top instructors around the world and giving students the flexibility of when they complete their work and meet the requirements. Digital learning resources like video tutorials and simulations augment course materials. Learners can collaborate through messaging, video conferences, and shared online documents. For today's students, networks remove geographic barriers and are integral to how today's students approach education.

Networks Support the Way We Communicate

Figure 5.3.1.1: Social media, Digitization, Faces image. Image by Gerd Altmann from Pixabay is licensed CC BY NC

Networks have revolutionized communication and collaboration. Here are some of the key ways:

Social Media

Platforms like Facebook, Instagram, X (Twitter), TikTok, and Snapchat dominate the social lives of most students, allowing you to instantly connect with friends, classmates, family, colleagues, employers, businesses, influencers, celebrities and public figures across the globe. These sites and apps are designed for sharing photos, videos, messages, and other user-generated content. From chatting privately to broadcasting to the world, social media enables continuous digital interaction.

Collaboration Tools

Tools like Slack, Microsoft Teams, Google Workspace, Discord, and Zoom have become essential for collaboration at school and work. You can chat one-on-one or in groups, video conference, co-author documents, share screens, assign tasks, and work together in real-time from anywhere. These tools enable seamless teamwork on group projects and remote work. Wikis like Wikipedia demonstrate the power of crowdsourced content creation.

Wikis

Wikipedia, the free online encyclopedia, is a prime example of a publicly editable wiki. This revolutionary concept allows anyone to contribute and edit articles, facilitating content creation by subject matter experts and passionate amateurs. Businesses often use private wikis on their corporate networks for internal documentation, knowledge management, and collaboration.

Networks Support the Way We Work

Networks are essential to almost every aspect of work today: communication, collaboration, operations, transactions, remote access, and more.

Relying on computer networks and the internet, the workplace of today depends heavily on information technologies, The communication tools to support communication and collaboration mentioned earlier apply equally to businesses to allow sharing of data, and collaboration among teams and external partners seamlessly. Video conferences enhance inclusivity by integrating remote teams together besides saving travel costs. Remote and hybrid work models would not be possible without the networks and the Internet. Email and instant messaging have revolutionized business communication for rapid coordination. Online commerce relies on secure business networks for payment. Reliable access, speed, and security have become critical success factors for an organization.

Networks Support the Way We Play

Networks have expanded new ways for us to have fun, and make friends from anywhere in the world.

Online multiplayer gaming allows friends to play allows friends to play the same game together in real-time from different locations over the internet. Media streaming services like Spotify, Netflix, and YouTube provide on-demand access to music, movies, and more. Social media lets fans follow their favorite players, celebrities, and influencers in real-time. Dedicated online communities form around particular games, TV shows, hobbies, sports teams, and pop culture, allowing users to share their passion. Without smartphones and mobile networks, we could not consume content anywhere, anytime.

Technology Then and Now

Envision a world without the Internet. No more Google, YouTube, texting, Facebook, Wikipedia, web-based gaming, Netflix, iTunes, and simple access to current data. No more social media, staying away from lines by shopping on the web, or rapidly looking into telephone numbers and guide headings to different areas at the snap of a finger. It's astonishing to think how much networks have transformed communication, information access, and our daily lives in just the past 10-20 years. Compare the technologies used in the early 2000s to today - from simple text messaging to entire social media worlds, from slow dial-up Internet to video streaming, from basic websites to immersive apps and games.

No Boundaries

Advances in network technologies have made geographic distances and physical limitations far less significant. People can now collaborate and share ideas without the barriers of location or time zones.

Sidebar: Cisco Inc.

Cisco is a global technology leader that designs, manufactures, and sells networking hardware, software, services and other technologies that power the Internet and corporate networks.

Figure $5.3.1.2$ Registered trademark of Cisco Systems, Inc.

Cisco Systems has been a major player in shaping modern communication and commerce through their influence on networking and internet infrastructure. Some key ways Cisco has made an impact:

- Cisco routers and switches have powered the growth of the Internet since its commercialization in the 1990s, helping route trillions of packets globally each day.
- Cisco advocated open standards and interoperability early on, helping the Internet avoid fragmentation. This promoted competition and innovation.
- Cisco acquired dozens of companies that created new product capabilities, business opportunities, and even entire industries like enterprise videoconferencing.
- Cisco certified over 2 million networking professionals globally through its Networking Academy, building the talent base for operating complex networks.
- Cisco anticipated major trends like unified communications, smart grid technologies, telepresence, 5G, and the Internet of Things - introducing new products, partnerships, and acquisitions to lead each wave.
- Cisco's leadership in networking spilled over into adjacent opportunities in cybersecurity, cloud, collaboration tools, services, and more as connectivity became integral to technology.

Without its infrastructure and solutions, global teams, global outsourcing, online commerce, and the yper-connect edworld, just to name a few, would not be possible.

5.3.2: Providing Resources in a Network

Networks of Many Sizes

Networks are the foundation enabling access and communication. Home networks allow families to share resources like printers and files. They also enable remote work access to a corporate network. Small office and home office networks do the same for entrepreneurs and remote employees.

For businesses, office networks increase productivity and efficiency. They connect employees to tools, resources, and information needed to collaborate and do their jobs effectively. Networks also link office locations for company-wide communication.

Companies rely on their corporate network to connect all of their devices and allow employees to:

- Stay connected to the Internet to complete their work.
- Have the ability to send and receive data fast.
- Can send small and large quantities of data globally via any device connected to the internet.

Whether at home, school, or work, networks bring people, devices, and systems together to share resources, collaborate, and exchange information.

Clients and Servers

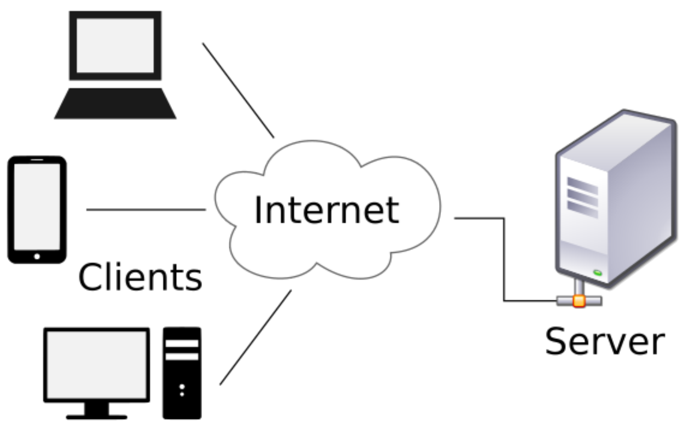


Figure 5.3.2.1: Client Server Model. (GNU Lesser General Public License ; Gnome-fs-client: David VignoniGnome-fs-server.svg: David Vignoni derivative work: Calimo, LGPL <http://www.gnu.org/licenses/lgpl.html>, via Wikimedia Commons)

All PCs associated with a network are named hosts. Hosts are also called end devices.

Servers are PCs with programming that empowers them to give data, like emails or website pages, to other network devices called clients. Each assistance requires separate server programming. For instance, a server requires web server programming to give web administration functions to the network. A PC with server programming can offer types of assistance at the same time to one or numerous customers. Furthermore, a solitary PC can run numerous sorts of server programming. It might be vital for one PC to go about as a document server, a web server, and an email server in a home or private company.

Clients are PCs with programming introduced that empowers them to ask for and show the server's data. A case of client programming is an internet browser similar to Chrome or Firefox. A solitary PC can likewise run different kinds of custom programming. For instance, a client can browse email and view a site page while texting and tuning in to Internet radio.

Peer-to-Peer

Client and server programming ordinarily run on discrete PCs, yet it is also feasible for one PC to simultaneously complete the two jobs. In private companies and homes, hosts work as servers or clients on the network. This sort of system is known as a shared network. An example would be several users connected to the same printer from their individual devices.

5.3.3: LANs, WANs, and the Internet

Overview of Network Components

The link between the sender and the receiver can be as simple as a single cable connection between these two devices or more sophisticated as a set of switches and routers between them.

Figure 5.3.3.1: Lan-wan Networks. Image by Stuart Gray is licensed CC BY-SA

The network framework contains three classes of network segments:

- Devices
- Media
- Services

Devices and media are the network's physical components or equipment. Equipment includes, a PC, switch, remote passageway, or the cabling used to associate the devices.

The administration of a network involves managing various essential network applications that people use in their daily lives, such as email and web management functions. These applications use procedures to facilitate the movement of messages through the network. Although procedures may seem inconspicuous, they are critical to the operation of networks.

End Devices

An end device is the source or destination of a message transmitted over the network. Each end device is identified by an IP address and a physical address. Both addresses are needed to communicate over a network. IP addresses are unique logical IP addresses that are assigned to every device within a network. If a device moves from one network to another, then the IP address has to be modified.

Physical addresses, also known as MAC (Media Access Control) addresses, are unique addresses assigned by the device manufacturers. These addresses are permanently burned into the hardware.

Intermediary Network Devices

Some devices act as intermediaries between devices. They are called delegated devices. These delegate devices give availability and guarantee that information streams over the network.

Routers utilize the destination end device address, related to data about the network interconnections, to decide how messages should take through the network.

Network Media

A medium called network media carries the act of transport data. The medium gives the channel over which the message makes a trip from source to destination.

Present-day organizations basically utilize three sorts of media to interconnect devices and give the pathway over which information can be transmitted.

These media are:

- Metallic wires within cables (Copper) - information is encoded into electrical driving forces.
- Glass or plastic fibers (fiber optic cable) - information is encoded as beats of light.
- Wireless transmission - information is encoded utilizing frequencies from the electromagnetic range.

Various sorts of network media have various highlights and advantages. Not all network media have similar qualities, nor are they all appropriate for the same purpose.

Figure 5.3.3.2 Network Cables. Image by blickpixel from Pixabay is licensed CC BY SA

Figure 5.3.3.3 Fiber Optic Cable. Image by blickpixel from Pixabay is licensed CC BY SA

Bluetooth

Bluetooth wireless technology enables devices to communicate over short distances without cables. It creates personal area networks (PANs) to link devices like smartphones, headsets, speakers, PCs, and cars. For example, Bluetooth allows you to stream music from your phone to wireless headphones, connect a printer to a personal computer, or connect a wireless keyboard and mouse to a computer.

Figure 5.3.3.4 Bluetooth combo wordmark 2011. Image by House is licensed under Public Domain

First created in 1994, Bluetooth has become the standard for wirelessly connecting peripheral devices. Key features like low power usage, wireless range up to 30 feet, and a widely adopted protocol make Bluetooth well-suited for these device pairing scenarios.

5.3.4: Network Representations

To draw a diagram of a network, symbols are utilized by network professionals to represent the different devices and connections which make up a network.

A diagram gives a simple method to see how devices in a huge network are associated. This kind of "picture" of a network is known as a topology diagram. The capacity to perceive the legitimate portrayals of the physical systems administration segments is basic to have the option to imagine the association and activity of a network.

Notwithstanding these portrayals, particular phrasing is utilized while discussing how every one of these devices and media interfaces with one another. Significant terms to recall are:

- **Network Interface Card**: A NIC or LAN connector gives the physical association with the PC or opposite end device's network. The media that are associating the PC to the network administration device plug legitimately into the NIC.
- **Physical Port**: A connector or outlet on a network administration device where the media is associated with an end device or another network administration device.
- **Interface**: Specialized ports on a network administration device that associate with singular networks. Since switches are utilized to interconnect networks, the ports on a network allude to network interfaces.

Topology Diagrams

Understanding topology diagrams are required for anybody working with a network. They give a visual guide of how the network is associated.

There are two sorts of Topology diagrams:

- Physical topology and Logical topology diagrams. The physical topology diagrams identify the physical location of intermediary devices and cable installation.
- The Logical topology diagrams identify devices, addressing schemes, and ports.

With physical topology, it is quite self-explanatory. It is how they are interconnected with cables and wires physically. The logical topology is how connected devices are seen to the user.

There are three common network topologies being used, discussed below.

Star Network:

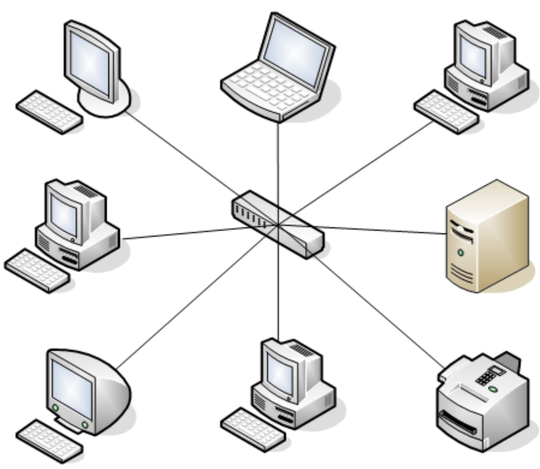


Figure 5.3.4.1: Star Topology used in a network. (2023, February 3) by Umapathy, via Wikipedia, is licensed CC BY-SA 3.0

The Star Network is one of the most common network topologies. It is a spoke-hub implement, meaning every node (devices, computers) is connected to a century hub. The hub acts as the mean to transmit messages. Twisted pair cable and optical fiber cables are commonly used to connect them.

One obvious advantage is if one node goes down, it does not affect other connections. A disadvantage is that the central hub is vulnerable since it is a single point of failure for the network. If the hub goes down, all nodes cannot transmit messages anymore.

Many home networks use the star topology to connect the devices in a home through a router (or hub).

Bus Network

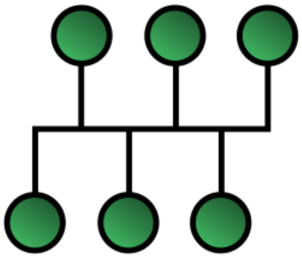


Figure 5.3.4.2 Bus network. (2022, December 13). In *Wikipedia*. Public Domain

The Bus Network uses a common backbone as a shared communication medium to connect all devices. It is an easy topology to set up since it only requires one backbone cable. However, if the backbone cable fails, the entire network stops working. It is best to use it to support a limited of devices.

Mesh Network

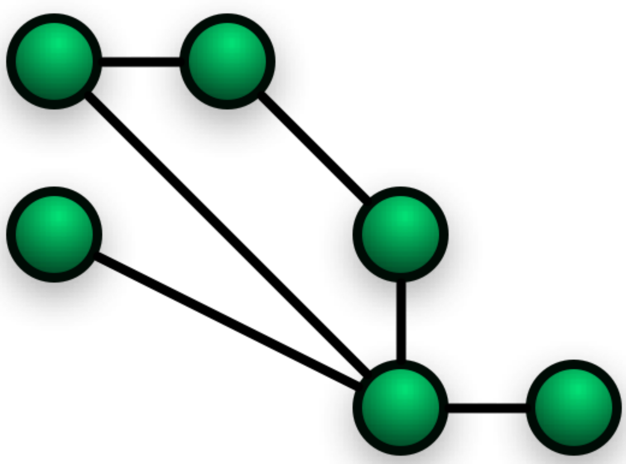


Figure 5.3.4.3 Illustration of a *partially connected mesh* network. A fully connected mesh network is where each node is connected to every other node in the network.. (2023, January 2). In *Wikipedia*. Public Domain

A Mesh Network is a local area network (LAN) topology where each node can connect directly to many other nodes and work together to transmit data. A full mesh is when every node connects to every other nodes. A partial mesh is when some nodes are connected indirectly through other nodes.

One advantage is the Mesh Network can be self-healed. It means that the network can still operate even when a node breaks down since the remaining nodes will find another efficient way to transmit data. It is preferred by organizations that want to have a reliable network.

Hybrid networks

Hybrid networks make use of the combination of the three networks above. For example, a Tree Topology integrates multiple star topologies.

Types of Networks

Networks foundations can vary regarding:

- Size of the territory secured
- Number of users connected
- Number and kinds of administrations accessible
- Territory of obligation

One key attribute to differentiate between different types is the size of the area it can serve.

Network Types and Areas Covered

Network Types	Size of the territory
A Personal Area Network (PAN)	Connect devices close to one person (e.g., pairing Bluetooth headphones to a smartphone creates a PAN between those two devices
A Local Area Network (LAN) Wireless LAN (WLAN)	connects users and devices within a small area (e.g., an office or a home)
A Metropolitan Area Network (MAN)	connects users and their devices in an area that spans a campus or city
A Wide Area Network (WAN)	connects users and devices across large geographic regions (i.e., many states and countries)

We will discuss the two most common networks: LAN and WAN.

Local Area Networks

Figure $5.3.4.1$ illustrates a Local Area Network (LAN) connecting devices together in a small geographical area such as a home, office, or campus. Some key features of LANs:

- LANs interconnect end-user devices like computers, printers, servers, and other equipment primarily within a single location.
- LANs are typically administered and managed by a single person or department, giving them control over security policies and access privileges on the network.
- LANs provide high-speed, reliable connectivity and throughput between connected devices, usually over Ethernet cabling or WiFi connections.

Definition: Term

Ethernet is a widely used technology for local area networking. It specifies standards for connecting devices over copper cabling and sending data between them as electrical signals.

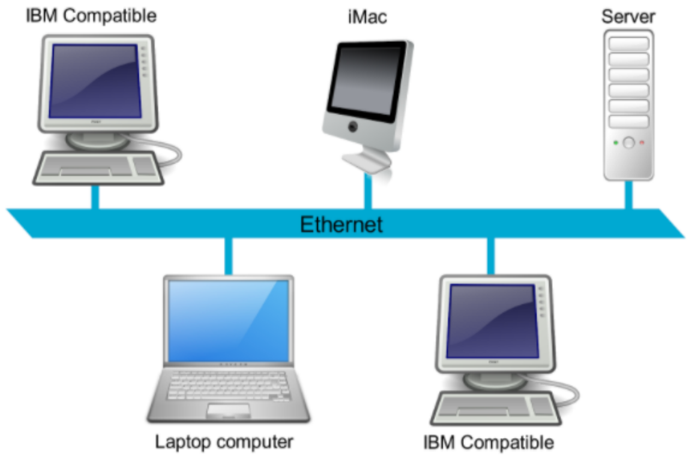


Figure 5.3.4.1: Local Area Network. Image by T.seppelt, derivative work from File:Ethernet.png, including content of the Open Clip Art Library, by © 2007 Nuno Pinheiro & David Vignoni & David Miller & Johann Ollivier Lapeyre & Kenneth Wimer & Riccardo Iaconelli / KDE / LGPL 3, User:George Shuklin and the Tango Project! is licensed CC BY-SA

Wide Area Networks

Wide Area Networks (WANs) are a network foundation that traverses a wide topographical zone. WANs are ordinarily overseen by specialist organizations (SP) or Internet Service Providers (ISP).

Key features of WANs include:

- WANs interconnect LANs over wide geological zones, for example, between urban areas, states, territories, nations, or the mainland.
- Numerous specialist organizations typically manage WANs.
- WANs ordinarily give more slow speed joins between LANs

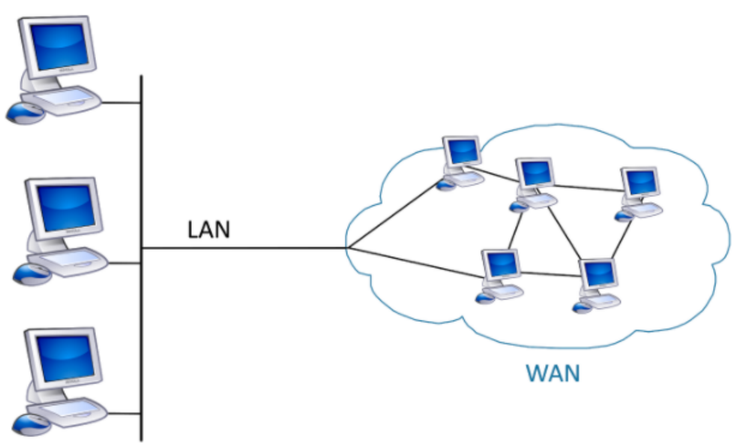


Figure 5.3.4.2 *LAN WAN scheme.Image by Gateway_firewall.svg: Harald Mühlböck derivative work: Ggia is licensed CC BY-SA*

5.3.5: The Internet, Intranets, and Extranets

The Internet

The Internet is a global network that allows computers and devices worldwide to connect and share information seamlessly. Have you ever wondered how your smartphone can function the way it does? Have you ever wondered how to search for information on the web and find it within milliseconds? The world's largest implementation of client/server computing and internetworking is the Internet. When you access a website, your device connects through a series of networking equipment that routes your request to the correct destination server. Complex technologies make this process fast and seamless – you type in a web address and the site appears in your browser within seconds! Advanced systems work behind the scenes to handle website address retrieval, connection establishment, data sending and receiving, and page display on your screen (Example $5.3.5.1$).

No individual or group doesn't own the Internet. Guaranteeing compelling correspondence over this various framework requires the use of steady and generally perceived advances and norms, just as the collaboration of many network organization offices. Some associations have been produced to keep up the structure and normalization of Internet conventions and procedures. These organizations incorporate the Internet Engineering Task Force (IETF), Internet Corporation for Assigned Names and Numbers (ICANN), and the Internet Architecture Board (IAB), in addition to numerous others.

The world's largest implementation of client/server computing and internetworking is the Internet. The internet is also a system, which is the most extensive public way of communicating.

Example $5.3.5.1$

What happens behind the scene when you type a URL, www.wikipedia.com, in the browser and press enter?

Solution

Once you press Enter, the browser then checks the cache for a DNS record to find the website's corresponding IP address. If the URL is not in the cache, ISP's (Internet Service Provider) DNS server starts a DNS query to find the server's IP address that hosts the website.

The browser then starts a TCP/IP connection with the server.

Then, the browser sends an HTTP request to the webserver.

After that, the server handles the request and sends an HTTP response back. www.Wikipedia.org has an IP address, that specific IP address could be searched starting with http:// on a browser/ The DNS contains a list of URLs, including their IP addresses. The DNS (Domain Name System) changes domain names into IP addresses. The domain name is the English name, and that has 32-bits which are unique and numeric to that English name. That is why people only need to specify the domain name.

Finally, the browser shows the HTML content.

Intranets and Extranets

Intranet and extranet are two types of private networks that share some similarities but also have distinct differences.

An **intranet** is a private network that belongs to a single organization. It enables employees to access internal information and applications within the organization. For example, a company's intranet may host HR policies, internal communications, project management tools, and other resources accessible only by employees.

An **extranet** is also a private network that extends to external users to selectively allow access for external users such as partners, vendors, or clients. For example,

- A delivery company uses extranet to give clients to see where their packages are in real time, same as their employees.
- An emergency clinic uses extranet to give a booking system to specialists so they can make arrangements for their patients.

The main difference between intranets and extranets is that extranets allow authorized external access to selected resources and tools.

5.3.6: Internet Connections

Internet Access Technologies

There is a wide range of approaches to associate users and associations with the Internet.

Home clients (telecommuters) and workplaces regularly require an association with an Internet Service Provider (ISP) to access the Internet. Association alternatives change significantly among ISP and topographical areas. Notwithstanding, companies incorporate a broadband link, broadband computerized endorser line (DSL), remote WANs, and versatile administrations.

Associations commonly expect access to other corporate destinations and the Internet. Quick associations are required to help business administrations, including IP telephones, video conferencing, and server farm stockpiling.

Business-class interconnections are normally given by specialist organizations (SP). Well-known business-class administrations incorporate business DSL, rented lines, and Metro Ethernet.

Home and Small Office Internet Connections

Regular connection choices for little office and home office users:

- **Cable**: Typically offered by digital TV specialist co-ops, the Internet information signal is carried on a similar link that conveys satellite TV. It gives a high transmission capacity, consistently on, association with the Internet.
- **DSL**: Digital Subscriber Lines gives a high data transmission, consistently on, association with the Internet. DSL runs over a phone line when all is said in done, small office and home office clients associate utilizing Asymmetrical DSL (ADSL), which implies that the download speed is quicker than the upload speed.
- **Cellular**: For a Cell phone network to connect, it utilizes cellular internet access. Any place you can get a phone signal, you can get cell Internet. Execution will be restricted by the telephone's abilities and the cell tower to which it is associated. The fourth generation of broadband cellular network technology is 4G, which most people are familiar with because it is on smartphones. 5G is upcoming and expected to be faster than and succeed 4G by 100 times, which will have the ability to transmit a lot more data at a much faster pace than 4G.
- **Satellite**: Internet access through satellite is a genuine advantage in those territories that would somehow or another have no Internet availability by any means. Satellite dishes require a clear line of sight to the satellite.
- **Dial-up telephone**: An economical choice that utilizes any telephone line and a modem. The low transmission capacity supported by a dial-up modem association is normally not adequate for huge information transfer. However, it is still a valuable choice wherever other options are not available such as in rural areas or remote locations where phones are the only means of communication.

Fiber optic links are increasingly becoming more available to home and small businesses. This empowers an ISP to give higher data transmission speeds and bolster more administrations, for example, Internet, telephone, and TV.

Business Internet Connections

Corporate connection choices contrast from home client alternatives. Organizations may require higher transmission capacity, devoted data transmission, and oversaw administrations. Business connection options include:

- **Dedicated Leased Line**: Leased lines are really saved circuits inside the specialist organization's system that interface geologically isolated workplaces for private voice or potentially information organizing. The circuits are ordinarily leased at a month-to-month or yearly rate. They can be costly.
- **Ethernet WAN**: Ethernet WANs broaden LAN access into the WAN. Ethernet is a LAN innovation you will find out about in a later section. The advantages of Ethernet are currently being reached out into the WAN.
- **DSL**: Business DSL is accessible in different organizations. A famous decision is Symmetric Digital Subscriber Lines (SDSL) which is like the purchaser rendition of DSL. However, it gives transfers and downloads at similar paces.
- **Satellite**: Like small office and home office clients, satellite help can give an association when a wired arrangement isn't accessible.

The decision of connection shifts relying upon topographical area and specialist organization accessibility.

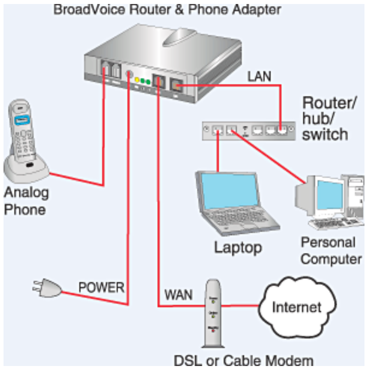


Figure 5.3.6.1 Devices connection. Image by BroadVoice is licensed CC BY 1.0

Sidebar: More Details About Wireless Communications

Wireless communications must adhere to regulations by the Federal Communications Commission (FCC)Links to an external site. to avoid interference with other wireless transmission.

Radio antennas on Sandia Peak, New Mexico, by Maveric149m, Attribution-Share Alike 3.0 Unported license

Wireless LAN (WLAN) channels that support IEEE 802.11 protocols and equipment are typically sold under the trademark Wi-Fi. IEEE 802.11 protocols are the standard that allows two or more devices to communicate with each other without a wired connection.

Some standard frequency ranges:

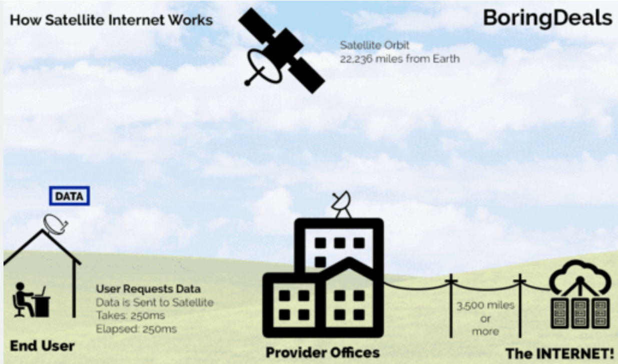
Radio waves

The intended use is for a short distance, and devices transmit data in the frequency range of 30Khz to 300 GHz. Examples include cordless phones, radio stations, Bluetooth devices, garage openers, and GPS.

Microwave

Satellite Internet access is Internet access provided through communication satellites. Communication satellites(CS) are used for television, telephone, radio, internet, and government. A CS, known as Geostationary Satellite, comprises a transmitter of high-frequency radio waves in space, operates about 22,300 miles above the equator, and a receiver at different places, known as a satellite station on earth, as illustrated below. Nothing obstructs the radio waves between the transmitter and the receiver, or they must be in the line of sight.

How does satellite communication work?



Animated Image of How Satellite Internet Works, by Vgeek15, Attribution-Share Alike 3.0 Unported license

What is Geostationary Satellite Transmission?

Satellites orbit above the earth and need to follow regulations of where they can circle to avoid interference with each other. Here is a brief description:

LEO (Low-Earth-Orbit) – 100 to 1000 miles out

- Used for wireless e-mail, special mobile telephones, pagers, spying, videoconferencing

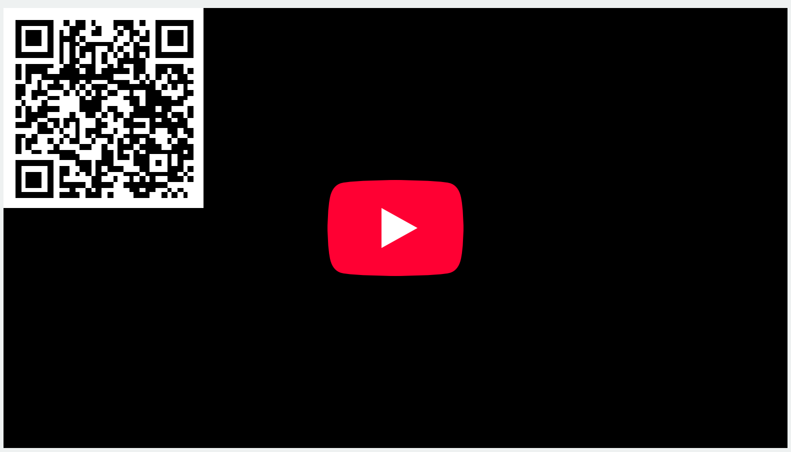
MEO (Middle-Earth-Orbit) – 1000 to 22,300 miles

- Used for GPS (global positioning systems) and government

GEO (Geosynchronous-Earth-Orbit) – 22,300 miles

- Consistently over the same position on earth (and constantly over the equator)
- Used for weather, television, government operations

Watch a 1-min video explanation by Neil deGrasse Tyson describing the different types and their capabilities.



Fun fact: StarlinksLinks from SpaceX is an example of a satellite internet constellation. It provides Internet access to several countries. It consisted of over 3000 small satellites in low Earth Orbit (LEO).

Infrared frequencies

The signals are invisible to the human eye and operate from 300 GHz to 400 GHz. Examples include remote controls, electrical heaters, security systems, and pointing devices. While the waves are not visible to human eyes, the heating effect of infrared light can blind and cause burns to people.

- **5.9: Internet Connections** by Ly-Huong T. Pham, Tejal Desai-Naik, Laurie Hammond, & Wael Abdeljabbar is licensed CC BY 3.0.

5.3.7: The Network as a Platform Converged Networks

Traditional Separate Networks

Consider a school that was built thirty years ago. A few study halls were cabled for the data network, phone network, and video network for TVs in those days and these different networks couldn't speak with one another.

Each network utilized various innovations to convey signals. Each network had its own arrangement of rules and measures to guarantee successful connections.

The Converging Network

Today, the separate data, phone, and video networks are converging. In contrast to traditional networks, merged networks are equipped for conveying information, voice, and video between a wide range of sorts of devices over a similar system foundation.

This network foundation utilizes a similar arrangement of rules, understandings, and implementation standards.

5.3.8: Reliable Network

Network Architecture

Networks must help a wide scope of applications and services, just as they work over a wide range of cables and devices, making up the physical infrastructure. In this specific situation, the term network architecture alludes to the technologies that help the foundation and the programmed services and rules, or protocols, that move data over the network.

As networks advance, there are four fundamental qualities that the underlying architectures need to deliver to meet users' needs:

- Fault Tolerance
- Scalability
- Quality of Service (QoS)
- Security

Fault Tolerance

The Internet is expected to be consistently accessible to many clients who depend on it. This requires a network architecture that is designed to tolerate flaws. A fault-tolerant network restrains the effect of failure, with the goal that the least number of devices are impacted. It is additionally designed to permit speedy recuperation when such a failure happens. These networks rely upon various ways between the source and destination of a message. If a path fails, the messages can be instantly sent over an alternate link. Having numerous ways to reach a destination is known as redundancy.

One way dependable networks give repetition is by executing a packet-switched network. Packet switching parts traffic into packets that are steered over a shared network.

> **Definition: Packet Switching**
>
> Packet switching is the process of breaking down data into small blocks called packets that are sent independently over a shared network. Each packet contains addressing information that allows it to be routed to the proper destination, where the packets are reassembled into the original data.

For example, a solitary message, an email, or a video stream, is broken into multiple message blocks, called packets. Every packet has a record of the addressing information for the source and destination of the message. Packet are routed independently and reassembled at the destination. This allows for efficient use of shared networks.

Scalability

A scalable network can grow rapidly to help new users and applications without affecting the service's performance being conveyed to existing users.

Another network can be effortlessly added to a current network. Furthermore, networks are versatile because the designers observe acknowledged protocols and standards. This permits software and hardware vendors to improve items and administrations without stressing over structuring another arrangement of rules for working inside the network.

Quality of Service

Ensuring quality of service (QoS) is becoming increasingly important in modern networks. With new applications, such as live video and voice transmissions, users expect a higher standard of service delivery. No one likes to watch a video that keeps pausing or buffering. As data, voice, and video content continue to merge onto the same network, QoS is an essential tool to manage congestion and ensure reliable delivery of content to all users.

Congestion happens when the interest for bandwidth surpasses the amount that is accessible. Network bandwidth is estimated in the number of bits transmitted in a solitary second or bits per second (bps). When synchronous correspondences have endeavored over the network, the interest for network bandwidth can surpass its accessibility, causing a network congestion.

When traffic volume is more than what can be shipped over the network, devices queue or hold the packets in memory until assets become accessible to transmit them.

With a QoS strategy, the router can deal with data and voice traffic progression, offering priority to voice communications if the network encounters congestion.

Security

Vital individual and business resources are the network infrastructure, services, and data on network-attached devices.

Two kinds of network security worries must be addressed: network infrastructure and information security.

Ensuring the physical security of devices providing network connectivity and preventing unauthorized access to management software.

Information security ensures the protection of data transmitted over networks and stored on attached devices. To accomplish the objectives of network security, there are three essential requirements:

- Confidentiality: Data secrecy implies that the planned and approved recipients can access and read information.
- Integrity: Data honesty affirms that the data has not been adjusted in transmission, from root to goal.
- Availability- Data accessibility implies confirmation of timely and solid access to information services for approved users.

We will delve deeper into the three requirements in a subsequent chapter.

5.4: Trends, the Changing Environment

Existing Trends Keep Getting Stronger

As new technologies and end-user devices come to market, businesses and purchasers must keep on acclimating to this ever-evolving condition. The job of the network is changing to empower the connections between individuals, devices, and data. There are a few new networking trends that will impact organizations and purchasers. A portion of the top trends include:

- Bring Your Own Device (BYOD)
- Video communications
- Online collaboration
- Cloud computing

Bring Your Own Device

The idea of any device, to any content, in any way, is a significant worldwide trend that requires huge changes to the manner in which devices are utilized. This trend is known as Bring Your Own Device (BYOD).

BYOD is about end users having the opportunity to utilize individual tools in order to get to data and convey over a business or campus network. With the development of customer devices and the related drop in cost, representatives and students can be relied upon to have probably the most progressive computing and networking tools for individual use. These individual tools can be laptops, e-books, tablets, cell phones, and tablets. These can be devices bought by the organization or school, bought by the individual, or both.

BYOD implies any device, with any possession, utilized anyplace. For instance, previously, a student who expected to get access to the campus network or the Internet needed to utilize one of the school's PCs. These devices were commonly constrained and seen as instruments just for work done in the study hall or in the library. Expanded availability through portable and remote access to the campus network gives students a lot of adaptability and opens doors of learning for the student.

Online Collaboration

People want to connect with the network, for access to data applications, in addition to team up with each other.

Collaboration is characterized as "the demonstration of working with another or others on a joint venture." Collaboration tools, give representatives, students, instructors, clients, and accomplices an approach to quickly interface, connect, and accomplish their targets.

For businesses, collaboration is a basic and vital need that associations are utilizing to sustain their competition. Collaboration is additionally a need in training. Students need to work together to help each other in learning, to create group abilities utilized in the workplace, and to cooperate on group based projects.

Video Communication

Another trend in networking that is basic to the correspondence and joint effort exertion is video. Video is being utilized for interchanges, cooperation, and amusement. Video calls can be made to and from anyplace with an Internet connection.

Figure 5.4.1: A video call showing a group of people on the screen. Image by photo by Chris Montgomery on Unsplash is licensed under CC BY SA 2.0

Video conferencing is an incredible asset for speaking with others from a distance, both locally and worldwide. Video is turning into a basic necessity for successful joint effort as associations stretch out across geographic and social limits.

Cloud Computing

Cloud computing is another worldwide trend changing how we access and store information. Cloud computing permits us to store individual files, even backup our whole hard disk drive on servers over the Internet. Applications, for example, word processing, and photograph editing, can be accessed utilizing the Cloud.

When it comes to businesses, cloud computing expands IT's capabilities without requiring interest in new infrastructure, preparing new faculty, or permitting new software. These services are accessible on request and conveyed economically to any device on the planet without trading off security or capacity.

There are four essential Clouds: Public Clouds, Private Clouds, Hybrid Clouds, and Custom Clouds.

Cloud computing is conceivable because of data centers. A data center is an office used to house PC frameworks and related parts. A data center can consume one room of a building, at least one story, or the whole thing. Data centers are commonly over the top expensive to manufacture and keep up. Therefore, just huge associations utilize secretly fabricated data centers to house their information and offer users assistance. Smaller associations that can't afford to keep up their own private data center can lessen the general expense of ownership by renting server and capacity services from a bigger data center association in the Cloud.

Emerging Technologies and Trends

5G Cellular

The next generation of wireless networks that promises faster speeds, lower latency, and ability to connect massive numbers of devices to expand Internet of Things (IoT) capabilities. 5G delivers theoretical peak speeds up to 20 Gbps, compared to 1 Gbps peak for 4G. Latency is reduced to 1-10 milliseconds vs. 40-70 ms on 4G. For example:

- 5G enables smart factories to wirelessly connect production systems, robots, automated guided vehicles (AGVs), sensors, and workers with ultra-reliable, high-bandwidth connections. This allows real-time control, automation, and data collection to optimize manufacturing. Failures can be rapidly detected and addressed to avoid costly downtime. Supply chain transparency is improved via interconnected systems.
- 5G enables much faster video and music streaming. You could download an HD movie in seconds versus minutes on 4G. Lag and buffering will be greatly reduced when gaming online or video chatting with friends. 5G also makes innovative technologies like virtual reality and augmented reality mobile experiences possible, which just aren't feasible on 4G networks. The high speeds and responsiveness open new doors for entertainment.

WiFi 6

Provides faster wireless network speeds, increased WiFi capacity, and improved performance when many devices are connected compared to typical existing WiFi. WiFi 6 supports maximum theoretical speeds up to 9.6 Gbps, compared to 3.5 Gbps for 802.11ac of today's technology. It allows for better supports bandwidth-intensive uses. For example:

- Enables retail stores to support digital signage, customer WiFi, IoT sensors, and point-of-sale systems without congestion.

- Improves streaming and large downloads in dense dorm or apartment buildings.

Space Networks

Satellite constellations in Low Earth Orbit (LEO) provide high-speed broadband Internet globally, including to rural and remote areas. Offers an alternative to ground-based infrastructure. For example:

- Allows businesses to access cloud services and operate anywhere without geographic restrictions.
- Provides Internet access to students from rural areas for distance learning.

Fun Fact: Is SpaceX's Starlink the first Low Earth Orbit (LEO) satellite network?

Before SpaceX, there are other companies that provided LEO satellite networks include Iridum, Globalstart, Orbcomm, Teledesic and are still active today. So, Starlink is not the first successful low Earth orbit satellite network, but it is probably the most ambitious and successful consumer LEO constellation to date.

SpaceX's Starlink is building a network of thousands of small low Earth orbit satellites to provide global high-speed broadband Internet access. With base stations connected to the Internet backbone, the satellites can relay signals to user terminals on the ground. Starlink offers speeds comparable to fiber optic networks and very low latency. It aims to provide affordable Internet to remote and rural areas unserved by traditional infrastructure. Some key facts include:

- Over 3,000 satellites launched since 2019 with plans for over 40,000
- Provides Internet globally including polar regions
- User terminal has motorized dish for uninterrupted signal
- Speeds of 100-200 Mbps download with 20-40 ms latency reported
- Leverages SpaceX's Falcon 9 rockets and in-house satellite production

Edge Computing

Processes data closer to where it is generated by users and IoT devices. Reduces latency, bandwidth use, and reliance on central cloud computing resources. For example:

- Enables real-time data analytics and quick decision -making by analyzing data on-site.
- Lowers lag time for online gaming by handling data processing closer to the user.

Quantum Networks

A quantum network utilizes unique quantum effects like superposition (particles can exist in multiple states at once) and entanglement (intrinsically linked particles share properties) to transmit information. It leverages quantum effects to enable capabilities not achievable with classical networks:

- Quantum encryption - Information is encoded in quantum states which cannot be copied or read without detection, providing virtually unbreakable security.
- Quantum teleportation - The quantum state of a particle can be transmitted to another distant particle without physically moving the first particle.
- Quantum computing - Multiple quantum processors can be connected over a quantum network to distribute computational tasks.

While still in the early research stages, quantum networks aim to provide ultra-secure communication, distributed quantum computing capabilities, and quantum-enhanced sensing and metrology. Their development is driven by recent advances in quantum computers, processors, and quantum memory. Significant technical challenges remain before wide deployment. For example:

- Will protect confidential corporate data from being hacked or accessed without authorization.
- May enable truly private online activities resistant to tracking or disclosure.

Ambient Computing

Integrates connectivity and intelligence into our everyday environments and activities. Computing fades into the background. For example:

- Enables smart conference rooms that can schedule meetings, set lighting and temperature, and start video calls automatically based on meeting details and participants.

- Allows a smart home to track activities and habits to customize and automate routines, like turning on the coffee maker when you wake up.

AI and Machine Learning

Automates network management, optimizes performance, identifies anomalies, predicts faults, and improves security through data insights. For example:

- AI can predictively detect network issues and misconfigurations before they cause outages.
- AI could tailor network priorities and bandwidth allocations based on individual usage patterns and devices.

Internet of Things

Billions of internet-connected smart devices, sensors, and everyday objects share data for automation and analytics. They will put more demands on networks. For example:

- Retailers implement IoT sensors, digital price tags, security cameras, robots, and more that rely on connectivity.
- Students could leverage smart devices like digital assistants, smart appliances, wearables, and lighting for convenience.

Virtual/Augmented Reality

Fully immersive digital experiences requiring high-speed, low latency networks to support advanced graphics, simulations, etc. For example:

- Replace in-person training with virtual reality simulations for serious situations like fire drills.
- Experience concerts, travel destinations or historic events through augmented reality.

Fun Factoid: What is Meta doing with Virtual/Augmented Reality?

Meta (formerly Facebook) sees a huge opportunity to transform gaming, work, education, shopping, and entertainment. It wants to lead the consumer virtual reality market with its Oculus VR headsets and Meta Quest platform. The Oculus Rift and Quest headsets immerse users in VR gaming, entertainment, and social interactions.

For augmented reality, Meta is developing smart glasses and other wearables to overlay digital information onto the real world. Prototypes include the Meta Frames glasses and Project Nazare concept. For more details, review this article Mark Zuckerberg's augmented reality from the Verge (2022.)

Meta also wants to extend beyond hardware to building 3D environments, digital commerce capabilities, avatar systems, and other software foundations to power virtual worlds to bring them to mainstream. Even though Meta is considered a leader for now, the market is still evolving and there are other competitors with deep pockets such as Apple, Google, Microsoft, Sony, among others. We are watching in real time the completion among these tech giants!

Reference:

Heath, A., *Mark Zuckerberg's augmented reality* (2022). Retrieved September 1, 2023 from The Verge.

5.4.1: Home Technology Trends

Networking trends are not just influencing how we work or study, and they are also changing pretty much every part of the home.

The most up-to-date home trends incorporate smart home technology, a technology that is coordinated into habitual appliances, permitting them to interconnect with different devices, making them progressively 'smart' or automated. For instance, envision having the option to set up a dish and spot it in the broiler for cooking before going out for the afternoon. Envision if the stove knew of the dish it was cooking and was associated with your 'schedule of occasions' so it could figure out what time you will be eating and change start times and length of cooking accordingly. It could even modify cooking times and temperatures dependent on plan changes. Furthermore, a cell phone or tablet connection permits the user to interface with the broiler straightforwardly to make any ideal changes. When the dish is "accessible," the stove sends an alarm message to a predefined end-user device that the dish is done and warming.

This situation isn't long-off. Actually, smart home technology is being created for all rooms inside a house. It will turn out to be a greater degree of reality as home networking and high-speed Internet technology become progressively far-reaching. New home networking technologies are being grown day by day to meet these sorts of developing technology needs.

Powerline Networking

Powerline networking is a rising trend for home networking that utilizes existing electrical wiring to connect devices.

The idea of "no new wires" signifies the capacity to connect a device to the network where there is an electrical outlet. This spares the expense of introducing data cables and with no extra expense to the electrical bill. Utilizing similar wiring that conveys power, powerline networking sends information by sending data on specific frequencies.

Utilizing a standard powerline adapter, devices can connect with the LAN any place there is an electrical outlet. Powerline networking is beneficial when wireless access points can't be utilized or can't arrive at all to the devices in the home. Powerline networking isn't intended to fill in for committed cabling in data networks. But it is an alternative when data network cables or wireless communications are not a reasonable choice.

Wireless Broadband

Connecting with the Internet is indispensable in savvy home innovation. DSL and cable are basic advances used to connect homes and private companies to the Internet. Nonetheless, remote access might be another choice in numerous regions.

Another remote answer for home and independent companies is wireless broadband. This uses the equivalent cell innovation to get to the Internet with an advanced mobile phone or tablet. A radio wire is introduced outside the house, giving either remote or wired availability for home devices. In numerous zones, home wireless broadband is contending legitimately with DSL and cable services.

Wireless Internet Service Provider (WISP)

Wireless Internet Service Provider (WISP) is an ISP that connects subscribers of an assigned passage or problem area utilizing comparable remote innovations found in-home wireless local area networks (WLANs). WISPs are all the more usually found in provincial situations where DSL or cable services are not accessible.

Though a different transmission tower might be introduced for the antenna, the antenna is usually connected to a current raised structure, such as a water tower or a radio pinnacle. A little dish or radio wire is introduced on the subscriber's rooftop in the WISP transmitter's scope. The subscriber's entrance unit is associated with the wired system inside the home. From the home user's point of view, the arrangement isn't vastly different from DSL or cable service. The principle distinction is that the home's connection to the ISP is remote rather than a physical link.

Note

Why Doesn't My Cell Phone Work When I Travel Abroad?

As mobile phone technologies have evolved, providers in different countries have chosen different communication standards for their mobile phone networks. In the US, both of the two competing standards exist GSM (used by AT&T and T-Mobile) and CDMA (used by the other major carriers). Each standard has its pros and cons, but the bottom line is that phones using one standard cannot easily switch to the other.

In the US, this is not a big deal because mobile networks exist to support both standards. But when you travel to other countries, you will find that most of them use GSM networks, with the one big exception being Japan, which has standardized on CDMA. It is possible for a mobile phone using one type of network to switch to the other type of network by switching out the SIM card, which controls your access to the mobile network. However, this will not work in all cases. If you are traveling abroad, it is always best to consult with your mobile provider to determine the best way to access a mobile network.

5.5: Network Security

5.5.1: Security Threats

Network security is an indispensable piece of computer networking today, whether or not the network is restricted to a home domain with a solitary connection with the Internet or as extensive as an organization with many users. The network security that is executed must consider the environment, just as the system's devices and prerequisites. It must have the option to keep the data secure while considering the quality of service anticipated from the network.

Ensuring a network is secure includes technologies, protocols, devices, tools, and techniques to keep data secure and moderate threat vectors. Threat vectors might be external or internal. Numerous external network security threats today are spread over the Internet.

We will discuss more details in the next chapter. Here is a list of most widely recognized external threats to networks include:

- Viruses, worms, and Trojan horses- malignant programming and subjective code running on a client device
- Spyware and adware - software installed on a user device that covertly gathers data about the user Zero-day attacks, likewise called zero-hour attacks - an assault that happens on a principal day that a defenselessness gets known
- Hacker attacks- an assault by an educated individual to user devices or network assets
- Denial of service attacks- assaults intended to slow or crash applications and procedures on a network device
- Data interception and theft - an assault to catch private data from an association's network
- Identity theft- an assault to take the login qualifications of a user to get to private information

It is similarly critical to think about internal threats. There have been numerous examinations showing that the most well-known data breaches happen due to the network's internal users. This can be credited to lost or taken devices, inadvertent abuse by workers, and in the business condition, even malignant representatives. With the advancing BYOD systems, corporate information is considerably more powerless. Accordingly, it is critical to address both outside and interior security dangers when building up a security strategy.

5.5.2: Security Solutions

No single arrangement can shield the network from the many threats that exist. Consequently, security ought to be implemented in various layers, utilizing more than one security arrangement. If one part of the security fails to recognize and shield the network, others will stand.

A home network security execution is typically rather essential. It is commonly executed on the interfacing end devices, just as connected with the Internet, and can even depend on contracted services from the ISP.

Conversely, the network security implementation for a corporate network, for the most part, comprises numerous segments incorporated with the network to screen and channel traffic.

In a perfect world, all segments cooperate, which limits maintenance and improves overall security.

Network security parts for a home or little office network should at least incorporate the following:

- Antivirus and antispyware: These are utilized to shield end devices from getting contaminated with vindictive software.
- Firewall filtering: This is utilized to prevent unapproved access to the network. This may incorporate a host-based firewall system that is actualized to forestall unapproved access to the end device or an essential separating service on the home router to keep unapproved access from the outside world into the network.

Bigger networks and corporate networks frequently have other security necessities:

- Dedicated firewall systems: These are utilized to develop further firewall abilities that can channel a lot of traffic with greater granularity.
- Access control lists (ACL): These are utilized to channel access and traffic sending additionally.
- Intrusion prevention systems (IPS): These are utilized to distinguish quick-spreading dangers, for example, zero-day or zero-hour assaults.
- Virtual Private Networks (VPN): These are utilized to give secure access to telecommuters.

Networks security necessities must consider the network condition, just like the different applications and processing prerequisites. Both home situations and organizations must have the option to secure their data yet consider the quality of service that is anticipated from every innovation. Furthermore, the security arrangement executed must be versatile to the developing and changing trends of the network.

The study of network security dangers and relief strategies begins with a concise understanding of the underlying switching and routing infrastructure utilized to organize network services.

5.6: Summary

5.6.1: Networks: Past, Present, and Future

Our hyperconnected world relies on the invisible fabric of networks that took root decades ago. In the 1960s, early networks like ARPANET emerged, pioneering the decentralized computing concept. This evolved into the global Internet through innovations like TCP/IP, email, and the World Wide Web.

Today, networks enable how we learn, work, collaborate, and get entertained - from video chat and streaming to remote collaboration and multiplayer gaming. The future promises faster 5G networks, global satellite-based Internet, and virtual worlds accessed through augmented reality.

However, there are always two sides. Our dependence on networks also introduces risks like hacking, identity theft, and denial-of-service attacks. Being mindful of threats is essential as networks continue advancing.

By understanding the pivotal role of networking across time, we can reap the benefits while being realistic about potential downsides. Networks provide opportunities to connect worldwide but also carry responsibilities to use them wisely. This knowledge prepares us to thrive in our modern, digitally networked world.

Technical Terms

ACL - Access Control List, method of controlling access to a network resource.

ARPANET - Early prototype network created by ARPA in 1969, gave rise to the Internet.

BSSID - Basic Service Set Identifier, identifies a wireless router.

BYOD - Bring Your Own Device, using personal devices at work.

CAN - Campus Area Network connecting buildings on a campus.

CSMA/CD - Carrier Sense Multiple Access/Collision Detection, Ethernet protocol.

DHCP - Dynamic Host Configuration Protocol, auto-assigns IP addresses.

DNS - Domain Name System, resolves domain names to IP addresses.

FTP - File Transfer Protocol, transfers files over the network.

HTTP - Hypertext Transfer Protocol, enables web browsing.

IP - Internet Protocol, method for addressing devices over a network.

IPS - Intrusion Prevention System, monitors traffic and blocks threats.

LAN - Local Area Network connecting nearby devices.

MAN - Metropolitan Area Network spanning a city/campus.

NAT - Network Address Translation, maps internal IPs to a public IP address.

OAuth - Open Authorization, allows third-party access validation.

PAN - Personal Area Network for wearable and portable devices.

QoS - Quality of Service, mechanisms for optimizing bandwidth usage.

SAN - Storage Area Network for data storage devices.

SMTP - Simple Mail Transfer Protocol, handles email.

SSID - Service Set Identifier, identifies a wireless network.

TCP/IP - Fundamental network protocol suite enabling internetworking.

VPN - Virtual Private Network for secure remote access.

WAN - Wide Area Network spanning long distances.

5.7: Study Questions

? Study Question 5.7.1

Identify the first four locations hooked up to the ARPANET.

Answer

The first four locations connected on the ARPANET were UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah.

? Study Question 5.7.2

Describe the difference between the Internet and the World Wide Web

Answer

The Internet is the physical interconnected network of networks. The World Wide Web is the system of hyperlinked documents accessed via the Internet.

? Study Question 5.7.3

List three of your favorite Web 2.0 apps or websites.

Answer

Web 2.0 apps: Facebook, Instagram, X (Twitter,) YouTube

? Study Question 5.7.4

Identify the killer app for the Internet.

Answer

Email was the killer app that drove early Internet adoption.

? Study Question 5.7.5

List a few home internet connections.

Answer

Home connections: cable, DSL, cellular, satellite.

? Study Question 5.7.6

List a few business internet connections.

Answer

Business connections: leased lines, Metro Ethernet, business DSL, satellite.

? Study Question 5.7.7

Describe the difference between a LAN and a WAN.

Answer

A LAN connects local devices; a WAN connects devices across a large geographic area.

? Study Question 5.7.8

Describe the difference between an intranet and an extranet.

Answer

An intranet is private to an organization; an extranet extends outside the organization to partners/vendors.

? Study Question 5.7.9

Explain what a network topology is.

Answer

Network topology illustrates how network components connect physically and logically.

? Study Question 5.7.10

What was the original motivation and purpose behind the creation of ARPANET?

Answer

The ARPANET was created by ARPA in the late 1960s to connect computers at academic and military research sites in order to share information and computing resources. It was meant to improve communication and decentralize the computer network to avoid outages.

? Study Question 5.7.11

What major innovation allowed different networks running different protocols to communicate?

Answer

The development of TCP/IP as a common standard protocol enabled internetworking between disparate networks. This led to the interconnected network of networks that became the Internet.

Study Question 5.7.12

What was the impact of the release of web browsers like Mosaic and Netscape Navigator?

Answer

Web browsers provided a graphical interface to the Internet, expanding its appeal beyond researchers to the general public. This drove rapid adoption in the mid 1990s.

Exercise 5.7.13

What are the differences between Internet connections for homes vs. businesses?

Answer

Home connections like cable and DSL focus on affordability and simplicity. Businesses require higher bandwidth, dedicated connectivity, managed services, and support for multiple sites.

Exercise 5.7.14

How does powerline networking work?

Answer

Powerline networking uses a building's existing electrical wiring to carry data signals, avoiding the need to install separate network cables.

Exercise 5.7.15

What is a key benefit of mesh topology compared to bus topology?

Answer

Mesh networks have built-in redundancy so they can still operate if one node fails. Bus networks have a single point of failure.

5.7.1: Exercises

1. Give an example of each of the following terms:

- Wireless LAN (WLAN)
- Wide-area network (WAN)
- Intranet
- Local-area network (LAN)
- Extranet

2. Give an example for each of the following:

- Fault tolerance
- Scalability
- Quality of service (QoS)

- Security

3. Create a google account at - google.com, create a new document using google docs, share the document with others and explore document sharing via your google account.
4. Find the IP address of your computer. Explain the steps how you find it.
5. Identify your or your school's Internet service provider.
6. Pretend you are planning a trip to three foreign countries in the next month. Consult your wireless carrier to determine if your mobile phone would work properly in those countries. Identify if there are costs and other alternatives to have your phone work properly.

CHAPTER OVERVIEW

6: Information Systems Security

Learning Objectives

Upon completion of this chapter, you will be able to:

- Identify the information security triad
- Explain the motivations of the threat actors
- Define the potential impact of network security attacks
- Describe the functions of a Security Operations Center (SOC)
- Explain security policies

We discuss the information security triad of confidentiality, integrity, and availability. We will review different types of threats and associated costs for individuals, organizations, and nations. We will discuss different security tools and technologies, how security operation centers can secure organizations' resources and assets, and a primer on personal information security.

6.1: Introduction

As computers and other digital devices have become essential to business and commerce, they have also increasingly become high-value attack targets. For example, in 2017 credit bureau Equifax suffered a major breach compromising the personal information of over 140 million people, resulting in massive fines and loss of consumer trust (FTC, 2019). This example demonstrates why effective information security is critical for any organization. Data breaches, malware infections, and cyber attacks can have cascading negative consequences, including lost revenue, decreased customer trust, high recovery costs, and damage to brand reputation and market value.

For a company or an individual to use a computing device with confidence, they must first be assured that the device is not compromised in any way and that all communications will be secure. For example, individuals can fall victim to identity theft if their personal information is obtained by hackers. This chapter reviews the fundamental concepts of information systems security and discusses some of the measures that can be taken to mitigate security threats. The chapter begins with an overview focusing on how organizations can stay secure;several different measures that a company can take to protect its data, systems, and IT infrastructure. Technical details will be avoided, instead emphasizing real-world impacts and developing a culture and policies for good security governance. Finally, you will review a list of security precautions individuals can take to secure their computing environment.

6.1.1: References:

FTC (2019). Equifax to Pay $575 Million as Part of Settlement with FTC, CFPB, and States Related to 2017 Data Breach. Retrieved from **https://www.ftc.gov/news-events/press-releases/2019/07/equifax-pay-575-million-part-settlement-ftc-cfpb-states-related**

6.2: The Information Security Triad- Confidentiality, Integrity, Availability (CIA)

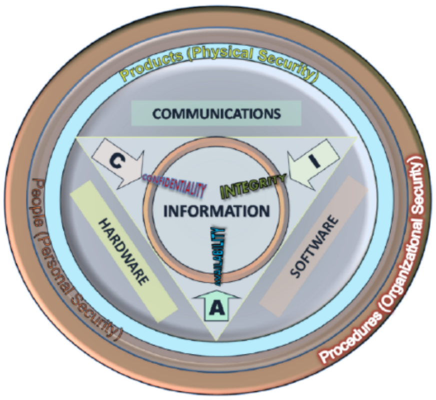


Figure 6.2.1: The Information Security triad: CIA. Image by John M. Kennedy T., is licensed under CC BY-SA

Confidentiality

Definition: Confidentiality

Confidentiality refers to restricting access to information only to authorized users.

Protecting information means you want to restrict access to those who are allowed to see it. This is sometimes referred to as NTK, Need to Know, and everyone else should be disallowed from learning anything about its contents. This is the essence of confidentiality. For example, federal law requires that universities restrict access to private student information. Access to grade records should be limited to those who have authorized access. Companies must keep sensitive data like customer records, trade secrets, and financial information confidential. A breach of confidentiality occurs when unauthorized entities access restricted data - for example, through a hack or stolen laptop. Loss of confidentiality can harm reputation, erode trust, and violate data privacy laws.

Integrity

Definition: Integrity

Integrity means maintaining the accuracy and completeness of data over its lifecycle.

Integrity is the assurance that the information being accessed has not been altered and truly represents what is intended. Just as people with integrity mean what they say and can be trusted to represent the truth consistently, information integrity means information truly represents its intended meaning. Information can lose its integrity through malicious intent, such as when someone who is not authorized makes a change to misrepresent something intentionally. An example of this would be when a hacker is hired to go into the university's system and change a student's grade. Lack of integrity undermines business decisions, compliance, and analytics.

Integrity can also be lost unintentionally, such as when a computer power surge corrupts a file or someone authorized to make a change accidentally deletes a file or enters incorrect information.

Availability

> **Definition: Availability**
>
> Availability ensures information systems and data are accessible by authorized users when needed.

Information availability is the third part of the CIA triad. Availability means information can be accessed and modified by anyone authorized to do so in an appropriate time frame. Depending on the type of information, an appropriate timeframe can mean different things. For example, a stock trader needs information to be available immediately, while a salesperson may be happy to get sales numbers for the day in a report the next morning. Online retailers require their servers to be available twenty-four hours a day, seven days a week. Other companies may not suffer if their web servers are down for a few minutes once in a while. Companies require high availability for critical systems - like e-commerce sites, cloud platforms, and customer databases - to maintain operations. Lengthy downtime and unreachable systems can cripple productivity, revenue, and customer satisfaction.

You'll learn about who, what, and why of cyber-attacks in this chapter. Different people commit cybercrime for different purposes. Neglecting confidentiality, integrity or availability exposes companies to significant cybersecurity risks that can impact finances, reputation, and continuity. Wise investments in CIA safeguards deliver value by reducing business disruption, preserving trust, and avoiding high recovery costs. For example, investing in Security Operations Centers that are designed to fight cybercrime. Jobs in a Security Operations Center (SOC) can be obtained by earning certifications, seeking formal education, and using employment services to gain internship experience and job opportunities.

The Danger

In chapter 5, we discussed various security threats and possible solutions. Here are a few scenarios to illustrate how hackers trick users.

Hijacked People

Melanie stopped at her favorite coffee shop to grab her drink for the afternoon. She placed her order, paid the clerk, and waited to fulfill orders' backup while the baristas worked furiously. Melanie took her phone out, opened the wireless client, and linked to what she thought was the free wireless network for the coffee shop.

Sitting in the corner of the store, however, a hacker had just set up a free, wireless hotspot "rogue" posing as the wireless network of the coffee shop. The hacker hijacked her session when Melanie logged on to her bank's website and accessed her bank accounts. The same risk can also happen to a business at a larger scale. in 2018, over 150,000 payment cards were compromised in a point-of-sale breach at coffee chain Caribou Coffee, caused by hacking into their systems via unsecured WiFi networks at some store locations. This illustrates the cybercrime risks of public WiFi use without proper IT security precautions (CBS News, 2018)

Hijacked Companies

Jeremy, an employee of a large, publicly-held corporation's finance department, receives an email from his CEO with an enclosed file in Adobe's PDF format. The PDF regards earnings for the organization in the third quarter. Jeremy does not recall his department making the PDF. His interest is triggered, and he opens his attachment.

The same scenario occurs around the company as thousands of other workers are enticed to click on the PDF attachment successfully. As the PDF opens, ransomware is mounted on the workers' computers, including Jeremy's, and the process of storing and encrypting corporate data begins. The attackers' target is financial gain, as they keep the company's ransom data until they get paid. As with Jeremy's case, the consequences for opening an attachment in a spam mail or from an unfamiliar address could be disastrous. In 2017, shipping giant Maersk suffered a destructive cyber attack that disabled IT systems across its global operations for weeks. This disruption to critical business systems cost Maersk an estimated $300 million in lost revenues. (Reuters, 2017)

Targeted Nations

Some of today's malware is so sophisticated and expensive to create that security experts believe that it could be created only by a nation-state or group of nations. This malware can be designed to attack vulnerable infrastructures, such as the water network or electric grid.

This was the aim of the Stuxnet worm, infecting USB drives. The movie [World War 3.0 Zero Days] tells a story of a malicious computer worm called Stuxnet. Stuxnet has been developed to penetrate Programmable Logic Controllers (PLCs) from vendors-supported nuclear installations. The worm was transmitted into the PLCs from infected USB drives and ultimately damaged centrifuges at these nuclear installations. China's APT10 hacking group allegedly stole IP from managed IT service providers to access customer data from firms in aviation, biotech, and other industries. Victim companies lost competitiveness. (US Department of Justice, 2018)

Threat Actors

Threat actors include amateurs, hacktivists, organized crime groups, state-funded groups, and terrorist organizations. Threat actors are individuals or a group of individuals conducting cyber-attacks on another person or organization. Cyberattacks are intentional, malicious acts intended to harm another individual or organization. The major motivations behind cyberattacks are money, politics, competition, and hatred.

Known as script kiddies, amateurs have little or no skill. They often use existing tools or instructions to start attacks found on the Internet. Some are only curious, while others seek to show off their abilities by causing damage. While they use simple methods, the outcomes can often be catastrophic.

Hacktivists

A hacktivist can act independently or as a member of an organized group. Hacktivists are hackers who rage against many social and political ideas. Hacktivists openly demonstrate against organizations or governments by publishing articles and images, leaking classified information, and crippling web infrastructure through distributed denial of service (DDoS) attacks with illegal traffic. A denial of service (DoS) attack is one of the most powerful cyberattacks in which the attacker bombards the target with traffic requests that overwhelm the target server in an attempt to crash it. A distributed denial of service (DDoS) attack is a more sophisticated version of DoS in which a set of distributed computer systems attacks the target.

Financial Gain

The financial gain motivates much of the hacking activity that constantly threatens our security. Cyber Criminals are people who utilize technology for their own malicious intentions, such as stealing personal information to make a profit. Cybercriminals want access to our bank accounts, personal data, and everything else they can use for cash flow generation.

Trade Secrets and Global Politics

In the past few years, several reports have seen nation-states hacking other nations or intervening with internal policies. National states are also keen to use cyberspace for industrial spying. Intellectual property theft can give a country a considerable advantage in international trade.

Defending against the consequences of state-sponsored cyberespionage and cyber warfare will continue to be a priority for cybersecurity professionals.

How Secure is the Internet of Things

The Internet of Things (IoT) is rapidly expanding all around us. The internet of things is a network of physical objects that collect and share data over the internet. We're now beginning to enjoy the IoT rewards. There is a constant creation of new ways of using connected things. The IoT helps people link items so they can enhance their quality of life. Smart security systems, smart kitchen appliances, smartwatches, and smart heating systems are few examples of the IoT products available today.

For starters, many people now use connected wearable devices to monitor their fitness activities. How many devices do you currently own that link to the Internet or your home network?

How safe are those devices? For instance, who wrote the software to support the embedded hardware (aka firmware)? Has the programmer been paying attention to the security flaws? Are your home thermostats connected to the internet? Your Electronic Video Recorder (DVR)? When there are security bugs, can the firmware be patched in the system to fix the vulnerability? The new firmware will not update many computers on the Internet. For updating with patches, some older devices were not even developed. These two conditions put the users of such devices to face threats and security risks.

References

World War 3 Zero Days (Official Movie Site) - Own It on DVD or Digital HD. Retrieved September 6, 2020, from www.zerodaysfilm.com

Caribou Coffee President: Customer Data Exposed In Security Breach (2018). Retrieved September 10, 2023, from https://www.cbsnews.com/minnesota/news/caribou-coffee-president-customer-data-exposed-in-security-breach/

Reuters. (2017). Maersk says global IT breakdown caused by cyber attack. **https://www.reuters.com/article/us-cyber-attack-maersk-idUSKBN19I1NO**

US Department of Justice. (2018). Two Chinese Hackers Associated With the Ministry of State Security Charged with Global Computer Intrusion Campaigns Targeting Intellectual Property and Confidential Business Information. **https://www.justice.gov/opa/pr/two-chinese-hackers-associated-ministry-state-security-charged-global-computer-intrusion**

6.3: Tools for Information Security

To ensure the confidentiality, integrity, and availability of information, organizations can choose from various tools. Each of these tools can be utilized as a part of an overall information-security policy, which will be discussed in the next section.

Authentication

The most common way to identify people is through physical appearance, but how do we identify someone sitting behind a computer screen or at the ATM? Tools for authentication are used to ensure that the person accessing the information is, indeed, who they present themselves to be.

Authentication can be accomplished by identifying someone through one or more of three factors: something they know, something they have, or something they are. For example, the most common form of authentication today is the user ID and password. In this case, the authentication is done by confirming something that the user knows (their ID and password). But this form of authentication is easy to compromise (see sidebar), and stronger forms of authentication are sometimes needed. Identifying someone only by something they have, such as a key or a card, can also be problematic. When that identifying token is lost or stolen, the identity can be easily stolen. The final factor, something you are, is much harder to compromise. This factor identifies a user through physical characteristics, such as an eye-scan or fingerprint. Identifying someone through their physical characteristics is called biometrics.

A more secure way to authenticate a user is to do multi-factor authentication. Combining two or more of the factors listed above makes it much more difficult for someone to misrepresent themselves. An example of this would be the use of an RSA SecurID token. The RSA device is something you have and will generate a new access code every sixty seconds. To log in to an information resource using the RSA device, you combine something you know, a four-digit PIN, with the device's code. The only way to properly authenticate is by both knowing the code and having the RSA device.

Figure 6.3.1: An RSA SecurID SID800 token with USB connector. Image by Alexander Klink is licensed CC BY

Access Control

Once a user has been authenticated, the next step is to ensure that they can access the appropriate information resources. This is done through the use of access control. Access control determines which users are authorized to read, modify, add, and/or delete information. Several different access control models exist. Here we will discuss two: the access control list (ACL) and role-based access control (RBAC).

For each information resource that an organization wishes to manage, a list of users who have the ability to take specific actions can be created. This is an access control list or ACL. For each user, specific capabilities are assigned, such as reading, writing, deleting, or adding. Only users with those capabilities are allowed to perform those functions. If a user is not on the list, they have no ability even to know that the information resource exists.

ACLs are simple to understand and maintain. However, they have several drawbacks. The primary drawback is that each information resource is managed separately. If a security administrator wanted to add or remove a user to a large set of information resources, it would not be easy. And as the number of users and resources increases, ACLs become harder to maintain. This has led to an improved method of access control, called role-based access control, or RBAC. With RBAC, instead of giving specific users access rights to an information resource, users are assigned to roles, and then those roles are assigned access. This allows the administrators to manage users and roles separately, simplifying administration and, by extension, improving security.

Access Control List

User	Read	Write	Add	Delete
jsmith	x			
rlee	x			
knguyen	x	x	x	x
mroberts	x	x		
manderson	x	x		

Role-Based Access Control

Role	Read	Write	Add	Delete
Reader	x			
Editor	x	x		
Administrato	x	x	x	x

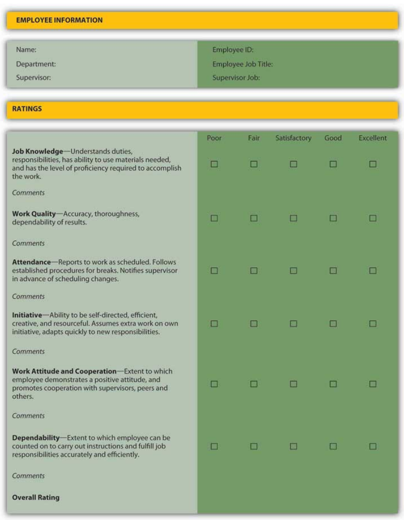
Role Assignments

User	Role
jsmith	Reader
rlee	Reader
knguyen	Admin
mroberts	Editor
manderson	Editor

Figure 6.3.2 Comparison of ACL and RBAC. Image by David Bourgeois is licensed CC BY 4.0

Encryption

An organization often needs to transmit information over the Internet or transfer it on external media such as a USB. In these cases, even with proper authentication and access control, an unauthorized person can access the data. Encryption is a process of encoding data upon its transmission or storage so that only authorized individuals can read it. This encoding is accomplished by a computer program, which encodes the plain text that needs to be transmitted; then, the recipient receives the ciphertext and decodes it (decryption). For this to work, the sender and receiver need to agree on the method of encoding so that both parties can communicate properly. Both parties share the encryption key, enabling them to encode and decode each other's messages. This is called symmetric key encryption. This type of encryption is problematic because the key is available in two different places.



EMPLOYEE INFORMATION

Name:
Department:
Supervisor:

Employee ID:
Employee Job Title:
Supervisor Job:

RATINGS

	Poor	Fair	Satisfactory	Good	Excellent
Job Knowledge—Understands duties, responsibilities, has ability to use materials needed, and has the level of proficiency required to accomplish the work. *Comments*	☐	☐	☐	☐	☐
Work Quality—Accuracy, thoroughness, dependability of results. *Comments*	☐	☐	☐	☐	☐
Attendance—Reports to work as scheduled. Follows established procedures for breaks. Notifies supervisor in advance of scheduling changes. *Comments*	☐	☐	☐	☐	☐
Initiative—Ability to be self-directed, efficient, creative, and resourceful. Assumes extra work on own initiative, adapts quickly to new responsibilities. *Comments*	☐	☐	☐	☐	☐
Work Attitude and Cooperation—Extent to which employee demonstrates a positive attitude, and promotes cooperation with supervisors, peers and others. *Comments*	☐	☐	☐	☐	☐
Dependability—Extent to which employee can be counted on to carry out instructions and fulfill job responsibilities accurately and efficiently. *Comments*	☐	☐	☐	☐	☐
Overall Rating					

Figure 6.3.3 Symmetric/private key encryption. Image by Phayzfaustyn is licensed CC0 1.0

An alternative to symmetric key encryption is public-key encryption. In public-key encryption, two keys are used: a public key and a private key. To send an encrypted message, you obtain the public key, encode the message, and send it. The recipient then uses the private key to decode it. The public key can be given to anyone who wishes to send the recipient a message. Each user needs one private key and one public key to secure messages. The private key is necessary to decrypt something sent with the public key.

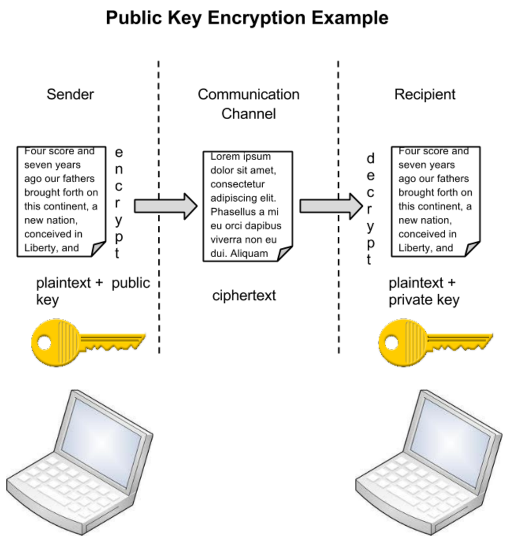


Figure 6.3.4 Public key encryption. Image by David Bourgeoi Ph.D. is licensed CC BY 4.0

Sidebar: Password Security

The security of a password depends on its strengths to guard against brute-force guesses. Strong passwords reduce overall breaches of security because it is harder for criminals to guess.

Password policies and technologies have evolved to combat security threats, from short to long passwords, from single-factor authentication to multi-factor authentications. Most companies now have specific requirements for users to create passwords and how they are authenticated.

Below are some of the more common policies that organizations should put in place.

- **Require complex passwords that make it hard to guess**. For example, a good password policy requires the use of a minimum of eight characters, and at least one upper-case letter, one special character, and one number.
- **Change passwords regularly**. Users must change their passwords regularly. Users should change their passwords every sixty to ninety days, ensuring that any passwords that might have been stolen or guessed will not be used against the company.
- **Train employees not to give away passwords**. One of the primary methods used to steal passwords is to figure them out by asking the users or administrators. Pretexting occurs when an attacker calls a helpdesk or security administrator and pretends to be a particular authorized user having trouble logging in. Then, by providing some personal information about the authorized user, the attacker convinces the security person to reset the password and tell him what it is. Another way that employees may be tricked into giving away passwords is through email phishing.
- **Train employees not to click on a link**. Phishing occurs when a user receives an email that looks as if it is from a trusted source, such as their bank or their employer. In the email, the user is asked to click a link and log in to a website that mimics the genuine website and enter their ID and password, which the attacker then captures.

Backups

Another essential tool for information security is a comprehensive backup plan for the entire organization. Not only should the data on the corporate servers be backed up, but individual computers used throughout the organization should also be backed up. A good backup plan should consist of several components.

- **A full understanding of the organizational information resources.** What information does the organization actually have? Where is it stored? Some data may be stored on the organization's servers, other data on users' hard drives, some in the cloud, and some on third-party sites. An organization should make a full inventory of all of the information that needs to be backed up and determine the best way to back it up.
- **Regular backups of all data**. The frequency of backups should be based on how important the data is to the company, combined with the company's ability to replace any data that is lost. Critical data should be backed up daily, while less critical data could be backed up weekly.
- **Offsite storage of backup data sets**. If all of the backup data is being stored in the same facility as the original copies of the data, then a single event, such as an earthquake, fire, or tornado, would take out both the original data and the backup! It is

essential that part of the backup plan is to store the data in an offsite location.
- **Test of data restoration**. Regularly, the backups should be put to the test by having some of the data restored. This will ensure that the process is working and will give the organization confidence in the backup plan.

Besides these considerations, organizations should also examine their operations to determine what effect downtime would have on their business. If their information technology were to be unavailable for any sustained period of time, how would it impact the business?

Additional concepts related to backup include the following:

- **Universal Power Supply (UPS)**. A UPS is a device that provides battery backup to critical components of the system, allowing them to stay online longer and/or allowing the IT staff to shut them down using proper procedures to prevent the data loss that might occur from a power failure.
- **Alternate or “hot” sites.** Some organizations choose to have an alternate site where their critical data replica is always kept up to date. When the primary site goes down, the alternate site is immediately brought online to experience little or no downtime.

As information has become a strategic asset, a whole industry has sprung up around the technologies necessary for implementing a proper backup strategy. A company can contract with a service provider to back up all of their data or purchase large amounts of online storage space and do it themselves. Most large businesses now use technologies such as storage area networks and archival systems.

Firewalls

Another method that an organization should use to increase security on its network is a firewall. A firewall can exist as hardware or software (or both). A hardware firewall is a device connected to the network and filters the packets based on a set of rules. A software firewall runs on the operating system and intercepts packets as they arrive at a computer. A firewall protects all company servers and computers by stopping packets from outside the organization’s network that does not meet a strict set of criteria. A firewall may also be configured to restrict the flow of packets leaving the organization. This may be done to eliminate the possibility of employees watching YouTube videos or using Facebook from a company computer.

Some organizations may choose to implement multiple firewalls as part of their network security configuration, creating one or more sections of their partially secured network. This segment of the network is referred to as a DMZ, borrowing the term demilitarized zone from the military. It is where an organization may place resources that need broader access but still need to be secured.

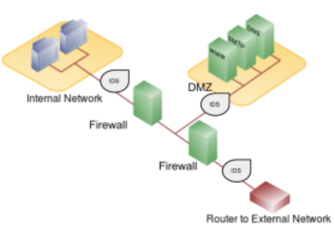


Figure 6.3.5 Network configuration with firewalls, IDS, and a DMZ. Image by [David Bourgeois](#) is licensed [CC BY 4.0](#)

Intrusion Detection Systems

Another device that can be placed on the network for security purposes is an intrusion detection system or IDS. An IDS does not add any additional security; instead, it provides the functionality to identify if the network is being attacked. An IDS can be configured to watch for specific types of activities and then alert security personnel if that activity occurs. An IDS also can log various types of traffic on the network for analysis later. An IDS is an essential part of any good security setup.

Physical Security

An organization can implement the best authentication scheme globally, develop the best access control, and install firewalls and intrusion prevention. Still, its security cannot be complete without the implementation of physical security. Physical security is the protection of the actual hardware and networking components that store and transmit information resources. To implement physical security, an organization must identify all of the vulnerable resources and ensure that these resources cannot be physically tampered with or stolen. These measures include the following.

- **Locked doors**: It may seem obvious, but all the security in the world is useless if an intruder can walk in and physically remove a computing device. High-value information assets should be secured in a location with limited access.
- **Physical intrusion detection**: High-value information assets should be monitored through the use of security cameras and other means to detect unauthorized access to the physical locations where they exist.
- **Secured equipment**: Devices should be locked down to prevent them from being stolen. One employee's hard drive could contain all of your customer information, so it must be secured.
- **Environmental monitoring**: An organization's servers and other high-value equipment should always be kept in a monitored room for temperature, humidity, and airflow. The risk of server failure rises when these factors go out of a specified range.
- **Employee training**: One of the most common ways thieves steal corporate information is to steal employee laptops while employees are traveling. Employees should be trained to secure their equipment whenever they are away from the office.

Security Policies

Besides the technical controls listed above, organizations also need to implement security policies as a form of administrative control. In fact, these policies should really be a starting point in developing an overall security plan. A good information-security policy lays out the guidelines for employee use of the information resources of the company. It provides the company recourse in the case that an employee violates a policy.

A security policy should be guided by the information security triad discussed above. It should lay out guidelines and processes for employees to follow to access all resources to maintain the three categories' integrity: confidentiality, integrity, and availability.

Policies require compliance and need to be enforceable; failure to comply with a policy will result in disciplinary action. SANS Institute's Information Security Policy Page (2020) lists many templates for different types of security policies. One example of a security policy is how remote access should be managed, which can be found here.

A security policy should also address any governmental or industry regulations that apply to the organization. For example, if the organization is a university, it must be aware of the Family Educational Rights and Privacy Act (FERPA), which restricts who has access to student information. Health care organizations are obligated to follow several regulations, such as the Health Insurance Portability and Accountability Act (HIPAA).

Mobile Security and Remote Work

Mobile devices like smartphones and laptops along with remote work capabilities introduce new security challenges for businesses. As mobile devices such as smartphones and tablets proliferate, organizations must be ready to address the unique security concerns that these devices use. One of the first questions an organization must consider is whether to allow mobile devices in the workplace.

Many employees already have these devices, so the question becomes: Should we allow employees to bring their own devices and use them as part of their employment activities? Or should we provide the devices to our employees? Creating a BYOD ("Bring Your Own Device") policy allows employees to integrate themselves more fully into their job and bring higher employee satisfaction and productivity. It may be virtually impossible to prevent employees from having their own smartphones or iPads in the workplace in many cases. If the organization provides the devices to its employees, it gains more control over the use of the devices, but it also exposes itself to the possibility of an administrative (and costly) mess.

Mobile devices can pose many unique security challenges to an organization. Probably one of the biggest concerns is the theft of intellectual property. It would be a straightforward process for an employee with malicious intent to connect a mobile device either to a computer via the USB port or wirelessly to the corporate network and download confidential data. It would also be easy to take a high-quality picture using a built-in camera secretly.

When an employee has permission to access and save company data on their device, a different security threat emerges: that device now becomes a target for thieves. Theft of mobile devices (in this case, including laptops) is one of the primary methods that data thieves use.

So, what can be done to secure mobile devices? It will start with a good policy regarding their use. Specific guidelines should include

- Mobile device management (MDM) software to configure security settings, encrypt data, remotely wipe lost devices, etc.
- Containerization to isolate and secure corporate data and apps separately from personal content.
- Multi-factor authentication and secure VPN for remote access.

- Policies requiring PIN/password protection, app blacklisting/whitelisting, and avoiding public WiFi.
- Securing cloud-based business apps and limiting employee BYOD usage if deemed high risk.

Besides policies, there are several different tools that an organization can use to mitigate some of these risks. For example, if a device is stolen or lost, geolocation software can help the organization find it. In some cases, it may even make sense to install remote data-removal software, which will remove data from a device if it becomes a security risk.

Note: Virtual Private Networks (VPN)

Using firewalls and other security technologies, organizations can effectively protect many of their information resources by making them invisible to the outside world. But what if an employee working from home requires access to some of these resources? What if a consultant is hired to work on the internal corporate network from a remote location? In these cases, a virtual private network (VPN) is called for.

A VPN allows a user outside of a corporate network to detour around the firewall and access the internal network from the outside. A combination of software and security measures lets an organization allow limited access to its networks while at the same time ensuring overall security.

Usability

When looking to secure information resources, organizations must balance the need for security with users' need to access and use these resources effectively. If a system's security measures make it difficult to use, then users will find ways around the security, which may make the system more vulnerable than it would have been without the security measures! Take, for example, password policies. If the organization requires an extremely long password with several special characters, an employee may resort to writing it down and putting it in a drawer since it will be impossible to memorize.

Reference:

Security Policy Templates. Retrieved September 6, 2020, from SANS Institute's Information Security www.sans.org/information-security-policy/

6.4: Threat Impact

Chapter 5 discussed the different security threats and solutions. However, users need to safeguard their personal information as well.

Personally identifiable information (PII)

According to the FBI's Internet Crime Complaint Center (IC3), $13.3 Billion of total losses has been reported from 2016 to 2020 (IC3, 2020). Examples of crime types include phishing, personal data breach, identity theft, credit card fraud. The age of the victim ranges from 20 to 60 years old. For a detailed report, see the 2020 Internet crime report. The true number may be even higher since many victims did not report for a variety of reasons.

Personally identifiable information (PII) is any information that can be used to identify a person positively. Particular PII Examples include:

- Name
- Social Security number
- Birthday
- Credit card information
- Bank
- Account Numbers
- Government ID
- Address (street, email, telephone numbers)

One of the cybercriminals' most lucrative targets is acquiring PII lists that can then be sold on the dark web. The dark web can only be accessed through special software, and cybercriminals use it to shield their activities. Stolen PII can be used to build fraudulent accounts, such as short-term loans and credit cards.

Protected Health Information (PHI) is a subset of PII. The medical community produces and manages PHI-containing electronic medical records (EMRs). In the U.S., the Health Insurance Portability and Transparency Act (HIPAA) governs PHI handling. In the European Union, a similar law is called data security.

Lost Competitive Advantage

In cyberspace, companies are constantly concerned about corporate hacking. Another major concern is the loss of trust that occurs when a firm cannot protect its customers' personal data. The loss of competitive advantage may result from this loss of confidence rather than from stealing trade secrets by another firm or country.

Major security breaches can severely impact organizations by disrupting operations, enabling cybercrime, eroding customer trust, and tarnishing reputations. Financial losses can also be substantial. Some examples:

- The 2013 Target data breach impacted 41 million payment cards and contact information for 60 million customers. This resulted in a 46% profit drop the following quarter, a 5% share price decline, and over $200 million in legal settlements. (Stempel J. and Bose N., 2015)
- The 2020 Twitter hack compromised high-profile accounts, causing Twitter's stock to drop 3% and highlighting security vulnerabilities. The FTC fined Twitter $150 million. (FTC, 2022)

Reference:

2020 IC3 Report. Retrieved April 6, 2021, from https://www.ic3.gov/Media/PDF/AnnualReport/2020_IC3Report.pdf

Stempel J. and Bose N. (2015). Target to Pay $39 Million in Settlement With Banks Over Data Breach. Retrieved August 2, 2023, Reuters.com

FTC (2022). FTC Settles with Twitter for Misusing Users' Phone Numbers and Email Addresses. Federal Trade Commission

6.5: Security Operations Centers

Besides the tools and practices discussed earlier to protect ourselves, companies also have increased their investment to fight against cybercrime. One such investment is a dedicated center called Security Operations Center to safeguard companies from internal and external threats.

Elements of a SOC

Defending against today's threats requires a formalized, structured, and disciplined approach that is carried out by Security Operations Centers professionals who work closely with other groups such as IT or networking staff. SOCs offers a wide variety of services tailored to meet customer needs, from monitoring and compliance to comprehensive threat detection and hosted protection. SOCs may be wholly in-house, owned and run by a company, or security providers, such as Cisco Systems Inc.'s Managed Security Services, may be contracted to elements of a SOC. The key elements of a SOC are individuals, processes, and technology.

A great way to fight against threats is through Artificial Intelligence (AI) and machine learning. AI and machine learning use multi-factor authentication, malware scanning, and fighting spam and phishing to fight against threats.

Process in the SOC

SOC professionals monitor all suspicious activities and follow a set of rules to verify if it is a true security incident before escalating to the next level severity for the incident for appropriate security experts to take appropriate actions.

The SOC has four principal functions:

- Use network data to check the security warnings
- Evaluate accidents that have been checked and determine how to proceed
- Deploy specialists to evaluate risks at the highest possible level.
- Provide timely communication by SOC management to the company or clients

Technologies deployed in the SOC

- Event collection, correlation, and analysis
- Security monitoring
- Security control
- Log management
- Vulnerability assessment
- Vulnerability tracking
- Threat intelligence

Enterprise and Managed Security

The organization will benefit from the implementation of an enterprise-level SOC for medium and large networks. The SOC could be a complete solution within the company. Yet many larger organizations will outsource at least part of the SOC operations to a security solution provider such as Cisco Systems Inc.

6.6: Security vs. Availability

Much of the business networks will still be up and running. Security staff recognizes that network stability must be maintained for the company to achieve its goals.

Any company or industry has a small tolerance for downtime on networks. Usually, this tolerance is based on calculating downtime costs with the cost of insuring against downtime.

For example, using a router as a single point of failure could be tolerable in a small retail business with only one location. However, if a large portion of that company's sales is from online shoppers, the owner may want to have a redundancy degree to ensure there is always a connection.

Desired uptime is also expressed in the number of down-minutes in a year. For example, an uptime of "five nines" means the network is up by 99.999 percent of the time or down by no more than 5.256 minutes a year. "Four nines" would be a 52.56-minute downtime per capita.

However, security cannot be so powerful that it interferes with employee needs or business functions. This is often a tradeoff between good security and allowing companies to work efficiently.

Availability %	**Downtime**
99.8%	17.52 hours
99.9% (“three nines”)	8.76 hours
99.99% (“four nines”)	52.56 minutes
99.999% (“five nines”)	5.256 minutes
99.9999% (“six nines”)	31.5 seconds
99.99999% (“seven nines”)	3.15 seconds

? Fun Fact - Three nines 6.6.1

Why 99.9% uptime is called 'three nines'? And downtime is 5.256 minutes?

Answer

99.9% uptime = "three nines".   This means the network is available 99.9% of the time.

To calculate the total allowable downtime:

1 year = 365 days x 24 hours x 60 minutes = 525,600 minutes

0.1% downtime = 525,600 minutes x 0.001 = 525.6 minutes

So "three nines" allows a downtime of 525.6 minutes per year.

6.7: The Human Element

Technical controls provide the first line of defense, but employees also make or break an organization's security posture.

> **Definition: Social Engineering**
>
> Social engineering refers to psychological manipulation tactics that cybercriminals use to trick people into divulging confidential information or performing actions that compromise security.

Human errors, whether intentional or not, contribute to a large portion of security incidents. Here are some statistics:

- The 2023 Verizon Data Breach Investigations Report found that 74% of all breaches include the human element, with people involved either via Error, Privilege Misuse, Use of stolen credentials or Social Engineering. (Verizon, 2023)
- An IBM study found that 95% of cybersecurity breaches are due to human error. (IBM, 2022)

Organizations need to create a strong security culture that engages all personnel is vital. Key elements include:

- Security Awareness Training - Regular training ensures employees are mindful of threats and equipped with best practices. This guards against risky behavior like password reuse or phishing susceptibility. Training should cover malware, social engineering, sensitive data handling, incident reporting, and more.
- Security Policies - Policies codifying expected behaviors, asset management, access controls, and incident response help govern actions and promote accountability. Employees should affirm their knowledge of policies.
- Organizational Buy-In - Management must spearhead security and exhibit commitment.
- Employees are more attentive to policies when leaders endorse their significance. A top-down culture of vigilance permeates the firm.
- Empowered Security Team - Security staff should have executive backing, resources, and visibility. This empowers them to enforce controls, audit processes, and guide strategic decisions. Their expertise steers the ship.
- Security-Minded Hiring - Personnel choices matter. Screening candidates reduces insider threat risks. Those valuing security and ethics are preferable.

A strong security culture that engages all personnel, at all levels, is a key approach to reconcile human strengths and fallibility to combat human errors and social engineering.

References:

Verizon. (2023). 2023 Data Breach Investigations Report. Retrieved on August 6, 2023, from verizon.com

IBM (2022). Cost of a Data Breach Report 2022 from ocedic.com

6.8: Legal and Compliance Requirements

The increase in consumers' concerns over their privacy has led to new legal and compliance regulations.

Here is a brief overview of some key legal and compliance regulations related to information security that are relevant to businesses:

- PCI DSS (Payment Card Industry Data Security Standard) - Sets security requirements for any organization that processes, stores or transmits credit card data. Ensures secure handling of payment information.
- HIPAA (Health Insurance Portability and Accountability Act) - Requires protection and limited disclosure of patient health data by healthcare providers, insurance companies, and related businesses.
- GDPR (General Data Protection Regulation) - European Union data privacy regulations that govern how personal data is collected, stored and shared. Impacts any company dealing with EU citizens' data.
- CCPA (California Consumer Privacy Act) - Gives California residents rights over the personal information that businesses collect about them. Affects any company with CA customers.
- FERPA (Family Educational Rights and Privacy Act) - Governs access to student educational records; applicable to any educational institution receiving US federal funding.
- NIST Framework - Cybersecurity guidance for US federal agencies and contractors working with the government. Widely adopted as best practices.

Adhering to these regulations is mandatory, not optional, for any business that falls under their jurisdiction.

Fun Facts: What was the impact of GDPR to Google and US businesses?

The EU's General Data Protection Regulation (GDPR) came into effect in 2018 and imposed strict new requirements around data privacy and security. As one of the first major cases enforcing GDPR, Google was fined €50 million euros (~$57 million USD) that same year by French regulators for lacking transparency and consent controls for ads personalization.

GDPR has compelled many US companies to overhaul their data collection practices and security measures if they have any customers in the EU. Violations can lead to fines up to 4% of global revenue. Even for small to mid-sized US companies, GDPR prompted significant investment in consent management, data minimization, breach notification procedures, and other areas to avoid facing similar non-compliance penalties.

Do you remember that in that time frame, when we visited websites and received new prompts such as "by clicking Agree', you consent to us...", or "manage your preferences," etc.

It was not cheap to implement GDPR either. It could cost small businesses with less than 500 employees, around $9000.00 to meet compliance. It could be up to millions for large global companies!

6.9: Summary

6.9.1: Summary

People, businesses, and even nations can all fall victim to cyberattacks. There are different types of attackers, including amateurs attacking for fun and prestige, hacktivists hacking for a political cause, and professional hackers attacking for profit. Besides, nations that attack other nations to gain an economic advantage by intellectual property theft or harm or destroy another country's properties. The vulnerable networks are PC and server business networks and the thousands of computers on the Internet of Things.

Fight against cyberattacks requires people, processes, and technology to follow best practices and good security policies. There are tools that users can employ to protect personally identifiable information. There are policies that companies can require of their customers and employees to protect their resources. Companies can also invest in dedicated Security Operations Centers (SOCs) for cybercrime prevention, identification, and response.

The human element is also a major factor in security incidents. With social engineering and insider risks, no organization can rely solely on technology. A strong security culture with training, leadership buy-in, and thoughtful hiring is key. Investment in around-the-clock security operations centers also enhances threat monitoring and response capabilities.

Finding the right balance between security, usability, and availability allows organizations to implement effective defenses while still furthering business goals. With vigilant governance and coordination between security staff, management, employees, and technical controls, companies can build resilience against today's ever-evolving cyber risks.

6.10: Study Questions

Study Question 6.10.1

Briefly define the three components of the information security triad.

Answer

Confidentiality, integrity, and availability.

Study Question 6.10.2

Explain what authentication means.

Answer

Confirming the identity of a user through something they know, have, or are before allowing access.

Study Question 6.10.3

Give two examples of a complex password.

Answer

Passwords with 8+ characters, uppercase/lowercase letters, numbers, and special characters.

Study Question 6.10.4

Give three examples of threat actors.

Answer

Hacktivists, cyber criminals, nation-states.

Study Question 6.10.5

Name two motivations of hacktivists to commit cybercrime.

Answer

Politics, social causes.

Study Question 6.10.6

List five ways to defend against cyber attacks.

Answer

Firewalls, encryption, access controls, security policies, awareness training.

Study Question 6.10.7

List three examples of PII.

Answer

Social Security Number, driver's license, bank account numbers.

Study Question 6.10.8

Briefly explain the role of SOC.

Answer

Security operations center monitors threats, analyzes events, and responds to incidents.

Study Question 6.10.9

Explain the purpose of security policies.

Answer

Provide rules and guidelines for employee security practices.

Study Questions 6.10.10

Explain how information availability related to a successful organization.

Answer

High availability of systems and data is required for most business operations.

Study Question 6.10.11

What are some ways mobile devices and remote work create security challenges for businesses?

Answer

Mobile devices can expose data if lost/stolen. Remote work requires secure remote access tools.

Study Question 6.10.12

What is social engineering and what are some examples?

Answer

Tricking people to release info or compromise security. Phishing, pretexting.

Study Question 6.10.13

Why is training employees on security best practices important?

Answer

Employees cause many breaches via errors or social engineering.

Study Question 6.10.14

What are some regulations like GDPR that businesses must comply with regarding data security and privacy?

Answer

GDPR, HIPAA, PCI DSS, CCPA.

Study Question 6.10.15

What was the impact of the GDPR regulation on Google and other US companies?

Answer

Google fined $57M. Cost US companies millions to implement.

Exercises

1. Research and analyze cybersecurity incidents to come up with scenarios of how organizations can prevent an attack.
2. Discuss some IoT (Internet of Things) application vulnerabilities with non-techie and techie technology users, then compare and contrast their different perspectives and reactions to IoT vulnerabilities.
3. Describe one multi-factor authentication method that you have experienced and discuss the pros and cons of using multi-factor authentication.
4. Identify the password policy at your place of employment or study. Assess if it is a good policy or not. Explain.
5. Take inventory of possible security threats that your home devices may be exposed to. List them and discuss their potential effects and what you plan to do about them.
6. Recall when you last back up your data. Discuss the method you use. Define a backup policy for your home devices.
7. Research the career of a SOC professional. Report what certificate training it requires to become SOC professionals, what the demand is for this career, and their salary range.
8. Describe a time you experienced a possible security threat or breach. How did you respond and what was the outcome?
9. What security best practices have you implemented for mobile devices you use for work or home?
10. Share an example of a company that you feel demonstrates a strong security culture. What makes their security culture effective?

CHAPTER OVERVIEW

7: Leveraging Information Systems for Strategic Advantage

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe Porter's competitive forces model and how information technology impacts competitive advantage.
- Describe and apply Porter's value chain model and its relationship to IT.
- Describe information systems that can provide businesses with a competitive advantage.
- Describe the collaborative systems that workers can use to contribute to their organization.
- Distinguish between a structured and an unstructured decision and its connection to IT.
- Discuss the challenges associated with a sustainable competitive advantage.

This chapter will explore how organizations use information systems to achieve and maintain a competitive advantage and enhance their operational efficiency in the value chain and decision-making processes. We will discuss the influential research of Brynjolfsson, Carr, and Porter on information technology and its role in gaining a competitive advantage.

7.1: Introduction

For more than fifty years now, computing technology has played a critical role in business since the invention of the microprocessor. It has been used in various ways, from UPC scanners and computer registers in local stores to large inventory databases, e-commerce, and cloud services, like those used by Amazon and Netflix, that have become the backbone of commerce. Companies are also quick to integrate emerging technologies, such as artificial intelligence and robotics, and have spent trillions of dollars on information technology. But has all this investment in IT made any difference? Do computers increase productivity? Are companies that invest in IT more competitive? This chapter examines the value IT can bring to an organization and answers these questions. We will begin by highlighting two significant works from the past two decades.

7.2: The Productivity Paradox

In 1991, Erik Brynjolfsson wrote an article published in the Communications of the ACM entitled "The Productivity Paradox of Information Technology: Review and Assessment." Many businesses believe that increasing their investment in information technology will lead to higher worker productivity. However, after conducting a thorough review of studies on the effects of IT investment on productivity, Brynjolfsson discovered that IT's addition to businesses had not improved worker productivity. This phenomenon is known as the "productivity paradox." He concluded that this paradox resulted from our inability to demonstrate IT's contribution to productivity due to a lack of quantitative measures.

Definition: Productivity Paradox

The productivity paradox (also referred to as the Solow paradox) is the observation made in business process analysis that, as more investment is made in information technology, productivity may go down instead of up.

In 1998, Brynjolfsson and Lorin Hitt published a follow-up paper, "Beyond the Productivity Paradox." The paper used recently gathered data to confirm that IT can positively affect businesses. The authors discovered that the benefits of technology may not be immediately linked to increased productivity but rather to more intangible factors such as organizational structure. Additionally, the impact of IT can differ significantly between different companies.

7.2.1: Does IT matter?

Just as a consensus was forming about IT's value, the Internet stock market bubble burst; two years later, in 2003, Harvard professor Nicholas Carr wrote his provocative article "IT Doesn't Matter" in the Harvard Business Review. In this article, Carr asserts that as information technology becomes more ubiquitous, it becomes less of a differentiator to distinguish one business from another. Since information technology is readily available and the software is easily copied, businesses cannot rely on these tools to provide a ***sustained*** competitive advantage. IT becomes a commodity over time, much like a utility such as electricity, and should be managed as such, focusing on minimizing costs and risks. IT management should see themselves as a utility within the company and work to keep costs down while providing the best service with minimal disruptions. As you can imagine, this article caused quite an uproar, especially from IT companies. Many articles were written in defense of the strategic value of IT; many others agreed that Carr was onto something.

Carr followed it up with a book in 2008's "*The Big Switch: Rewiring the World, from Edison to Google*," to examine how the cloud is reshaping business, society, and culture. He draws a parallel between the impact of electricity and the transformative power of cloud computing.

The best thing to come out of the article and the subsequent book was that it opened up discussion on IT's place in a business strategy and what role IT could play in developing and sustaining competitive advantages. We want to address that question in the rest of this chapter.

7.2.2: References

Brynjolfsson, E. and Hitt, L. (1998). *Beyond the Productivity Paradox*. Communications of the ACM. Retrieved August 16, 2020, from https://doi.org/10.1145/280324.280332

Brynjolfsson, E. (1992). *The Productivity Paradox of Information Technology: Review and Assessment*. Center for Coordination Science MIT Sloan School of Management Cambridge, MA. Retrieved from August 16, 2020, from http://ccs.mit.edu/papers/CCSWP130/ccswp130.html

Carr, Nicholas G (2003) *IT Doesn't Matter*. Retrieved August 20, 2020 from https://hbr.org/2003/05/it-doesnt-matter

Carr, Nicholas G (2008) *The Big Switch: Rewriting the World, from Edison to Google*. Retrieved July 11, 2023, from https://www.nicholascarr.com/?page_id=21

7.3: Competitive Advantage

What do Walmart, Apple, and McDonald's have in common?

Figure 7.3.1: Image Competitive landscape by PaulaD.MezaD is licensed CC BY-SA 4.0

All three businesses have a competitive advantage. What does it mean when a company has a competitive advantage? What are the factors that play into it? Do they achieve a competitive advantage in the same way? According to Michael Porter in his book "Competitive Advantage: Creating and Sustaining Superior Performance," a company is said to have a competitive advantage over its rivals when it can generate profits that surpass the industry average and continue to do so over time. Porter identified two basic types of competitive advantage:

- **Cost advantage**: A firm has a cost advantage when it can deliver the same benefits as competitors but at a lower cost. McDonald's and Walmart utilize economies of scale to maintain their cost advantage.
- **Differentiation advantage**: A firm has a differentiation advantage when it can deliver benefits that exceed the competing products. Apple's innovative products are known to be easy to use, complement each other, and share the same operating system. They offer a unique user experience that gives consumers a sense of exclusivity, and their trade-in programs build consumer loyalty.

The question, then, is: How can information technology be a factor in achieving a competitive advantage? We will explore this question through two analysis tools: from Porter's book "Competitive Advantage: Creating and Sustaining Superior Performance:"

- The Value chain
- The Five Forces Framework

We will discuss how Porter used the Five Forces framework to evaluate the influence of the Internet and IT on the profitability of an industry.

7.3.1: The Value Chain

Porter analyzes the basis of competitive advantage and describes how a company can achieve it using the value chain as a framework. A value chain is a step-by-step business model transforming a product or service from an idea (i.e., materials) to reality (i.e., products or services). Value chains help increase a business's efficiency so the business can deliver the most value (i.e., profit) for the least possible cost. Each step (or activity) in the value chain contributes to a product or service's overall value. While the value chain may not be a perfect model for every type of company, it provides a way to analyze how a company produces value.

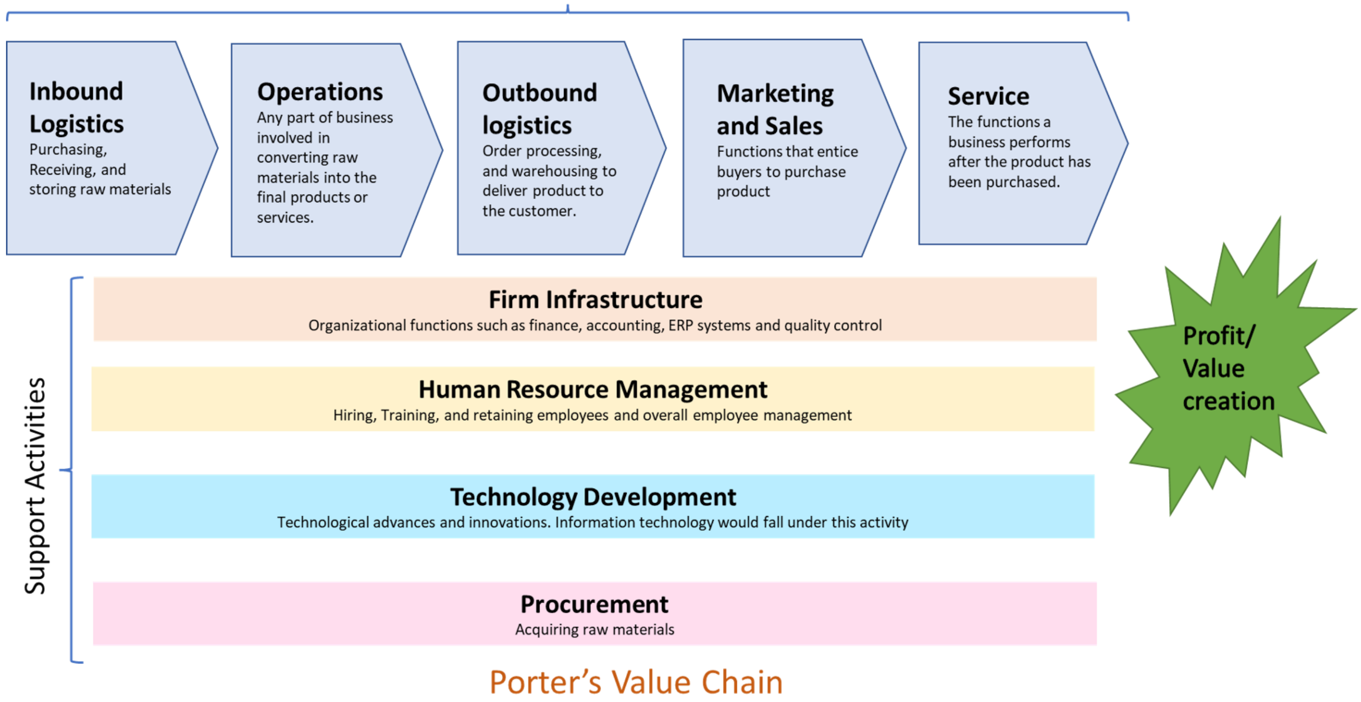


Figure $7.3.2$ Porter's Value Chain. Image by Tejal Desai-Naik is licensed under CC-BY-NC 4.0 derivative of David Bourgeois is licensed CC BY 4.0

The value chain is made up of two sets of activities: primary activities and support activities. We will briefly examine these activities and discuss how information technology can create value by contributing to cost advantage or differentiation advantage, or both.

The primary activities are the functions that directly impact a product or service's creation, sales, and after-sales service. The primary activities aim to add more value than they cost. The primary activities are:

- **Inbound logistics**: Purchasing, Receiving, and storing raw materials. Information technology can make these processes more efficient, such as with supply-chain management systems, allowing suppliers to manage their inventory. Starbucks has company-appointed coffee buyers that select the finest quality coffee beans from producers in Latin America, Africa, and Asia.
- **Operations**: Any part of a business involved in converting the raw materials into the final products or services is part of operations. From manufacturing to business process management (covered in Chapter 8), information technology can provide more efficient processes and increase innovation through information flows.
- **Outbound logistics**: These functions include order processing and warehousing required to deliver the product to the customer. As with inbound logistics, IT can improve processes, such as allowing for real-time inventory checks. IT can also be a delivery mechanism itself.
- **Marketing/Sales**: The functions that entice buyers to purchase the products (advertising, salesforce) are part of sales and marketing. Information technology is used in almost all aspects of this activity. From online advertising to surveys, IT can innovate product design and reach customers like never before. The company website can be a sales channel itself.
- **Service**: The functions a business performs after the product has been purchased, such as installation, customer support, complaint resolution, and repair to maintain and enhance its value, are part of the service activity. Service can also be enhanced via technology, including support services through websites and knowledge bases.

The support activities are the functions in an organization that support and cut across all primary activities. The support activities are:

- **Firm infrastructure**: Organizational functions such as finance, accounting, ERP Systems (covered in Chapter 9), and quality control, all of which depend on information technology.
- **Human Resources Management**: Hiring, training, and retaining employees and overall employee management are needed for marketing, logistics, and operations that benefit all primary activities.

- **Technology development**: Technological advances and innovations support primary activities. These advances are integrated across the company to add value to different departments. Information technology would fall specifically under this activity.
- **Procurement**: Acquiring the raw materials used to create products and services is called procurement. Business-to-business e-commerce can be used to improve the acquisition of materials.

A value chain is a powerful tool for analyzing and breaking down a company into relevant activities that result in higher prices and lower costs. By understanding how these activities are connected and the company's strategic objectives, companies can identify their core competencies and insight into how information technology can be used to achieve a competitive advantage.

Example 7.3.1: Starbucks value chain model analysis

When you think of international coffee shops, Starbucks is the first name that comes to mind. You can conduct a value chain analysis to understand how it maintains its competitive edge and success through its activities, and which of the activities or groups of activities are the source of its competitive advantages.

Solution

Review this example of the Starbucks value chain model analysis, including a short video by Prableen Bajpai: Analyzing Starbucks Value Chain Model.

Have a look at this infographic showing Starbuck's value chain analysis.

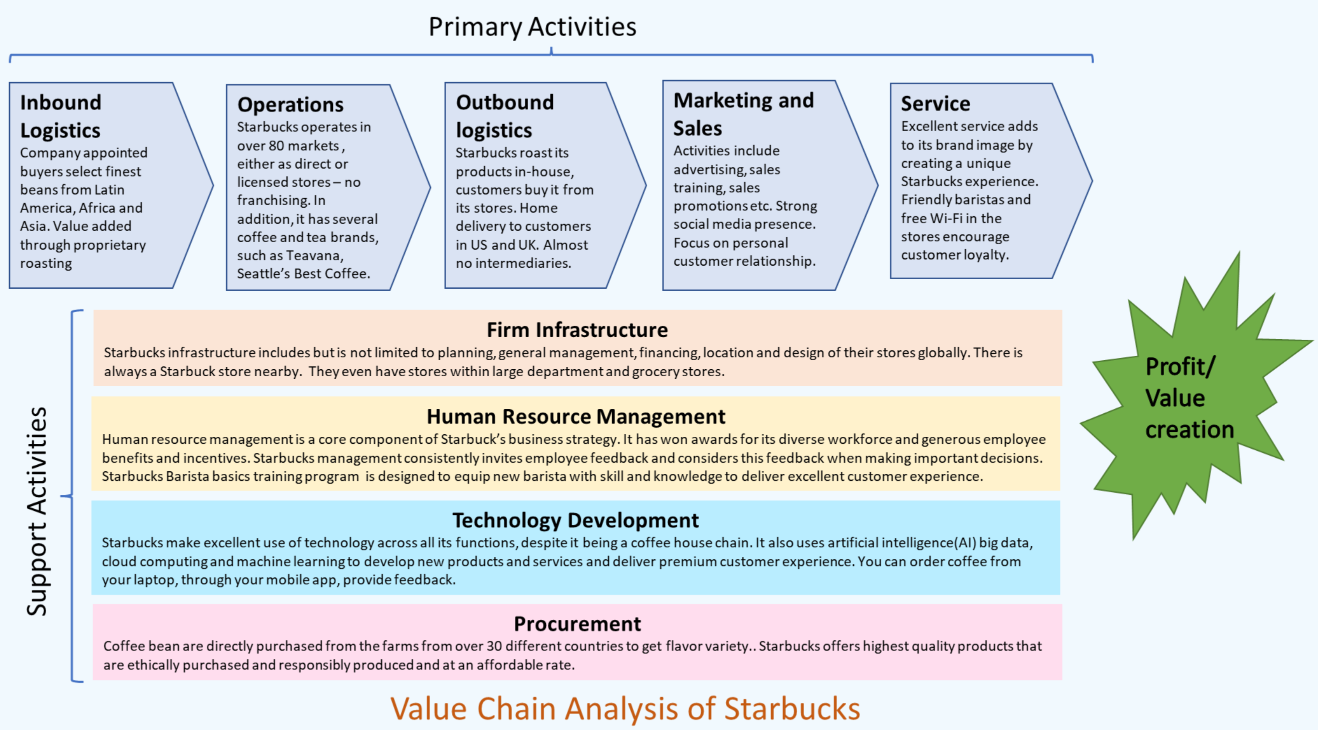


Figure 7.3.3: Infographic showing Starbuck's value chain analysis using Porter's value chain model. Image by Tejal Desai-Naik licensed under CC-BY-NC.

As you can see from our value chain analysis of Starbucks, the company follows a unique operational plan in that it controls everything from production to sales. This gives it a competitive edge and enables substantial profit generation.

7.3.2: Porter's Five Forces

Porter recognized that other factors could impact a company's profit in addition to competition from its rivals. He developed the "five forces" model as a framework for analyzing the competition in an industry and its strengths and weaknesses. The model consists of five elements, each of which plays a role in determining an industry's average profitability.

Figure 7.3.4 Porter's Five Forces. Image by Grahams Child is licensed CC BY-SA 3.0

In 2001, Porter wrote an article entitled" Strategy and the Internet," in which he takes this model and looks at how the Internet(and IT) impacts an industry's profitability. Although the model's details differ from one industry to another, its general structure of the five forces is universal. Let's have a look at how the internet plays a role in Porter's five forces model:

- **Threat of New Entrants**: The easier it is to enter an industry, the tougher it will be to profit in that industry. The Internet has an overall effect of making it easier to enter industries. Traditional barriers are drastically reduced, such as the need for a physical store and a sales force to sell goods and services. Dot-coms multiplied for that very reason: All a competitor has to do is set up a website. The geographical reach of the internet enables distant competitors to compete more directly with a local firm. For example, a manufacturer in Northern California may now have to compete against a manufacturer in the Southern United States, where wages are lower.
- **Threat of Substitute Products**: How easily can a product or service be replaced with something else? The more types of products or services there are that can meet a particular need, the less profitability will be in an industry. For example, the advent of the mobile phone has replaced the need for pagers. The Internet has made people more aware of substitute products, driving down industry profits in those industries being substituted. Any industry in which digitized information can replace material goods such as books, music, and software is at particular risk. For example, Amazon's Kindle and other ebook readers are a threat to paper books and magazines.
- **Bargaining Power of Suppliers**: Companies can more easily find alternative suppliers and compare prices more easily. When a sole supplier exists, then the company is at the mercy of the supplier. For example, if only one company makes the controller chip for a car engine, that company can control the price, at least to some extent. The Internet has given companies access to more suppliers, driving down prices. On the other hand, suppliers now also have the ability to sell directly to customers. As companies use IT to integrate their supply chain, participating suppliers will prosper by locking customers and increasing switching costs.
- **Bargaining Power of Customers**: A company that is the sole provider of a unique product has the ability to control pricing. But the Internet has given customers access to information about products and more options (small and big businesses) to choose from.

- **Competitive Rivalry within an industry**: The more competitors, the bigger a factor price becomes. The visibility of internet applications on the Web makes proprietary systems more difficult to keep secret. It is straightforward to copy technology, so innovations will not last that long. For example, Sony Reader was released in 2006, followed by Amazon Kindle in 2007, and just two years later, Barnes and Noble Nook, which was the best-selling unit in the US before iPad (with built-in reading app iBooks) hit the market in 2010. (Wikipedia: E-Reader, 2020)

According to this framework, the company's average profitability depends on the five forces' collective strength. If the five forces are intense, for example, in the airline industry, almost no company makes a huge profit. If the forces are mild, for example, the soft drink industry, there is room for higher profits. The Internet provides better opportunities for companies to establish strategic advantage by boosting efficiency in various ways, as we will see in the next section. However, the internet also tends to dampen suppliers' bargaining power and increase the threat of substitute products by making it easier for buyers and sellers to do business. Thus, the Internet (and, by extension, information technology in general) has the overall impact of increasing competition and lowering profitability. This is the great paradox of the internet.

While the Internet has certainly produced many big winners, the overall winners have been the consumers, who have been given an ever-increasing market of products and services and lower prices.

7.3.3: References

Bajpai, P (2020). *Analyzing Starbucks Value Chain Model*. Retrieved August 16, 2020, from https://www.investopedia.com/articles/investing/103114/starbucks-example-value-chain-model.asp

Porter, M. (2001). *Strategy and the Internet.* Harvard Business Review. Retrieved August 20, 2020, from http://hbswk.hbs.edu/item/2165.html

---

7.4: Using Information Systems for Competitive Advantage

Information systems (IS) is an umbrella term for the systems, people, technology, and processes designed to run a business.

Information Systems support or shape a business unit's organizational strategy to provide a competitive advantage. Any information system - Business Process Management (BPM), Electronic Data Interchange (EDI), Management Information System (MIS), Decision Support System (DSS), Transaction Processing System (TPS) - that helps a business deliver a product or service at a lower cost, that is differentiated, that focuses on a specific market segment or is innovative is a strategic information system.

There are many different ways in which systems are utilized to automate processes and transactions. Factories use information systems to automate production processes and manage inventory. Banks use a variety of systems to process transactions such as deposits, ATM withdrawals, and loan payments. Information systems are also used to process customer orders and handle billing and vendor payments. Companies typically have several different types of information systems; each type serves a different level of organization based on the information requirements and types of decisions - Operational (workers), tactical (middle and senior managers), and strategic (executives).

Before we look at the different types of information systems, lets take a look at the types of decisions that are made at different levels of an organization.

- **A structured decision** is usually one that is repetitive and routine and is based directly on the inputs. For example, a company decides whether or not to withdraw funds from an international account depending on the current exchange rate. EDI and TPS typically handle structured decisions. Structured decisions are good candidates for automation and typically occur at operational level.
- **An unstructured decision** has a lot of unknowns and relies on knowledge and/or expertise. An information system can support these decisions by providing the decision-makers with information-gathering tools and collaborative capabilities. These are typically long-term, complex and strategic in nature, made at executive level. An example of an unstructured decision might be what types of a new product should be created and what market should be targeted.
- **Semi-structured decision**: A semi-structured decision is one in which most of the factors needed for making the decision are known, but human experience, judgement and other outside factors may still play a role. These are medium-term, less complex and typically made at tactical level.

The image below shows the relationship between the type of information system used for different decision types at different levels of an organization. Lets take more detailed look at how companies and organizations use these information systems.

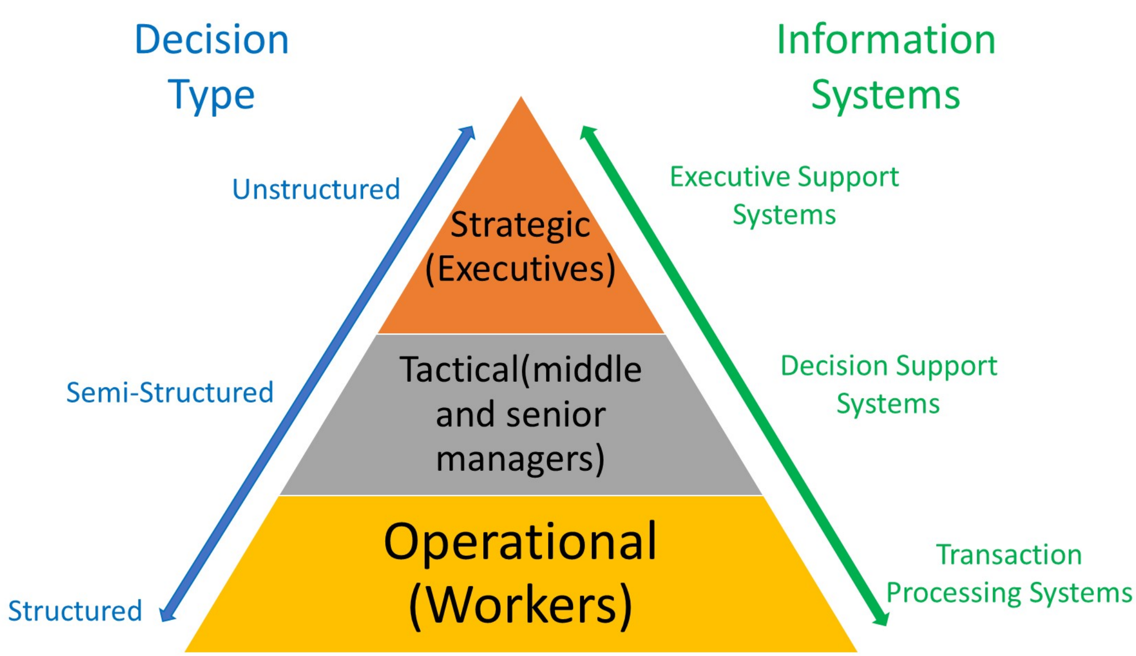


Figure $7.4.1$: A three-level pyramid model of different types of Information Systems based on the decision types at different levels of hierarchy in an organization. Image by Tejal Desai-Naik is licensed under CC BY- 4.0

Example $7.4.2$

Give an example for a structured, semi-structured, and unstructured decision. Match each decision with the appropriate Information as depicted in Figure $7.4.1$.

Solution

Structured Decision: A company has a policy to provide a 5% discount on orders over $1,000. When an order comes in, the Transaction Processing System (TPS) automatically checks the order total and applies the 5% discount if it is over $1,000. This is a structured decision - the rules are pre-defined and consistently applied.

Semi-Structured Decision: A retailer is deciding pricing for the upcoming holiday season. This decision is not a simple decision. The manager either gets the historical data from the TPS or inputs data into a Decision Support System (DSS) about historical sales, demand forecasts, inventory levels, and competitor pricing. The DSS analyzes this data and provides a recommended optimal pricing strategy. The manager reviews the recommendations, but also applies their judgment based on experience.

Unstructured Decision: A company executive is evaluating whether to enter a new product line. The Executive Support System (ESS) provides data on market trends, growth projections, the company's core competencies, and potential partners. The executive weighs this information against strategic goals. But the final decision relies heavily on judgment and insight beyond quantifiable factors.

Transaction Processing Systems (TPS)

Transaction processing systems (TPS) are computerized information systems developed to process large amounts of data for routine business transactions such as payroll, order processing, airline reservations, employee records, accounts payable, and receivable. TPS eliminates the tedium of necessary repetitive transactions that take time and labor and makes them efficient and accurate, although people must still input data to computerized systems. Transaction processing systems are boundary-spanning systems that allow the organization to interact with external environments. TPS examples include ATMs, credit card authorizations, online bill payments, and self-checkout stations at retail stores. IT enables all of this to happen in real-time, meaning all the events and transactions that occur in a business or over the system are processed immediately causing no delay.

Figure $7.4.3$ illustrates a transaction processing system in which the transaction is a customer's electronic payment of a bill. The TPS takes the customer's electronic payment as input, records the transaction, and the output consists of not only documents sent to outside parties (notification of payment received) but also of information circulated internally (in the form of reports), as well as information entered into the database for updating.

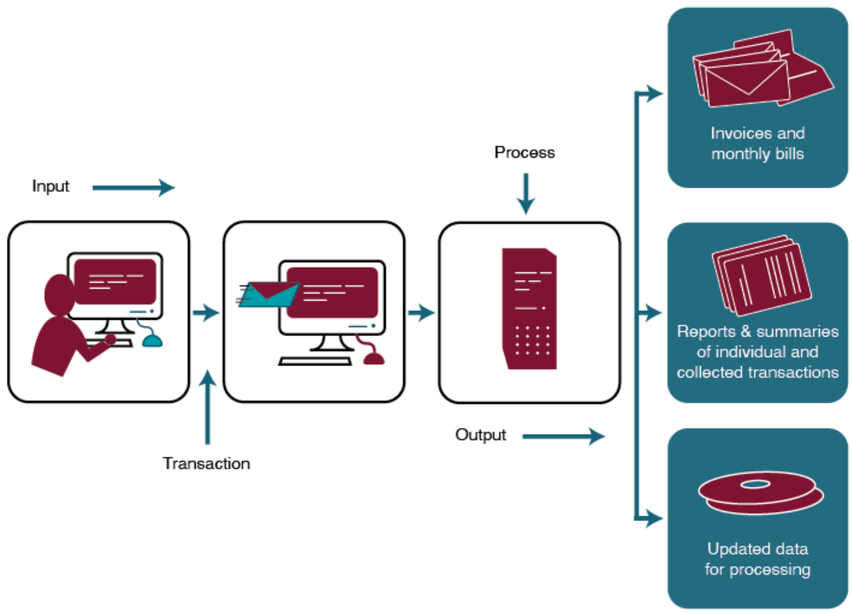


Figure 7.4.3: Transaction processing system adapted from Matthew Pauley licensed under *CC-By-NC-SA*

Decision Support Systems (DSS)

A decision support system (DSS) is a computerized information system that supports business or organizational decision-making activities by sifting through and analyzing a huge amount of data and producing comprehensive information reports. As technology continues to advance, DSS is not limited to just huge mainframe computers - DSS applications can be loaded on most desktops, laptops, and even mobile devices. For example, GPS route planning determines the fastest and best route between two points: analyzing and comparing multiple options and factoring in traffic conditions.

Marketing executives at a furniture company(like Living Spaces) could run DSS models that use sales data and demographic assumptions to develop forecasts of the types of furniture that would appeal to the fastest-growing population groups.

DSS can be as simple as a spreadsheet that allows for the input of specific variables and then calculates required outputs such as inventory management. Another DSS might assist in determining which products a company should develop. Input into the system could include market research on the product, competitor information, and product development costs. The system would then analyze these inputs based on the specific rules and concepts programmed into them. Finally, the system would report its results, with recommendations and/or key indicators to decide.

Decision support systems work best when the decision-maker(s) are making semi-structured decisions. A good example of a semi-structured decision would be diagnosing a medical condition Part of the decision is structured (symptoms, age, gender, history, etc of the patient) and part is based on human experience and judgment (doctor's interaction with the patient, medical knowledge and understanding). Farmers using crop-planning tools to determine the best time to plant, fertilize, and reap is another example.

A DSS can be looked at as a tool for competitive advantage in that it can give an organization a mechanism to make wise decisions about products and innovations.

Executive Support Systems(ESS)

Senior executives tend to be exposed to many unstructured decision situations that are open-ended and evaluative and that require insight based on many sources of information and personal experience. For example, a CEO of a company needs to decide to acquire another company. This is an unstructured decision. Executive support systems (ESS) compiles information from across the value chain - external industry reports, financial models, internal compatibility assessments, leadership profiles. These systems can assist in making more informed decisions by presenting timely and useful information (in the form of reports, charts and graphs) on changes in industry and society at large that may affect long-term and near-term future of the organization, its strategic goals, its performance, and overall ability of the organization to achieve its objectives.

Electronic Data Interchange (EDI)

EDI is a critical standard that ensures the above systems are a structured and standardized electronic communication method to allow businesses to exchange data within and between different organizations. Typically, processing a paper-based exchange of purchase orders and invoices takes a week. Using EDI, the process can be completed within hours since it eliminates the need for manual data entry, hence reducing human errors! By integrating suppliers and distributors via EDI, a company can improve speed, efficiency, and security, thus vastly reducing the resources required to manage relevant business information. IBM Sterling B2B Omtegrator, Cleo Integration Cloud, OpenText Trading Grid, SPS Commerce Fulfillment are some EDI software that can be used in conjunction with a data integration platform.

EDI allows TPS, MIS, DSS, and ESS to seamlessly exchange data, increase data accuracy, and support data-driven decisions at all levels of an organization.

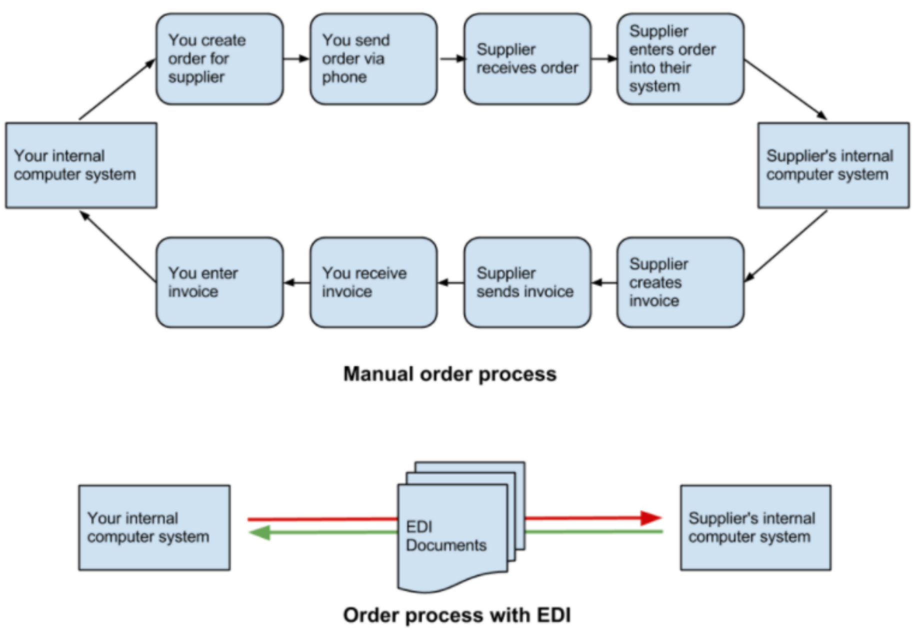


Figure 7.4.4

Comparison of Process with and without EDI. Image by [David Bourgeois](#) is licensed [CC BY 4.0](#)

> **Fun Fact: Do you know Walmart's role in driving EDI into mainstream business practices?**
>
> Walmart played a major role in driving the adoption of EDI (Electronic Data Interchange) in business, though it did not originate the technology itself. EDI was first used in the transportation industry to exchange shipment data electronically in the 1960s to 19070s.
>
> It was not until the mid-1980s when Walmart became one of the first major retailers to require its suppliers to use EDI to manage orders and invoices. Walmart continues to invest money to adopt EDI and forces its suppliers to adopt EDI to continue

to do business with the company. This drove EDI into the mainstream business practice and a competitive advantage for Walmart.

EDI continues to be adopted for today's companies such as Amazon, Home Depot, Ford Motor.

Business Process Management (BPM)

Before a firm can automate a given process, it must understand its workflow and process how tasks get done. BPM is a method that helps companies to manage and optimize workflows, and there are many BPM software tools to aid in a firm's effort to systematically design, model, execute, monitor, and optimize workforces and processes within an organization. Some examples include IBM Business Process Manager, Oracle BPM Suite, SAP NetWeaver BPM, Appian BPM suite. Business process management is the automated integration of process information to streamline operations, reduce costs and improve customer service (Ken Vollmer, BPMInstitute.org). Like EDI, BPM is used both internally and externally, between applications within a business and between companies. Business process management can be narrow or large in scope.

Large financial institutions like Bank of America use BPM on a large scale to link, integrate and automate different applications - Credit cards, bank accounts, loans - thus resulting in a delivery time for financial transactions from weeks to minutes. On the other hand, a car rental company would use BMP to streamline and enable real-time vehicle rentals for customers. The BPM would automate everything from Renter information, selection of available vehicles, selecting the car, and making reservations to confirming and showing reservations all at the click of a few keys. This makes the process more efficient and productive giving the business a competitive edge. The figure below shows a simplified version of business process management for renting a car and can be implemented in a TPS, MIS, DSS, and ESS. We will discuss BPM in more detail in Chapter 8.

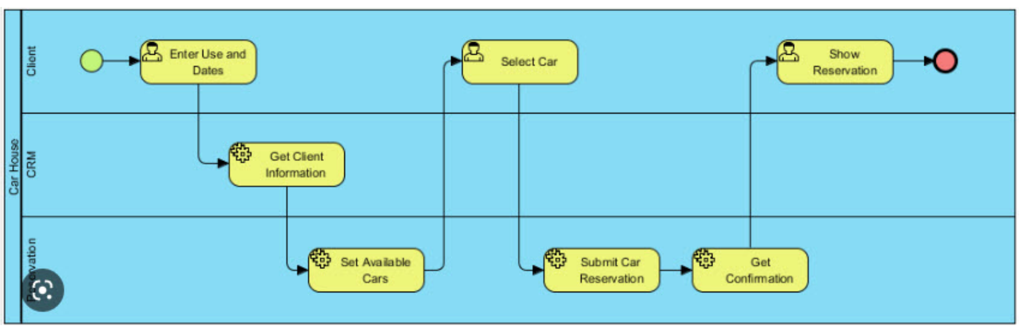


Figure 7.4.5: Simplified BPM for Car Rental Process image by Howard Pruitt by Visual Paradigm shared under Public Domain

Management Information Systems (MIS)

Management Information systems(MIS) consists of users, hardware, and software that support decision-making. MIS collects and stores its key data and produces information that managers need for analysis, control, and decision-making. For example, input from the sales of different products can be used to analyze trends of performing well and those that are not. Managers use this analysis to make semi-structured decisions such as changes to future inventory orders and manufacturing schedules.

In Chapter 1, we defined IT and IS (Figure 1.2.2). Where does MIS fit in?

Caution - MIS, IS, IT terms

Information Technology (IT) and Information Systems (IS) are sometimes used interchangeably. However, there is a difference between the two terms. The first four components, hardware, software, network communications, and data, are considered essential elements of IT infrastructure. An IS includes the four components of IT and the remaining two components, People and Process, that deliver value to organizations in setting up and using IT to meet specific organizations' goals (Figure 1.2.2)

MIS sounds similar and are often confused with IT and IS. Let's clarify it. MIS is a specific-purpose information system designed to support management, focusing on collecting, storing, and reporting data to managers within an organization to support business operations and tactical decision making. An example is a retail chain's sales reporting system.

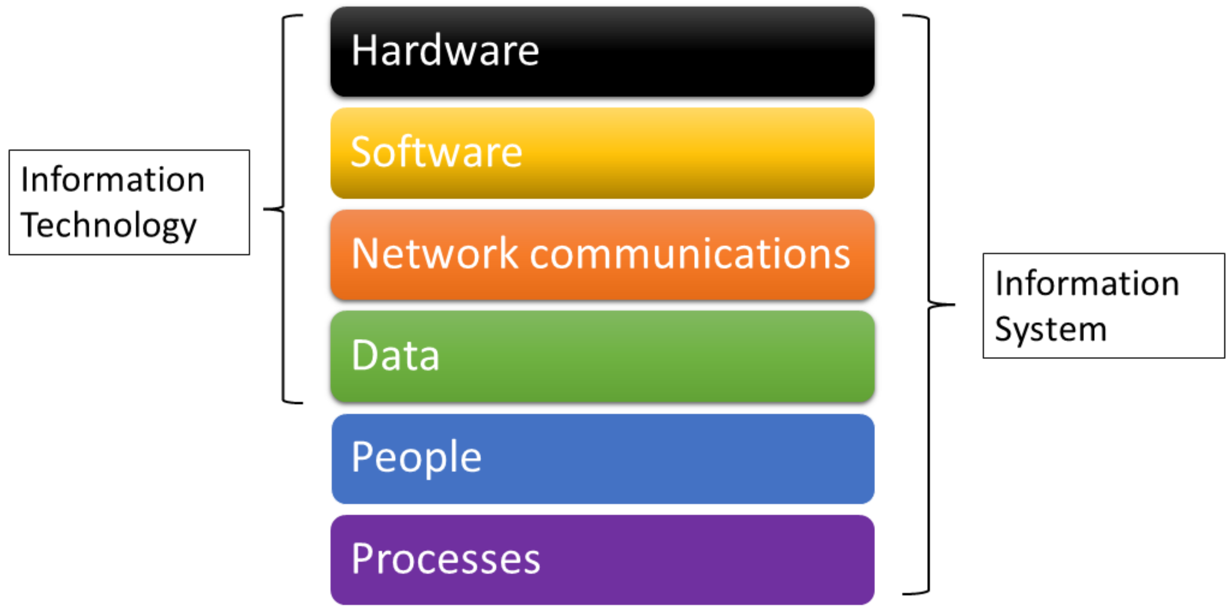


Figure 1.2.2: IT vs. IS Image by Ly-Huong Pham is licensed under CC BY NC.

Collaborative Systems

As organizations began to implement networking technologies, information systems emerged that allowed employees to collaborate differently. Tools such as document sharing and video conferencing allowed users to brainstorm ideas together and collaborate without the necessity of physical, face-to-face meetings.

Broadly speaking, any software that allows multiple users to interact on a document or topic could be considered collaborative. Electronic mail, a shared Word document, social networks, and discussion boards would fall into this broad definition. However, many software tools have been created that are designed specifically for collaborative purposes. These tools offer a broad spectrum of collaborative functions. They can exist as stand-alone systems or integrated with any of the information systems above. Here is just a shortlist of some collaborative tools available for businesses today:

Cloud Services refer to a wide variety of services delivered on-demand to companies and customers over the internet without the need for internal infrastructure or hardware.

Cloud Services

IBM Lotus Notes	• One of the first true “groupware” collaboration tools. • Provides a full suite of collaboration software, including integrated e-mail • Obsolete with the advent of newer, easier-to-use technologies like Google Drive and Microsoft SharePoint.
GitHub	• Code hosting platform for collaboration amongst programmers/developers of computer software • Used primarily for version control – to track changes in source code during software development.
Microsoft SharePoin	• Web-based document management and collaboration tool • Integrates with Office 365, which educators, students, office workers are familiar with. • Sharepoint was covered in more detail in Chapter 5

G Suite	• Formerly known as Google Apps for Work • Software as a Service (SaaS) product that groups all cloud-based productivity and collaboration tools developed by Google. • The innovative interface allows real-time document editing and sharing • Allows collaboration of other products, like Office 365. • Another SaaS that you may be familiar with is Dropbox

Online Video Conferencing Services allows two or more people in different geographical locations to meet and collaborate.

Online Video Conferencing Services

Zoom	• Most popular online video conferencing and meeting platform due to its user-friendly interface. • Great for small and large businesses as it can support up to 100p participants in online meetings • Wide variety of options such as screen share, whiteboard, live chat and messaging, recording, and breakout rooms. • Collaboration and Interaction from a variety of devices(computers, tablets, smartphones, etc.) • Google Chrome and Linux OS support
Cisco Webex	• Business communications platform that combines video and audio • Allows participants to interact with each other's computer desktops • Top of the line security features, making it excellent for business with legitimate security concerns
Skype for Business	• Microsoft's online meeting platform • Can support up to 250 participants for online meetings • Combines instant messaging, video conferencing, calling, and document collaboration in a single integrated app. • Skype that you use at home is good for small businesses and can support up to 50 participants.

With the explosion of the worldwide web, the distinction between these different systems has become fuzzy. Information systems are available to automate practically any business aspect - from managing inventory to sales and customer service. " Information Technology(IT)" is now the category to designate any software-hardware-communications structures that today work as a virtual nervous system of society at all levels.

7.5: Investing in IT for Competitive Advantage

In 2008, Brynjolfsson and McAfee published a study in the Harvard Business Review on IT's role in competitive advantage, titled “Investing in the IT That Makes a Competitive Difference.” Their study confirmed that IT could play a role in competitive advantage if deployed wisely. In their study, they draw three conclusions:

- **First**, the data show that IT has sharpened differences among companies instead of reducing them. This reflects that while companies have always varied widely in their ability to select, adapt, and exploit innovations, technology has accelerated and amplified these differences.
- **Second**, good management matters: Highly qualified vendors, consultants, and IT departments might be necessary for the successful implementation of enterprise technologies themselves, but the real value comes from the process innovations that can now be delivered on those platforms. Fostering the right innovations and propagating them widely are executive responsibilities that can’t be delegated.
- **Finally**, the competitive shakeup brought on by IT is not nearly complete, even in the IT-intensive US economy. We expect to see these altered competitive dynamics in other countries, as well, as their IT investments grow.

In the tech-driven and ever-changing business landscape, successfully leveraging and implementing IT has become the solution for maintaining competitive advantage and growth. One such solution is artificial intelligence (AI).

7.5.1: Artificial Intelligence (AI)

Today, artificial intelligence has emerged as a new technology that can provide opportunities like personalized recommendations, fraud detection, process automation, and data insights. Companies like Amazon have successfully leveraged AI for competitive advantage. This shows that IT-driven impacts continue to evolve.

However, human innovation and management remain essential. The right innovations must be fostered and propagated through good leadership. With the reliance on IT systems and data, security has also become crucial for operations and competitiveness.

Artificial intelligence (AI) is intelligence demonstrated by machines, as opposed to intelligence displayed by humans and animals. We discussed AI in Chapter 3. Let's review what it is and how it is used in our daily life.

Definition: Artificial Intelligence

Artificial intelligence (AI) refers to computer systems or software that can perform tasks normally requiring human intelligence, such as visual perception, speech recognition, and decision-making. AI leverages large amounts of data and complex algorithms to mimic human cognitive skills in an automated manner. It is used in applications like digital assistants, image analysis, autonomous vehicles, and fraud detection.

Let's watch this short video by The Royal Society, What is Artificial Intelligence?, that explains what AI is and its role and impact in society.

Figure 7.5.1: Technology with AI at its heart has the power to change the world, but what exactly is Artificial Intelligence? (The Royal Society; The Royal Society via https://youtu.be/nASDYRkbQIY)

AI (or machine intelligence) - machines' ability to operate like a human brain - to learn patterns, provide insights and even predict future occurrences based on inputted data/information can give companies a competitive edge in marketing by providing insights into how to market, who to market to, when, and how to market. AI offers insights that are objective and data-driven. For example, Amazon uses AI to follow users' behavior on their website - what type of products they buy, how long they spend on a product page, etc. The AI system quickly learns to generate tailored recommendations to each user's taste and preference based on their activity. Another advantage of AI is in cybersecurity and fraud protection. AI technologies can use user behavior data to identify and flag any activity that is out of the ordinary for any user (such as credit card use outside your home state). AI systems are very versatile in that they can handle all three types of decisions - structured, semi-structured, and unstructured.

Sidebar: AI in daily life

AI can be found everywhere today. It is difficult to imagine our daily routines without the help of AI. Check out this neat infographic from Caltech science exchange: How is AI applied in everyday life?

AI is used by smart assistants like Alexa, Siri. Bixby, Google Assistant, Cortana. Your phone's facial recognition also uses AI. Social media platforms such as Facebook, Twitter, and Instagram use AI to personalize your feeds, suggest friend requests, and identify and filter out fake news. Netlfix's powerful AI uses your past viewing history to deliver suggestions for what you might want to watch including genres, actors, time periods, and more. It even makes suggestions based on what time of the day you are watching and what you traditionally watch during that timeframe!

AI is used by Grammarly, Smart Compose in Gmail, to check your spelling and grammar. A prominent example is ChatGPT, an AI powered large language model chatbot that can be used to write blog posts, give recipes, generate and debug complex code, write papers and essays, weave vivid stories and answer almost any question you would ask it. In 2023, academy introduced "Khanamigo", an experimental AI powered guide based on GPT-4. Check out Sal khan's introducing "Khanamigo" in this video.

Credit card companies use AI to verify if a purchase is within your normal transaction and purchase patterns, and if not send you a fraud alert or even decline transactions. Amazon uses AI algorithms to learn what you like and what other people who are like you purchased to deliver recommendations for what you might like to buy. Many companies and retail stores such as H&M use AI chatbots to provide customer support.

GPS navigation systems use AI to monitor traffic and give you real-time traffic and weather conditions as well as suggest detours. This led to the new industry - ride share apps. Uber and Lyft have become very popular and they use AI to resolve the conflicting needs of drivers and passengers. AI is at the heart of the push towards self-driving cars. Tesla's autopilot function uses AI to navigate roads, highways and parking lots without human intervention. At the time this was written, the city of San Francisco granted Driverless Cruise and Waymo permits to offer and charge for robotaxis - fully autonomous vehicles.

? Use Case - How Spotify uses AI to gain competitive advantage 7.5.1

Problem: Spotify wanted to better understand users' musical tastes and preferences to provide more personalized recommendations and increase engagement on their platform. However, manually curating playlists tailored to each of their over 286 million users is not feasible (Spotify Technology S.A., 2022). How can Spotify use AI to solve this problem?

Answer

Spotify used artificial intelligence algorithms to dissect attributes of songs and match them to each user's listening habits. The AI recommendation engine analyzes parameters like genre, tempo, key and previous playlists to determine similarities. It then suggests new artists, albums, and playlists tailored to each user. This context-aware recommendation functionality based on AI has driven increased engagement. The strategic use of AI-powered personalization has given Spotify a competitive advantage in user satisfaction and retention.

7.5.2: Global Competition

Many companies today are operating in a global environment. In addition to multinational corporations, many companies now export or import and face competition from products created in countries where labor and other costs are low or where natural resources are abundant. Electronic commerce facilitates global trading by enabling even small companies to buy from or sell to businesses in other countries. Amazon, Netflix, Apple, Samsung, LG, and many more have customers and suppliers worldwide.

? Use case - Global Banks fight cybercriminals 7.5.2

Problem: Banks and financial firms process millions of transactions daily from locations worldwide. As cybercriminals become more sophisticated, fraud detection is extremely challenging when transactions originate globally. Manual review cannot keep up with massive global volumes. How AI can help?

Answer

Banks use AI software that can analyze millions of data points in real-time and detect subtle patterns indicating fraud. By applying machine learning algorithms, the AI can quantify risk on each transaction and flag suspicious ones for further review.

Applying AI to massive global datasets has become essential for financial firms to combat fraud, cybercrime, and manage risk worldwide.

7.5.3: References

McAfee, A. and Brynjolfsson, E. 2008). *Investing in the IT That Makes a Competitive Difference*. Harvard Business Review. Retrieved August 16, 2020, from https://hbr.org/2008/07/investing-in-the-it-that-makes-a-competitive-difference

The Royal Society. (2018). What is Artificial Intelligence? YouTube. [video file: 2:31 minutes] Closed Captioned.

Spotify Fourth Quarter 2021 Earning Report. Retrieved September 2, 2022 from Spotify.com.

7.6: Summary

7.6.1: Summary

In this chapter, we discussed various information systems such as EDI, TPS, BPM, MIS, DSS, which many US companies, including Walmart, Starbucks, Amazon, Netflix, and Apple, use strategically to create and sustain competitive advantage. Acquiring a competitive advantage is hard, and sustaining it can be just as difficult because of technology's innovative nature. Organizations that want to gain a market edge must understand how they want to differentiate themselves and then use all the elements of information systems (hardware, software, data, people, and process) to accomplish that differentiation.

However, simply adopting the latest technologies does not guarantee a competitive advantage. True differentiation comes from leveraging IT strategically to improve business processes and decision-making. Companies must align technology with clearly defined goals for efficiency, innovation, or customer value. Applications like AI and collaborative systems can provide new capabilities, but require skillful management and implementation to generate real gains.

Technologies are enablers and not an automatic solution. Making smart IT investments aligned with business strategy is key. Ultimately, sustainable competitive advantage arises from combining the right technologies, employee training, infrastructure, and good management.

7.7: Study Questions

Study Question 7.7.1

List the five forces in Porter’s Competitive forces model.

Answer

The five forces in Porter's Competitive Forces model are: threat of new entrants, threat of substitute products or services, bargaining power of suppliers, bargaining power of customers, and position among current contestants.

Study Question 7.7.2

What does it mean for a business to have a competitive advantage?

Answer

A company has a competitive advantage when it can generate greater profits than the industry average over a sustained period.

tudy Question 7.7.3

What are the primary activities and support activities of the value chain?

Answer

The primary activities are inbound logistics, operations, outbound logistics, marketing & sales, and service. The support activities are procurement, human resource management, technological development, and firm infrastructure.

Study Question 7.7.4

What has been the overall impact of the Internet on industry profitability? Who has been the true winner.

Answer

The Internet has increased competition and lowered profitability overall by making it easier for new entrants and suppliers. The true winners from the Internet are consumers, who have greater choice and lower prices.

Study Question 7.7.5

List two examples of how Amazon.com used Porter’s five forces model to gain a competitive advantage.

Answer

Amazon reduced supplier power by allowing easy comparison of alternative vendors on its marketplace. It increased threat of substitution with digital media like ebooks.

Study Question 7.7.6

Give an example of how the internet impacted Barnes and Noble's online(bn.com) profitability.

Answer

The Internet enabled new online entrants like Amazon to compete directly with bn.com, limiting its profitability. Digital books also became a threat of substitution.

tudy Question 7.7.7

List and Compare the different information systems. How are they the same? How are they better?

Answer

TPS automates transactions, DSS analyzes data for decisions, ESS provides strategic information to executives for complex data-driven decisions. They enable operations, tactical management, and strategy development.

tudy Question 7.7.8

Give an example of a semi-structured decision and explain what inputs would be necessary to make the decision.

Answer

Pricing holiday merchandise requires analyzing past sales data, demand forecasts, and competitor pricing, but also manager judgment based on experience.

tudy Question 7.7.9

What does a collaborative information system do?

Answer

It allows workers to communicate, share information, coordinate, and make decisions collectively through tools like shared documents, video conferencing, and shared workspaces.

tudy Question 7.7.10

How can IT play a role in competitive advantage, according to the 2008 article by Brynjolfsson and McAfee?

Answer

IT can provide competitive advantage through process innovations if applied strategically, but it requires good management and implementation. IT tends to amplify differences between companies.

Study Question 7.7.11

What is the productivity paradox and how did the perception around it change over time?

Answer

The productivity paradox refers to the observation that as investment in IT increased, productivity decreased or remained stagnant. Later research found that IT can positively impact businesses in less tangible ways that are difficult to quantify.

Study Question 7.7.12

How does Business Process Management (BPM) software provide a competitive advantage?

Answer

BPM helps companies optimize workflows and business processes. This improves efficiency, lowers costs, and enhances customer service.

Study Question 7.7.13

What are some examples of collaborative systems used in business?

Answer

Examples of collaborative systems include shared documents, cloud-based services like Google Drive, video conferencing tools like Zoom, and enterprise social networks.

tudy Question 7.7.14

How can artificial intelligence provide business value?

Answer

AI can provide insights from data, personalized recommendations, more natural interfaces, automation of tasks, and improvements in areas like security.

tudy Question 7.7.15

15. What are some differences between a transaction processing system (TPS) and a decision support system (DSS)?

Answer

A TPS automates structured routine transactions while a DSS helps analyze data to support semi-structured management decisions.

Exercises

1. Discuss the idea that an information system by itself can rarely provide a sustainable competitive advantage.
2. Review the Zoom website. What features of Zoom would contribute to good collaboration? What makes Zoom a better collaboration tool than something like Skype or Google Hangouts?
3. Think of a semi-structured decision that you make in your daily life and build your own DSS using a spreadsheet to help you make that decision.
4. Give an example of AI that you see used in your daily life. Describe one way it can be improved or combined with another information system to gain an advantage.
5. What is an example of a business process you interact with regularly that could be improved through automation? How would technology streamline this process?
6. Think of a key business decision you recently made. What type of information system (TPS, DSS, ESS) would have helped you make that decision? Why?
7. What daily tasks could you automate using a personal TPS? How would this save you time and effort?
8. What collaborative tool would make you more productive working on a group project? How specifically would it help?
9. What data could you analyze with a personal DSS to help make better financial decisions?
10. Pick an industry and analyze it using Porter's Five Forces model. What does this reveal about competition levels and profit potential?

CHAPTER OVERVIEW

8: Business Processes

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Define the term business process
- Identify different systems needed to support business processes in an organization
- Explain the value of an enterprise resource planning(ERP) system
- Explain how business process management and business process engineering work; and
- Understand how information technology combined with business processes can bring an organization competitive advantage.

Business processes are the essence of what a business does, and information systems play an important role in making them work. This chapter will discuss business process management, business process reengineering, and ERP systems.

8.1: Introduction

In the last seven chapters, we have gone through the first four components of an information system (IS). In this chapter, we will discuss the fifth component of information systems, which is a process. People build information systems to solve problems faced by people. Have you wondered how organizations use IS to run their organizations, help their people communicate and collaborate? That is the role of Business Processes in an organization.

This chapter will introduce you to three key concepts that are transforming modern businesses:

- Business process management: How companies improve workflows for greater efficiency
- Business process reengineering: Radically rethinking processes to maximize performance
- ERP systems: Software that integrates data across departments

These ideas will show you how aligning information systems with well-designed business processes can bring competitive advantages. We'll use examples of processes you interact with daily - ordering products, customer service, project collaboration. Let's get started!

8.2: What Is a Business Process?

> **Definition: Business Process**
>
> A business process is a series of related tasks that are completed in a stated sequence to accomplish a business goal.

What exactly are business processes? Imagine the key activities that occur at your favorite restaurant, from customers entering to receiving their meal. These workflows that produce value make up the restaurant's business processes. More formally, a business process is a set of structured activities that interact to produce a product or service for a specific customer. Other examples are a retailer's online order fulfillment process or a doctor's office visit process from check-in to discharge. Well-designed processes are crucial for businesses to deliver value efficiently.

This set of ordered tasks can be simple or complicated. However, the steps involved in completing these tasks can be documented or illustrated in a flow chart. If you have worked in a business setting, you have participated in a business process. Anything from a simple process for making a sandwich at Subway to building a space shuttle utilizes one or more business processes.

Processes are something that businesses go through every day to accomplish their mission. The better their processes, the more effective the business. Some businesses see their processes as a strategy for achieving competitive advantage. A process that uniquely achieves its goal can set a company apart. A process that eliminates costs can allow a company to lower its prices (or retain more profit).

8.2.1: Documenting a Process

Every day, we will conduct many processes without even thinking about them: getting ready for work, using an ATM, reading our email, etc. But as processes grow more complex, they need to be documented.

For businesses, it is essential to do this because it allows them to ensure control over how activities are undertaken in their organization. It also allows for standardization: McDonald's has the same process for building a Big Mac in its restaurants.

The simplest way to document a process is to create a list. The list shows each step in the process; each step can be checked off upon completion. For example, a simple process, such as how to create an account on Amazon, might look like a checklist such as:

1. Go to www.amazon.com.
2. Click on "Hello Sign in Account and Lists" on the top right of the screen
3. Click on "Create your Amazon account." box below the question "New to Amazon?'
4. Enter your name, email, choose your password and then press continue
5. Check your email to verify your new Amazon account

For processes that are not so straightforward, documenting the process as a checklist may not be sufficient. Some processes may need to be documented as paths to be followed depending on certain conditions being met. For example, here is the process for determining if an article for a term needs to be added to Wikipedia:

- Search Wikipedia to determine if the term already exists.
- If the term is found, then an article is already written, so you must think of another term. Repeat step 1.
- If the term is not found, then look to see if there is a related term.
- If there is a related term, then create a redirect.
- If there is not a related term, then create a new article.

This procedure is relatively simple – in fact, it has the same number of steps as the previous example – but because it has some decision points, it is more difficult to track with a simple list. In these cases, it may make more sense to use a diagram to document the process to illustrate both the above steps and the decision points:

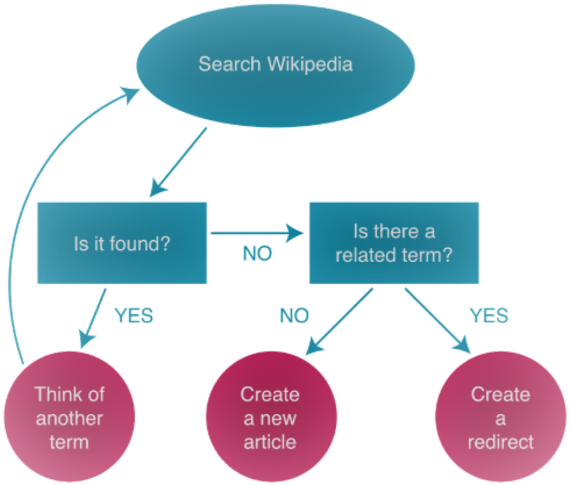


Figure 8.2.1: Business process example to determine if a new term should be added to Wikipedia. Image by Tejal Naik adapted from David Bourgeois is licensed under CC-BY-NC

8.2.2: Managing Business Process Documentation

To standardize a process, organizations must document and continuously keep track of processes to ensure accuracy. As processes change and improve, knowing which processes are the most recent is important. It is also important to manage the process so it is easily updated and changes can be tracked!

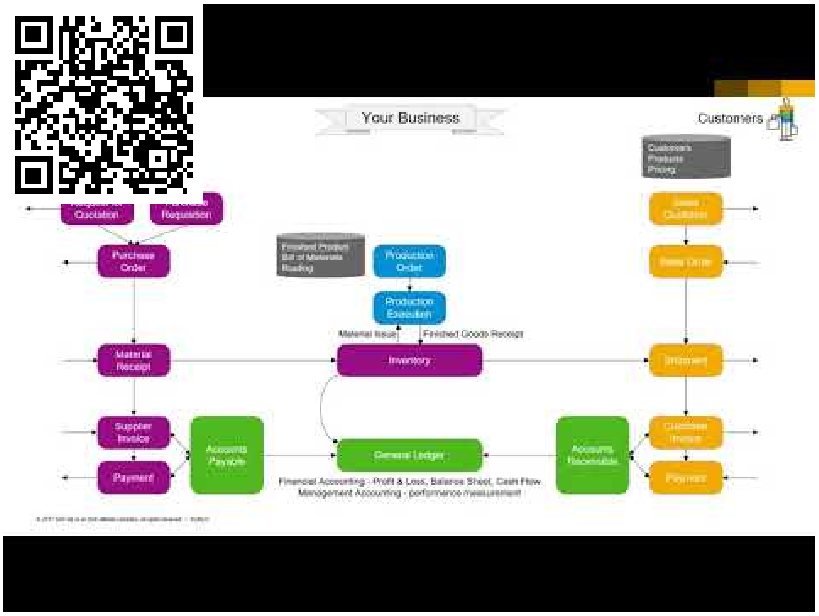
The requirement to manage the documentation process drove the creation of document management systems such as document management, project management, or Business Process Modeling (BPM) software (discussed later in this chapter). Examples include Microsoft Project, IBM's Business Process Manager. A document management system stores and tracks documents and supports the following functions.

- **Versions and timestamps**: BPM will keep multiple versions of documents. The most recent version of a document is easy to identify and will be served up by default.
- **Approvals and workflows**: When a process needs to be changed, the system will manage both access to the documents for editing and the document's routing for approvals.
- **Communication**: When a process changes, those who implement the process need to be aware of the changes. The system will notify the appropriate people when a change to a document is approved.
- **Techniques to model the processes**. Standard graphical representations such as a flow chart, Gantt chart, Pert diagram, or Unified Modeling Language can be used, which we will touch upon in Chapter 10.

Of course, these systems are not only used for managing business process documentation, but they have continued to evolve. Many other types of documents are managed in these systems, such as legal or design documents.

8.2.3: Enterprise Resource Planning (ERP) Systems

An ERP system is a software application with a centralized database that can be used to run an entire company. Have a listen to this video in which Glen Mofattt explains and demonstrated What is ERP, Businesss processes, such as Order-to-cash and procure-to-pay and conversational ERP.



Let's look at an ERP and associated modules as illustrated in Figure 8.2.2.

- **It is a software application**: The system is a software application, which means that it has been developed with specific logic and rules. It must be installed and configured to work for an individual organization.
- **It has a centralized database**: The inner circle of Figure 8.2.2 indicates that all data in an ERP system is stored in a single, central database. This centralization is key to the success of an ERP – data entered in one part of the company can be immediately available to other parts of the company. Examples of data types are shown: business intelligence, eCommerce, assets management, among others.
- **It can be used to run an entire company**: An ERP can be used to manage an entire organization's operations, as shown in the outermost circle of Figure 8.2.2. Each function is supported by a specific ERP module, reading clockwise from the top: Procurement, Production, Distribution, Accounting, Human Resources, Corporate performance and government, Customer services, Sales. Companies can purchase some or all available modules for an ERP representing different organization functions, such as finance, manufacturing, and sales, to support their continued growth.

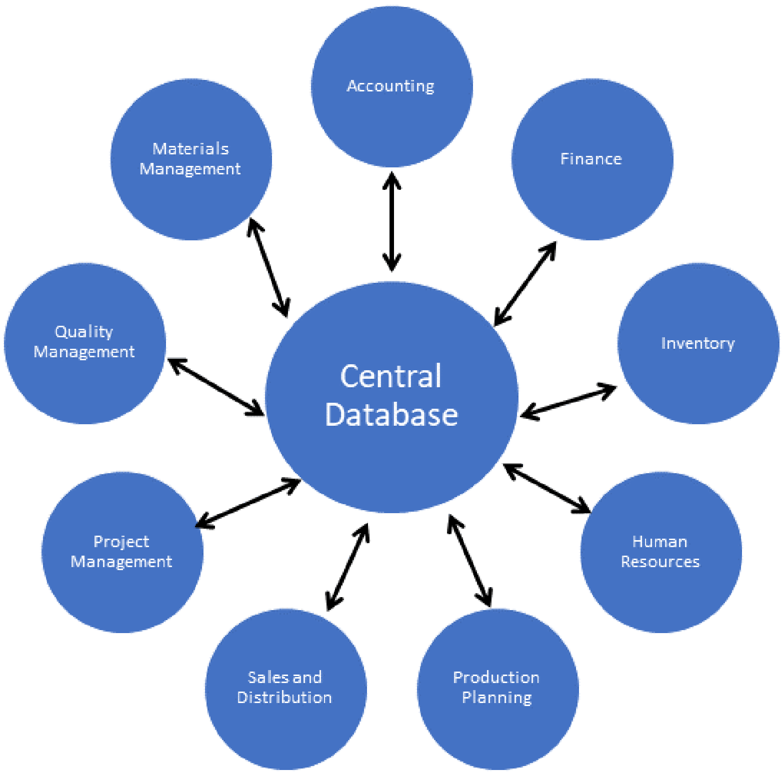


Figure 8.2.2 Enterprise Resource Planning (ERP) Systems' Modules. Image by Ly-Huong Pham, is licensed under CC BY-NC

8.2.3.1: ERP Implementation Costs

Implementing an enterprise resource planning system is a major investment, and costs can vary substantially based on the size of the company, scope of the project, customization needed, and other factors. However, some typical costs include:

- Software Licenses - The fees paid to the ERP vendor for accessing their system. Can range from thousands to millions based on modules, users, etc.
- Hardware Upgrades - New servers and infrastructure may be required to support the ERP. Budget at least $50,000+.
- Implementation Services - Consultants paid to install, test, integrate, migrate data, and configure the system. Often the largest cost.
- Training - End user training on new ERP processes and software use. Plan for at least 10-20% of total budget.
- Customization - Modifying and extending the ERP to support unique processes often adds significant costs.
- Data Conversion - Tedious process of converting legacy data and testing integrations.
- Maintenance - Annual fees ~20% of license costs cover ongoing ERP support and upgrades.

Total costs for a new ERP system in a midsized company can easily exceed $1 million when all the above are factored in. And projects often take 1-3 years from planning to rollout. While costly, the benefits of successfully implementing an ERP are often well worth the investment for growing organizations.

8.2.3.2: When Is It Time to deploy ERP?

Given the cost of an ERP, a decision to purchase and implement it is a serious investment decision. Here are some signs that indicate it may be time to consider implementing an enterprise resource planning system for businesses to make benefits/costs trade-off:

- Disconnected Systems - Data is siloed in disparate systems that don't "talk" to each other, leading to inconsistencies.
- Limited Visibility - Lack of reporting and data analytics makes it difficult to get a big picture view of the business.

- Manual Processes - Too many workflows rely on spreadsheets, email, and paper documents.
- Supply Chain Bottlenecks - More stockouts, delays, and problems with suppliers as production and sales ramp up.
- Customers Frustrated - When current systems can't deliver the experience customers expect.
- Growth Stalling - If the business can't efficiently handle increased sales volume and new business units.
- Lack of Standardization - Processes vary across locations, making management difficult.
- Scale Limitations - Existing systems won't support the business needs at the next stage.

When these pain points start to hinder a company's growth trajectory and operational efficiency, it's a sign an ERP could provide the integration and automation needed to reach the next level.

Use Case: Wawa Inc. Implements SAP ERP 8.2.1

Wawa is a large convenience store chain operating more than hundreds of convenience stores and gas stations along the East Coast. In 2005, Wawa wanted to expand its growth. It decided to implement SAP ERP to replace their outdated legacy systems and support continued growth. An example that it experienced before employing SAP ERP is that it could only have a general idea on topics like spoilage but could not always determine specifically what products were affecting its bottom line. (Csnews.com, 2013)

Answer

Wawa became the first convenience store chain to adopt the SAP Retail Solution company-wide (Cspdailynews.com, 2005). It completed the implementation in 2007, transforming nearly all operations of Wawa, which had more than 540 convenience store locations at the time.

- Highlights of their successful ERP adoption include:
- Integrated various business functions like finance, supply chain, HR, and inventory management onto a single platform.
- Provided new real-time reporting and analytics capabilities across the enterprise.
- Customized the system to meet Wawa’s unique operational needs.
- Completed rollout in under 2 years.

Wawa has continued to invest in the ERP to streamline operations and support growth to over 1,000 locations by 2022 and is ranked as one of 10 brands with a winning strategy for 2023 (csnews.com, 2023)

8.2.3.3: Why ERP Implementations Fail

Despite the potential benefits, many ERP projects unfortunately fail to meet expectations. Some common pitfalls that doom implementations include:

- Lack of clear goals and metrics - Without defined objectives and success metrics, benefits are difficult to measure.
- Insufficient training and change management - Employees won't adopt new processes if proper training and communication is lacking.
- Customization creep - Excessive modifications drive up costs and delay rollout. Should customize only essential processes.
- Poor data quality - Inaccurate or incomplete legacy data migrating into the new system reduces reliability.
- Technical issues - Things like performance problems, integrations not working, lack of support.
- Lack of executive buy-in - Success requires commitment from leadership.

✓ Grocery Brand Lidl's cancels SAP ERP in 2018 8.2.1

Lidl is a major German discount supermarket chain. In an effort to expand into the competitive US grocery market, Lidl ambitiously rushed to roll out SAP ERP across their new US stores in 2018. However, their implementation ran into major issues:

- Unrealistic timeline - Their aggressive 9 month schedule to deploy the system nationally was impractical.
- Lack of customization - Lidl did not properly customize processes for regional supplier and distribution differences.
- Change management flaws - Employees struggled with mandated workflow changes without proper training and communication.
- Technical bugs - System glitches led to inventory management failures like warehouses missing orders.
- Loss of competitiveness - Standardized processes led them to lose differentiation against entrenched US chains.

After nearly two years of struggles, Lidl ultimately abandoned their troubled SAP ERP rollout. The failed implementation cost them over €500 million and made it harder to compete in the US market.

Solution

What happened? Lidl has always based their inventory systems on the price they pay for goods, whereas most companies base their systems on the retail price they sell the goods for. So the SAP implementation had to be customized, which set off a cascade of implementation problems. It also suffered from change management flaws, including turnover in the executive ranks, and you have a recipe for ERP disaster (cio.com, 2022)

When an ERP vendor designs a module, it has to implement the associated business processes' rules. A selling point of an ERP system is that it has best practices built right into it. In other words, when an organization implements an ERP, it also gets improved best practices as part of the deal.

For many organizations, implementing an ERP system is an excellent opportunity to improve their business practices and upgrade their software simultaneously. But for others, an ERP brings them a challenge: Is the process embedded in the ERP better than the process they are currently utilizing? If they implement this ERP, which happens to be the same one that all of their competitors have, will they become more like them, making it much more difficult to differentiate themselves?

This has been one of the criticisms of ERP systems: they commoditize business processes, driving all businesses to use the same processes, thereby losing their uniqueness. The good news is that ERP systems also have the capability to be configured with custom processes. For organizations that want to continue using their own processes or even design new ones, ERP systems offer ways to support this through customizations.

However, a drawback to customizing an ERP system is that organizations must maintain the changes themselves. Whenever an update to the ERP system comes out, any organization that has created a custom process will be required to add that change to their ERP. This will require someone to maintain a listing of these changes and retest the system whenever an upgrade is made. Organizations will have to wrestle with this decision: When should they accept the best-practice processes built into the ERP system, and when should they spend the resources to develop their own processes? It makes the most sense only to customize those processes critical to the company's competitive advantage.

Some of the best-known ERP vendors are SAP, Microsoft, and Oracle.

Registered trademark of SAP, Microsoft and Oracle

Adopting an ERP is about adopting a standard business process across the entire company. The benefits are many, and so are the risks of adopting an ERP system. Organizations can spend up to millions of dollars and a few years to fully implement an ERP. Hence, adopting an ERP is a strategic decision to decide how a company wants to run its organization based on a set of business rules and processes to deliver competitive advantages.

Unique Features of Major ERP System

ERP System	Key Unique Features
SAP	Powerful analytics and BI Flexible cloud options Industry solutions for 25+ verticals Global reach and localization Tight integration across modules
Oracle	Unified data model Embedded social/analytics Flexible deployment models Strong usability focus Deep retail and manufacturing capabilities
Microsoft Dynamics	Integrates with other Microsoft apps Cloud-first delivery model Strong CRM and retail functionality Global partner network
Infor	Specialized by industry Embedded machine learning/AI Contextual learning engine Developed for multi-tenant SaaS Lower cost of ownership

8.2.4: Business Process Management (BPM)

Organizations that are serious about improving their business processes will also create structures to manage those processes. BPM can be thought of as an intentional effort to plan, document, implement, and distribute an organization’s business processes with information technology support.

BPM is more than just automating some simple steps. While automation can make a business more efficient, it cannot provide a competitive advantage. On the other hand, BPM can be an integral part of creating that advantage, as we saw in Chapter 7.

Not all of an organization’s processes should be managed this way. An organization should look for processes essential to the business's functioning and those that may be used to bring a competitive advantage. The best processes to look at include employees from multiple departments, those who require decision-making that cannot be easily automated, and processes that change based on circumstances.

Example 8.2.1

Suppose a large clothing retailer is looking to gain a competitive advantage through superior customer service.

Solution

They create a task force to develop a state-of-the-art returns policy that allows customers to return any clothing article, no questions asked. The organization also decides that to protect the competitive advantage that this returns policy will bring, they will develop their own customization to their ERP system to implement this returns policy.

As they prepare to roll out the system, they invest in training for all of their customer-service employees, showing them how to use the new system and process returns.

Once the updated returns process is implemented, the organization will measure several key indicators about returns that will allow them to adjust the policy as needed. For example, if they find that many customers are returning their high-end clothing after wearing it once, they could implement a change to the process that limits – to, say, fourteen days – the time after the original purchase that an item can be returned. As changes to the returns policy are made, the changes are rolled out via internal communications, and updates to the system's returns processing are made. In this example, the system would no longer allow an item to be returned after fourteen days without an approved reason.

If done properly, business process management will provide several key benefits to an organization, contributing to competitive advantage. These benefits include:

- **Empowering employees**: When a business process is correctly designed and supported with information technology, employees will implement it on their own authority. In our returns policy example, an employee would be able to accept returns made before fourteen days or use the system to make determinations on what returns would be allowed after fourteen days.
- **Built-in reporting**: By building measurement into the programming, the organization can keep up to date on key metrics regarding their processes. In our example, these can improve the returns process and, ideally, reduce returns.
- **Enforcing best practices**: As an organization implements processes supported by information systems, it can implement the best practices for that business process class. In our example, the organization may require that all customers returning a product without a receipt show a legal ID. This requirement can be built into the system so that the return will not be processed unless a valid ID number is entered.
- **Enforcing consistency**: By creating a process and enforcing it with information technology, it is possible to create consistency across the organization. In our example, all stores in the retail chain can enforce the same returns policy. And if the returns policy changes, the change can be instantly enforced across the entire chain.

An emerging trend is that companies are looking for process automation technologies. Robotic Process Automation (RPA) is one such technology that can automate repetitive, rules-based tasks. RPA utilizes software "robots" that can interact with applications and systems to perform mundane activities such as data entry, processing transactions, and generating reports. This enables faster processing, reduced errors, and lower operational costs. For example, an RPA bot can log into a system, extract customer data, calculate insurance premiums, generate documents, and interface with other systems automatically based on predefined rules. RPA complements BPM well - BPM provides the strategic analysis of processes, while RPA enables automating the tactical workflow steps.

8.2.5: Business Process Re-engineering (BPR)

As organizations look to manage their processes to gain a competitive advantage, they also need to understand that their existing ways of doing things may not be the most effective or efficient. A process developed in the 1950s will not be better just because it is now supported by technology.

In 1990, Michael Hammer's article (1990) "Reengineering Work: Don't Automate, Obliterate." discusses how simply automating a bad process does not make it better. Instead, companies should "blow up" their existing processes and develop new processes that take advantage of the new technologies and concepts. Instead of automated outdated processes that do not add value, companies should use modern IT technologies to re-engineer their processes to achieve significant performance improvements radically.

Business process reengineering is not just taking an existing process and automating it. BPR fully understands the process's goals and then dramatically redesigns it from the ground up to achieve dramatic improvements in productivity and quality. But this is easier said than done. Most of us think about making small, local improvements to a process; complete redesign requires thinking on a larger scale.

Hammer provides some guidelines for how to go about doing business process reengineering. You can read an excerpt from the July-August 1990 HBR issue (accessible with a free account at HBR, at the time of this writing). A summary of the guidelines is below:

- **Organize around outcomes, not tasks.** This means to design the process so that, if possible, one person performs all the steps. Instead of repeatedly repeating one step in the process, the person stays involved in the process from start to finish. For example, Mutual Benefit LIfe’s use of one person(a case manager) to perform all tasks required for a completed insurance application from paperwork, medical checks, risk checks to policy pricing.
- **Have those who use the outcomes of the process perform the process**. Using information technology, many simple tasks are now automated to empower the person who needs the process's outcome to perform it. Hammer's example is purchasing: instead of having every department in the company use a purchasing department to order supplies, have the supplies ordered directly by those who need the supplies using an information system.
- **Subsume information-processing work into the real work that produces the information**. When one part of the company creates information (like sales information or payment information), it should be processed by that department. There is no need for one part of the company to process information created in another part of the company. An example of this is Ford's redesigned accounts payable process where receiving processes the information about goods received rather than sending it to accounts payable.
- **Treat geographically dispersed resources as though they were centralized**. With the communications technologies in place today, it becomes easier than ever to not worry about physical location. A multinational organization does not need separate support departments (such as IT, purchasing, etc.) for each location.
- **Link parallel activities instead of integrating their results**. Departments that work in parallel should share data and communicate with each other during their activities instead of waiting until each group is done and then comparing notes.
- **Put the decision points where the work is performed, and build controls into the process**. The people who do the work should have decision-making authority, and the process itself should have built-in controls using information technology. The workers become self-managing and self-controlling, and the manager’s role changes to supporter and facilitator.
- **Capture information once at the source**. Requiring information to be entered more than once causes delays and errors. With information technology, an organization can capture it once and then make it available whenever needed.

These principles may seem like common sense today, but in 1990 they took the business world by storm. Ford and Mutual Benefit Life’s successful attempt at reengineering a core business process have become textbook examples of Business process Reengineering.

Organizations can improve their business processes by many orders of magnitude without adding new employees, simply changing how they did things (see sidebar). For examples of how modern businesses of this century undergo process reengineering to competitive advantage, read this blog by Carly Burdova on minit.

The resulting changes of a BPR project can be disruptive to the workforce even when they significantly improve the efficiency of the operations, such as removing bottlenecks or duplicates of work, etc. that may lead to laying off part of the workforce or job roles. Hence, business process engineering must be managed carefully, to keep all stakeholders informed to manage their expectations and to retain talents by reducing unfounded rumors about a BPR project. In today's environment, BPR principles have been integrated into businesses and are considered part of good business process management and continuous improvement effort.

Sidebar: Re-engineering the College Bookstore

The process of purchasing the correct textbooks on time for college classes has always been problematic. And now, with online bookstores such as Amazon and Chegg competing directly with the college bookstore for students' purchases, the college bookstore is under pressure to justify its existence.

But college bookstores have one big advantage over their competitors: they have access to students' data. In other words, once a student has registered for classes, the bookstore knows exactly what books that student will need for the upcoming term. To leverage this advantage and take advantage of new technologies, the bookstore wants to implement a new process that will make purchasing books through the bookstore advantageous to students. Though they may not compete on price, they can provide other advantages, such as reducing the time it takes to find the books and guaranteeing that the book is the correct one for the class. To do this, the bookstore will need to undertake a process redesign.

The process redesign's goal is simple: capture a higher percentage of students as customers of the bookstore. The before and after the reengineering is shown in Figure $8.2.3$.

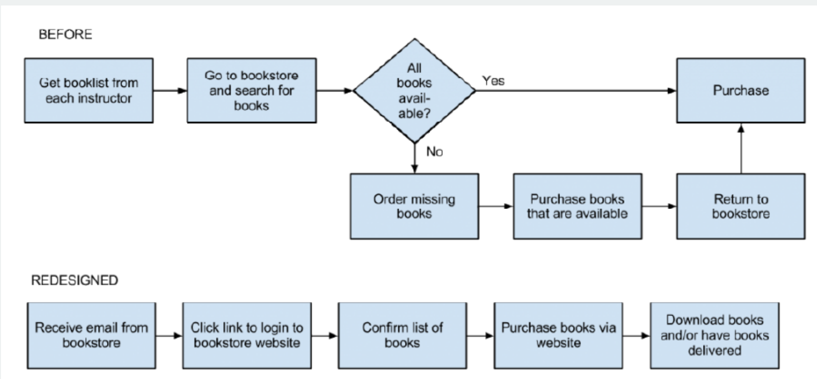


Figure $8.2.3$ College bookstore process redesign. Image by David Bourgeois, Ph.D. is licensed CC BY 4.0

The Before process steps are:

1. The students get a booklist from each instructor
2. Go to the bookstore to search for the books on the list
3. If they are available, then students can purchase them
4. If they are not available, then the students will order the missing books
5. The students purchase the missing books
6. Students may need to do step 3 if it is not yet done

After diagramming the existing process and meeting with student focus groups, the bookstore develops a new process. In the newly redesigned process:

1. The bookstore utilizes information technology to reduce the amount of work the students need to do to get their books by sending the students an email with a list of all the books required for their upcoming classes along with purchase options(new, used, or rental)
2. By clicking a link in this email, the students can log into the bookstore, confirm their books, and pay for their books online.
3. The bookstore will then deliver the books to the students.

The new re-engineered process delivers the business goal of capturing a larger percentage of students as customers of the bookstore using technology to provide a valuable value-added service to students to make it convenient and faster.

8.2.6: Managing Process Change

We discussed People as an important of any IS. Implementing new processes or technologies often requires changing employee behaviors and established ways of working require buy-in from all the key stakeholders from all levels. Without proper change management, people may resist or circumvent the changes. Some change management best practices include:

- Communicate early and often - Have leadership announce the coming changes and rationale well in advance through meetings, email, intranet sites.
- Involve employees upfront - Get employee input on the process redesign and system requirements. This builds buy-in.
- Provide continuous updates - As the project progresses, regularly inform staff through status reports, newsletters, training invitations.
- Offer hands-on training - Provide training sessions and user manuals to develop competency and comfort with process and system changes.
- Highlight benefits - Demonstrate how the changes will make employees' work easier with time savings and productivity gains.
- Share success stories - As small implementation milestones are hit, publicly highlight successes to build confidence and enthusiasm.
- Address concerns - Provide forums for employees to voice concerns and gain clarification, through feedback channels, focus groups.
- Incentivize adoption - Consider offering rewards for achieving proficiency milestones in using new systems and processes.
- Monitor progress - Track usage metrics and feedback. Identify adoption issues early to allow corrective actions.

In fact, change management is vital for any successful company-wide project. Gaining user buy-in reduces resistance and increases compliance with redesigned processes.

8.2.7: ISO Certification

Have you noticed those "ISO 9001 Certified" stamps on products or in company brochures? ISO 9000 is an internationally recognized set of standards for quality management across any industry. Companies get certified to show customers they have documented procedures that ensure high-quality, reliable products.

For example, an electronics manufacturer might establish processes for inspecting parts, testing finished goods, calibrating lab equipment, and training employees. Even the customer service department needs standardized protocols. By routinely auditing and updating their ISO 9000 quality system, companies can identify inefficiencies and prevent defects. This boosts customer satisfaction, as well as sales from the trust ISO certification brings.

ISO is an acronym for International Standard Organization, representing a global network of national standards bodies

Registered trademark of International Standard Organization. Image by International Organization for Standardization is licensed CC-by-SA 4.0 International

This body defines quality standards that organizations can implement to show that they are, indeed, effectively managing business processes. The ISO 9000 certification is focused on quality.

To receive ISO certification, an organization must be audited and found to meet specific criteria. In its most simple form, the auditors perform the following review:

- Tell me what you do (describe the business process).
- Show me where it says that (reference the process documentation).
- Prove that this is what happened (exhibit evidence in documented records).

Over the years, this certification has evolved, and many branches of the certification now exist. The ISO 9000 family addresses various aspects of quality management. ISO certification is one way to separate an organization from others regarding its quality and services and meet customer expectations.

8.2.7.1: References

Hammer, Michael (1990). *Reengineering work: don't automate, obliterate.* Harvard Business Review 68.4: 104–112

Wawa Taps SAP (2005). Retrieved August 1, 2023 from CSP Daily News.

Wawa Turns to SAP to Power Entry Into New Markets (2013). Retrieved on August 1, 2023 from CSnews.com.

Wawa Ranks Among Brands to Watch in 2023. Retrieved on October 1, 2023 from CSnews.com.

Lidl cancels SAP introduction having sunk €500 million into it (2018). Retrieved on August 1, 2023 from Consultancy.uk.

Lidl: Big problem for German supermarket giant (2022). Retrived on August 1, 2023 from cio.com

8.3: Summary

The advent of information technologies has had a huge impact on how organizations design, implement, and support business processes. This chapter explored how information systems integrate with business processes to drive efficiency, innovation, and competitive advantage. We defined business processes and examined how documentation, analysis, and strategic management of these workflows are transforming modern organizations.

Major topics included business process management frameworks to continually optimize operations. Business process reengineering provides more radical redesign thinking and allows organizations to vastly improve their effectiveness and the quality of their products and services. Robotic process automation offers new capabilities for automating repetitive tasks. Practical use cases illustrated how technologies like ERP integrate data and processes across departments.

Key lessons are that competitive advantage comes from aligning information systems with thoughtfully redesigned processes. Technologies enable and accelerate well-designed workflows. A process viewpoint remains essential; technology alone cannot transform results.

8.4: Study Questions

? Study Question 8.4.1

What does the term business process mean?

Answer

A business process is a series of related tasks that are completed in a stated sequence to accomplish a business goal.

? Study Question 8.4.2

What are three examples of business processes (from a job you have had or an organization you have observed?)

Answer

Example of processes could include order fulfillment, customer service, recruiting, accounting, etc.

? Study Question 8.4.3

What is the value of documenting a business process?

Answer

Documenting processes allows organizations to standardize procedures, provide training, measure performance, identify improvements, and automate tasks.

? Study Question 8.4.4

What is an ERP system? How does an ERP system enforce best practices for an organization?

Answer

An ERP integrates data and processes across departments onto a centralized platform. ERP systems incorporate industry best practices into their process workflows.

? Study Question 8.4.5

What is one of the criticisms of ERP systems.

Answer

One criticism is that ERPs can make companies more similar by standardizing their processes. Customization may be needed to retain uniqueness.

? Study Question 8.4.6

What is business process reengineering (BPR)? How is it different from incrementally improving a process?

Answer

BPR radically redesigns processes for dramatic gains. It differs from incremental improvements by fully rethinking entire workflows.

? Study Question 8.4.7

Why did business process reengineering (BPR) get a bad name?

Answer

BPR was associated with layoffs as reengineered processes needed fewer employees. Change management was lacking.

? Study Question 8.4.8

List the guidelines for redesigning a business process.

Answer

Organize around outcomes, have users perform process, subsume information processing into work, centralize dispersed resources, link parallel activities, put decision points where work is performed, capture info once at source.

? Study Question 8.4.9

What is business process management (BPM)? What role does it play in allowing a company to differentiate itself?

Answer

BPM involves strategically managing workflows through documentation, analysis, automation, and continuous improvement. Aligned processes can differentiate a company.

? Study Question 8.4.10

What are the key benefits that a Business Process Management (BPM) provides?

Answer

Key BPM benefits are empowering employees, enforcing best practices, building in reporting, ensuring consistency, and facilitating continuous improvement.

? Study Question 8.4.11

What does ISO certification signify?

Answer

ISO certification shows a company has documented procedures and processes that conform to international quality standards.

? Study Question 8.4.12

What are some top reasons a growing business may decide to adopt an ERP system?

Answer

Reasons to adopt ERP include integrating financial data, improving supply chain management, standardizing processes, accessing real-time data analytics, enhancing customer experience, and supporting growth.

? Study Question 8.4.13

What are some indicators it may be time for a business to implement an ERP?

Answer

Signs it may be time for ERP include disconnected systems, limited visibility, reliance on manual processes, supply chain bottlenecks, frustrated customers, stalled growth, lack of standardization, and systems hitting scalability limits.

? Study Question 8.4.14

What are some common reasons ERP projects fail?

Answer

Common failure reasons are lack of clear goals/metrics, insufficient training, excessive customization, poor data quality, technical issues, and lack of executive buy-in.

? Study Question 8.4.15

What are some differences between business process management and business process reengineering?

Answer

BPM focuses on incremental optimization versus BPR's radical redesign. BPM is continuous while BPR is typically a one-time project.A

? Study Question 8.4.16

What is robotic process automation and how does it relate to business process management?

Answer

RPA uses software bots to automate repetitive tasks. It complements BPM's process focus by handling tactical workflow automation.

Exercises

1. Think of a business process that you have had to perform in the past. How would you document this process? Would a diagram make more sense than a checklist? Document the process both as a checklist and as a diagram.
2. Review the return policies at your favorite retailer and then answer this question: What information systems do you think need to be in place to support their return policy.

3. If you were implementing an ERP system, in which cases would you be more inclined to modify the ERP to match your business processes? What are the drawbacks of doing this?
4. Which ERP is the best? Do some original research and compare three leading ERP systems to each other. Write a two- to three-page paper that compares their features.
5. Research a company that chooses to implement an ERP. Write a report to describe it.
6. Research a failed implementation of an ERP. Write a report to describe why.
7. Research and write a report on how a company can obtain an ISO quality management certification.
8. Interview someone who has experience with an ERP implementation and write up their insights.
9. Diagram an order fulfillment or recruiting process; identify ways to improve it using BPR principles.
10. Evaluate processes at a retailer; propose an ERP implementation plan to improve operations.
11. Compare BPM suites from vendors like IBM, Appian, and Oracle.
12. Assess manual processes at your university; recommend process automation technologies to optimize them.
13. Interview employees at a company that recently implemented a new process or system. Report on their change management experience.
14. Review job listings for Business Process Management or ERP-related roles; summarize required skills and qualifications.
15. Find a case study online about a company's use of business process reengineering; summarize the key lessons.
16. Select a simple process you regularly follow, like making coffee. Diagram the process as-is. Redesign it incorporating BPR principles.

CHAPTER OVERVIEW

9: The People in Information System

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe each of the different roles that people play in the design, development, and use of information systems;
- Understand the different career paths available to those who work with information systems;
- Explain the importance of where the information-systems function is placed in an organization;
- Describe the different types of users of information systems.

This chapter will provide an overview of the different types of people involved in information systems. This includes people(and machines) who create information systems, those who operate and administer information systems, those who manage or support information systems, those who use information systems, and IT's job outlook.

9.1: Introduction

In this text's opening chapters, we focused on the technology behind information systems: hardware, software, data, and networking. In the last chapter, we discussed business processes and the key role they can play in a business's success. In this chapter, we will be discussing the last component of an information system: people.

Figure $9.1.1$: People in Information systems. Image by Karen Arnold - PublicDomainPicutres is licensed CCO-PD

People are involved in information systems in just about every way you can think of: people imagine information systems, develop information systems, support information systems, and, perhaps most importantly, people use information systems.

9.2: The Creators of Information Systems

The first group of people we are going to look at plays a role in designing, developing, and building information systems. These people are generally very technical and have a background in programming and mathematics. Just about everyone who works in creating information systems has a minimum of a bachelor's degree in computer science or information systems. However, that is not necessarily a requirement. We will be looking at the process of creating information systems in more detail in chapter 10.

9.2.1: Systems Analyst

The systems analyst's role is unique in that it straddles the divide between identifying business needs and imagining a new or redesigned computer-based system to fulfill those needs. This individual will work with a person, team, or department with business requirements and identify the specific details of a system that needs to be built. Generally, this will require the analyst to understand the business itself, the business processes involved, and the ability to document them well. The analyst will identify the different stakeholders in the system and work to involve the appropriate individuals.

Once the requirements are determined, the analyst will begin translating these requirements into an information-systems design. A good analyst will understand what different technological solutions will work and provide several different alternatives to the requester, based on the company's budgetary constraints, technology constraints, and culture. Once the solution is selected, the analyst will create a detailed document describing the new system. This new document will require that the analyst understand how to speak in systems developers' technical language.

A systems analyst generally is not the one who does the actual development of the information system. The design document created by the systems analyst provides the detail needed to create the system and is handed off to a programmer (or team of programmers) to do the actual creation of the system. In some cases, however, a systems analyst may create the system that he or she designed. This person is sometimes referred to as a programmer-analyst.

In other cases, the system may be assembled from off-the-shelf components by a person called a systems integrator. This is a specific type of systems analyst that understands how to get different software packages to work with each other.

To become a systems analyst, you should have a background in business and systems design. You also must have strong communication and interpersonal skills plus an understanding of business standards and new technologies. Many analysts first worked as programmers and/or had experience in the business before becoming systems analysts. The best systems analysts have excellent analytical skills and are creative problem solvers.

9.2.2: Computer Programmer (or Software developer)

A computer programmer or software developer is responsible for writing the code that makes up computer software. They write, test, debug and create documentation for computer programs. In the case of systems development, programmers generally attempt to fulfill the design specifications given to them by a systems analyst. Many different programming styles exist: a programmer may work alone for long stretches of time or may work in a team with other programmers. A programmer needs to understand complex processes and the intricacies of one or more programming languages. They are usually referred to by the programming language they most often use: Java programmer or Python programmer. Good programmers are very proficient in mathematics and excel at logical thinking.

9.2.3: Computer Engineer

Computer engineers design the computing devices that we use every day. There are many types of computer engineers who work on various types of devices and systems. Some of the more prominent engineering jobs are as follows:

- **Hardware engineer**: A hardware engineer designs hardware components, such as microprocessors. A hardware engineer is often at the cutting edge of computing technology, creating something brand new. Other times, the hardware engineer's job is to engineer an existing component to work faster or use less power. Many times, a hardware engineer's job is to write code to create a program that will be implemented directly on a computer chip.
- **Software engineer**: Software engineers do not actually design devices; instead, they create new programming languages and operating systems, working at the lowest hardware levels to develop new kinds of software to run on the hardware.
- **Systems engineer**: A systems engineer takes the components designed by other engineers and makes them all work together. For example, to build a computer, the motherboard, processor, memory, and hard disk all have to work together. A systems

engineer has experience with many different hardware and software types and knows how to integrate them to create new functionality.
- **Network engineer**: A network engineer’s job is to understand the networking requirements and then design a communications system to meet those needs, using the networking hardware and software available.

There are many different types of computer engineers, and often the job descriptions overlap. While many may call themselves engineers based on a company job title, there is also a professional designation of “professional engineer,” which has specific requirements behind it. In the US, each state has its own set of requirements for using this title, as do different countries around the world. Most often, it involves a professional licensing exam.

9.2.4: References

Careers in IT. Retrieved November 13, 2020, from https://www.itcareerfinder.com/it-careers/mobile-application-developer.html

9.3: Information-Systems Operations and Administration

Another group of information-systems professionals is involved in the day-to-day operations and administration of IT. These people must keep the systems running and up-to-date so that the rest of the organization can make the most effective use of these resources.

9.3.1: Computer Operator

A computer operator is a person who keeps large computers running. This person's job is to oversee the mainframe computers and data centers in organizations. Some of their duties include keeping the operating systems up to date, ensuring available memory and disk storage, and overseeing the computer's physical environment. Since mainframe computers have increasingly been replaced with servers, storage management systems, and other platforms, computer operators' jobs have grown broader and include working with these specialized systems.

9.3.2: Database Administrator

A database administrator (DBA) is the person who manages the databases for an organization. This person operates and maintains databases, including database recovery and backup procedures, used as part of applications or the data warehouse. They are responsible for securing the data and ensuring that only users who are approved to access the data can do so. The DBA also consults with systems analysts and programmers on projects requiring access to or creating databases.

- **Database Architect**: Database architects design and create secure databases that meet the needs of an organization. They work closely with software designers, design analysts, and others to create comprehensive databases that may be used by hundreds, if not thousands, of people. Most organizations do not staff a separate database architect position. Instead, they require DBAs to work on both new and established database projects.
- **Database Analys**t: Some organizations create a separate position, Database Analyst, who looks at databases from a higher level. He analyzes database design and the changing needs of an organization, recommends additions for new projects, and designs the tables and relationships.
- **Oracle DBA**: A DBA that specializes in Oracle database. Oracle DBA's handle capacity planning, evaluate database server hardware, and manage all aspects of an Oracle database, including installation, configuration, design, and data migration.

9.3.3: Help-Desk/Support Analyst

Most midsize to large organizations have their own information-technology help desk and are the most visible IT roles. The help desk is the first line of support for computer users in the company. Computer users who are having problems or need information can contact the help desk for assistance. Often, a help-desk worker is a junior-level employee who does not necessarily know how to answer all of the questions that come his or her way. In these cases, help-desk analysts work with senior-level support analysts or have a computer knowledgebase at their disposal to help them investigate the problem at hand. The help desk is a great place to break into IT because it exposes you to all of the company's different technologies. A successful help-desk analyst has conflict resolutions, active listening skills, problem-solving abilities, and a wide range of technical knowledge across hardware, software, and networks.

9.3.4: Trainer

A computer trainer conducts classes to teach people specific computer skills. For example, if a new ERP system is installed in an organization, one part of the implementation process is to teach all users how to use the new system. A trainer may work for a software company and be contracted to come in to conduct classes when needed; a trainer may work for a company that offers regular training sessions, or a trainer may be employed full time for an organization to handle all of their computer instruction needs. To be successful as a trainer, you need to be able to communicate technical concepts well and have a lot of patience!

9.3.5: Quality Support Engineers

A quality engineer establishes and maintains a company's quality standards and tests systems to ensure efficiency, reliability, and performance. They are also responsible for creating documentation that reports issues and errors relating to the computer and software systems.

9.3.6: Change Management Roles

As we have discussed in previous chapters, people play a critical role in the functioning of an information system. Whenever a new information system is introduced, change management professionals are responsible for leading the organization through the transition process. They create plans for communication, training, and user adoption strategies. It is crucial to consider the needs of employees affected by the new system and ensure that they feel supported and prepared throughout the process. Failure to provide proper training or to gain employees' support for significant changes, including major software adoption, often results in failed implementations that can be costly for companies and even lead to job losses.

9.3.7: Change Management Models

Frameworks like Kotter's 8-Step Change Model and Lewin's Three-Stage Model provide guidance for leading organizational change. Common steps include creating urgency, forming a coalition, developing a vision, training employees, empowering action, and institutionalizing change. Understanding and applying established change management models can increase success when implementing major IT initiatives.

9.4: Managing Information Systems

The management of information-systems functions is critical to the success of information systems within the organization. Here are some of the jobs associated with the management of information systems.

9.4.1: Chief Information Officer(CIO)

The CIO, or chief information officer, is the head of the information-systems function. This person aligns the plans and operations of the information systems with the strategic goals of the organization. This includes tasks such as budgeting, strategic planning, and personnel decisions for the information-systems function. This is a high-profile position as the CIO is also the face of the organization's IT department. This involves working with senior leaders in all parts of the organization to ensure good communication and planning.

Interestingly, the CIO position does not necessarily require a lot of technical expertise. While helpful, it is more important for this person to have good management and people skills and understand the business. Many organizations do not have someone with the CIO's title; instead, the head of the information-systems function is called vice president of information systems or director of information systems.

9.4.2: Functional Manager

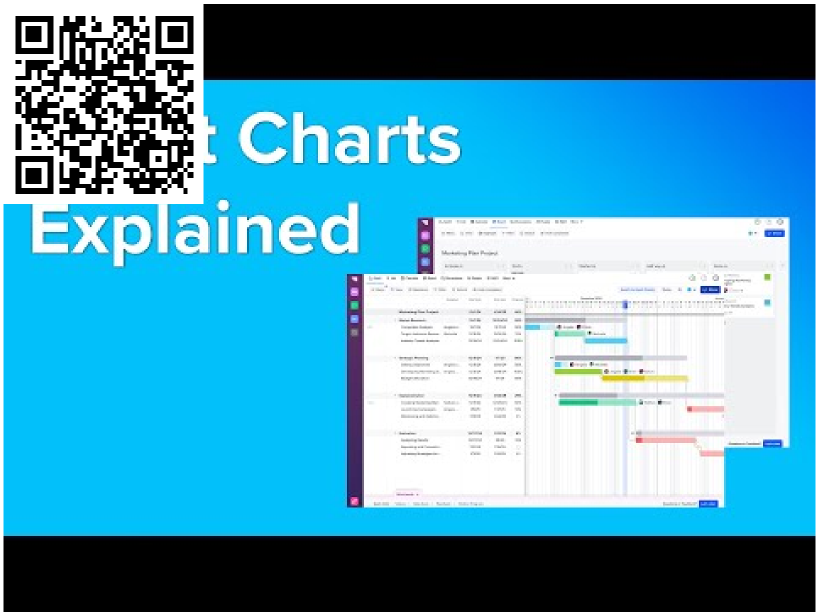
As an information-systems organization becomes larger, many of the different functions are grouped and led by a manager. These functional managers report to the CIO and manage the employees specific to their function. For example, in a large organization, a group of systems analysts reports to a systems-analysis function manager. For more insight into how this might look, see the discussion later in the chapter of how information systems are organized.

9.4.3: ERP Management

Organizations using an ERP require one or more individuals to manage these systems. These people make sure that the ERP system is completely up to date, work to implement any changes to the ERP needed, and consult with various user departments on needed reports or data extracts.

9.4.4: Project Managers

Information-systems projects are notorious for going over budget and being delivered late. In many cases, a failed IT project can spell doom for a company. A project manager is responsible for keeping projects on time and budget. This person works with the project stakeholders to keep the team organized and communicates the status of the project to management. A project manager does not have authority over the project team; instead, the project manager coordinates schedules and resources to maximize the project outcomes. Whether you are new or a veteran project manager, you will most likely use the Gantt chrt to manage your project. Watch this video (8:02 min) from Team Gannt for an overview of a Gantt chart.



A project manager must be a good communicator and an extremely organized person. A project manager should also have good people skills. Many organizations require their project managers to become certified as project management professionals (PMP).

9.4.5: Information-Security Officer

An information security officer is in charge of setting information-security policies for an organization and then overseeing those policies' implementation. This person may have one or more people reporting to them as part of the information security team. As information has become a critical asset, this position has become highly valued. The information-security officer must ensure that the organization's information remains secure from both internal and external threats.

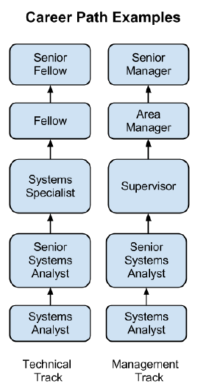
9.5: Emerging Roles

As technology evolves, many new roles are becoming more common as other roles fade. For example, as we enter the age of “big data,” we see the need for more data analysts and business-intelligence specialists. Many companies are now hiring social media experts and mobile-technology specialists. The increased use of cloud computing and virtual-machine technologies also is breeding demand for expertise in those areas.

- **Cloud system engineer**: In the past, companies would typically store their data in large physical databases or even hire database firms, but today, they turn to cloud storage as a low-cost and effective means of storing data. This is where cloud engineers come in. They are responsible for the design, planning, management, maintenance, and support of an organization's cloud computing environment.
- **Cyber Security Analyst** (or engineer): As new technologies emerge, so do the number of security threats online. Cybersecurity is a growing field that focuses on protecting organizations from digital attacks and keeping their information and networks safe. The following are examples of some of the many cybersecurity roles:
  - Security Administrator: These professionals serve in high-level roles, overseeing the IT security efforts of their organization. They create policies and procedures, identify weak areas of networks, install firewalls, and respond to security breaches.
  - Security Architect: Security architects design, plan, and supervise systems that thwart potential computer security threats. They must find the strengths and weaknesses of their organizations' computer systems, often developing new security architectures.
  - Security Analyst: Organizations employ a security analyst to protect computer and networking systems from cyber-attacks and hackers and keep information and networks safe.
- **AI/Machine Learning Engineer**: These engineers develop and maintain AI (artificial intelligence) machines and systems that have the ability to learn and utilize existing knowledge. As more and more industries turn towards automating certain aspects of the workforce, AI/Machine learning engineers will be in high demand. With a background in machine learning, you can get a high-paying job as a Machine Learning Engineer, Data Scientist, NLP Scientist, Business Intelligence Developer, or a Human-Centered Machine Learning Designer
- **Computer Vision Engineer**: Computer vision engineers create and use computer vision and machine learning algorithms that acquire, process, and analyze digital images, videos, etc. Their work is closely linked to AR(augmented reality) and VR (virtual reality). As we see the rise of such technologies as self-driving vehicles, these skills' demands will continue to grow.
- **Big Data Engineer**: Big Data Engineers create and manage a company's Big Data infrastructure, such as SQL engines and tools. A big data engineer installs continuous pipelines that run to and from huge pools of filtered information from which data scientists can pull relevant data sets for their analyses.
- **Health Information Technician**: Health information technicians use specialized computer programs and administrative techniques to ensure that patient's electronic health records are complete, accurate, accessible, and secure.
- **Mobile Application developers**: Mobile App developers create software for mobile devices. They write programs inside a mobile development environment using Objective C, C++, or Java programming languages. A mobile app developer will typically choose an OS such as Google’s Android or Apple's IOS and develop apps for that environment.

9.6: Career Path in Information Systems

The job descriptions described in the previous sections do not represent all possible jobs within an information system organization. Larger organizations will have more specialized roles; smaller organizations may combine some of these roles. Many of these roles may exist outside of a traditional information-systems organization, as we will discuss below.



Working with information systems can be a rewarding career choice. Whether you want to be involved in very technical jobs (programmer, database administrator) or want to be involved in working with people (systems analyst, trainer), there are many different career paths available.

Often, those in technical jobs who want career advancement find themselves in a dilemma: do they want to continue doing technical work, where sometimes their advancement options are limited or do they want to become a manager of other employees and put themselves on a management career track? In many cases, those proficient in technical skills are not gifted with managerial skills. Some organizations, especially those that highly value their technically skilled employees, will create a technical track that exists in parallel to the management track to retain employees who are contributing to the organization. Today, most large organizations have dual career paths - the Managerial and Technical/Professional.

Then there are people from other fields who want to get into IT. For example, a writer wants to become a technical writer, and a salesperson may want to become a quality tester.

People have many different reasons for transitioning into the IT industry, and the timing couldn't be better. The IT industry is facing a massive shortage of workers, both domestic and international, and there are many employment opportunities at every level.

Figure $9.6.1$: Jobs in Information Systems - Image is licensed CCO-PD

Sidebar: Are Certificates Worth Pursuing?

As technology is becoming more important to businesses, hiring employees with technical skills is becoming critical. But how can an organization ensure that the person they are hiring has the necessary skills? These days, many organizations are including technical certifications as a prerequisite for getting hired.

Certifications are designations given by a certifying body that someone has a specific knowledge level in a specific technology. This certifying body is often the vendor of the product itself, though independent certifying organizations, such as [1] CompTIA, also exist. Many of these organizations offer certification tracks, allowing a beginning certificate as a prerequisite to getting more advanced certificates. To get a certificate, you generally attend one or more training classes and then take one or more certification exams. Passing the exams with a certain score will qualify you for a certificate. In most cases, these classes and certificates are not free and, in fact, can run into the thousands of dollars. Some examples of the certifications in the highest demand include Microsoft (software certifications), Cisco (networking), and SANS (security), Oracle (database, SQL).

For many working in IT (or thinking about an IT career), determining whether to pursue one or more of these certifications is an important question. For many jobs, such as those involving networking or security, the employer will require a certificate to determine which potential employees have a basic level of skill. For those already in an IT career, a more advanced certificate may lead to a promotion. However, other cases, when experienced with a certain technology, will negate the need for certification. For those wondering about the importance of certification, the best solution is to talk to potential employers and those already working in the field to determine the best choice. Perusing different job websites to see the trend of hot IT jobs and associated requirements is a good place to start.

9.6.1: Organizing the Information-Systems Function

In the early years of computing, the information-systems function (generally called data processing) was placed in the organization's finance or accounting department. As computing became more important, a separate information-systems function was formed. However, it was still generally placed under the CFO and considered an administrative function of the company. In the 1980s and 1990s, when companies began networking internally and then linking up to the Internet, the information-systems function was combined with the telecommunications functions and designated the information technology (IT) department. As information technology's role continued to increase, especially the increased risk over security and privacy, its place in the organization also moved up the ladder. In many organizations today, the head of IT (the CIO) reports directly to the CEO or COO. There are still places where IT reports to a VP of finance.

IT is often organized into these functions:

- IT support (call support)
- Security
- Database
- Network
- Applications to support end-user apps (i.e., Office) or enterprise apps (ERP, MRP).

The size of each function varies depending on the level of outsourcing a company decides to do.

Not all IT-related tasks are done directly by IT staff. Some tasks may be done by other groups in a firm such as Marketing or Manufacturing. For example, marketing or engineering groups may choose their own vendor to support and provide cloud services for the company's products or services. Collaboration with IT is critical to avoid creating confusion for end-user support and training. Some IT tasks can also be outsourced to external partners.

9.6.2: Outsourcing

Outsourcing- using third-party service providers- to handle some of your business processes became a popular business strategy back in the '80s and 90's to combat rising labor costs and allow firms to focus on their core functions. For example, an early function that firms outsourced is payroll. With the Internet boom and bust in 2000-2001 and the rise of the global marketplace, outsourcing is now a common business strategy for companies of all sizes.

Popular outsourcing models like Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) allow organizations to pay for only the IT resources and capabilities they need. IaaS provides networked storage, servers, and virtualization, while PaaS delivers development tools, middleware, and databases. Leveraging these cloud-based services can offer greater flexibility and scalability.

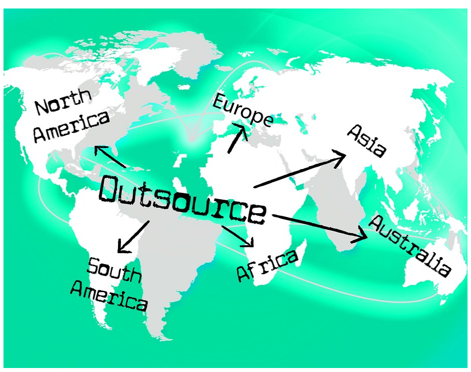


Figure 9.6.2 Outsourcing. Image by Jireh Gibson is licensed Pixabay

If an organization needs a specific skill for a limited period of time, instead of training an existing employee or hiring someone new, the job can be outsourced. Outsourcing can be used in many different situations within the information-systems function, such as designing and creating a new website or the upgrade of an ERP system. Some organizations see outsourcing as a cost-cutting move, contracting out a whole group or department. In some cases, outsourcing has become a necessity - the only feasible way to grow your business, launch a product, or manage operations is by using an outside vendor for certain tasks.

9.6.3: Job Outlook

IT jobs and demand for computer and informations systems managers are projected to grow due to continued increase in cloud computing, cybersecurity concert, and firms' expansion, from both computing and non-computing industries, to adopt new technologies and digital platforms. According to US bureau of labor Statistics, employment growth is projected to result from the need to bolster cybersecurity in computer and information systems that businesses use.

According to the Bureau of Labor Statistics, jobs in computer and information system managers are projected to grow 16% from 2021 to 2031, and 12% for operation specialists managers.

9.6.4: Training and Change Management

Implementing new information systems often requires training end users and facilitating organizational change. IT should partner closely with Human Resources and organizational development to provide training programs and guide employees through transitions. Change management is an essential competency for those in IT management roles.

9.6.5: References

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, Computer and Information Systems Managers. Retrieved November 13, 2020, from https://www.bls.gov/ooh/management/computer-and-information-systems-managers.htm

Careers in IT. Retrieved November 13, 2020, from https://www.itcareerfinder.com/it-careers/mobile-application-developer.html

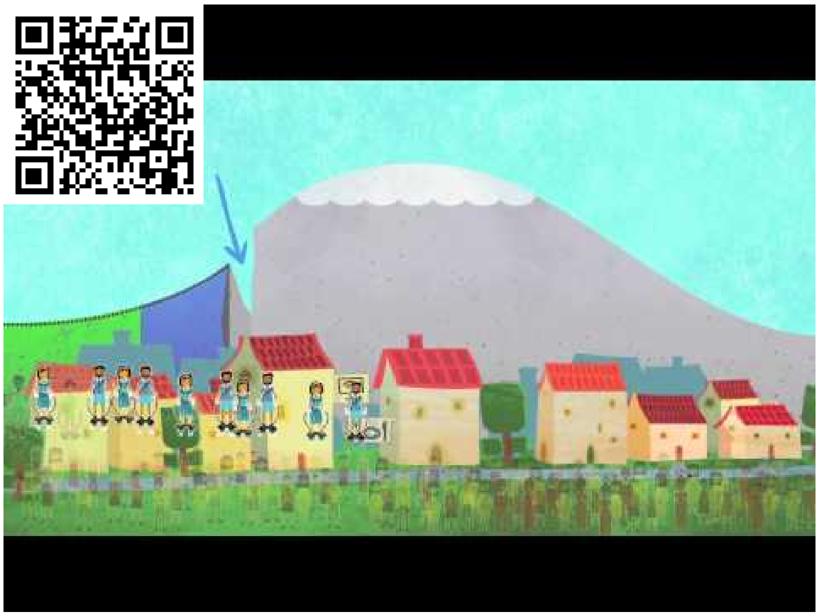
---

9.7: Information-Systems Users – Types of Users

9.7.1: Information-Systems Users – Types of Users

Besides the people who work to create, administer, and manage information systems, one more significant group of people: the users of information systems. This group represents a considerable percentage of the people involved. If the user cannot successfully learn and use an information system, the system is doomed to failure.

One tool used to understand how users will adopt a new technology comes from a 1962 study by Everett Rogers. Have a listen to this short video (3:33 min) that explains the Diffusion of Innovation theory.



In his book, Diffusion of Innovation, Rogers explains how new ideas and technology spread via communication channels over time. Innovations are initially perceived as uncertain and even risky. To overcome this uncertainty, most people seek out others like themselves who have already adopted the new idea or technology. Thus, the diffusion process consists of successive groups of consumers adopting new technology(shown in blue in the graph below); the adoption rate will start slowly and then dramatically increase once adoption reaches a certain point - its market share(yellow curve) reaches saturation level and becomes self-sustaining.

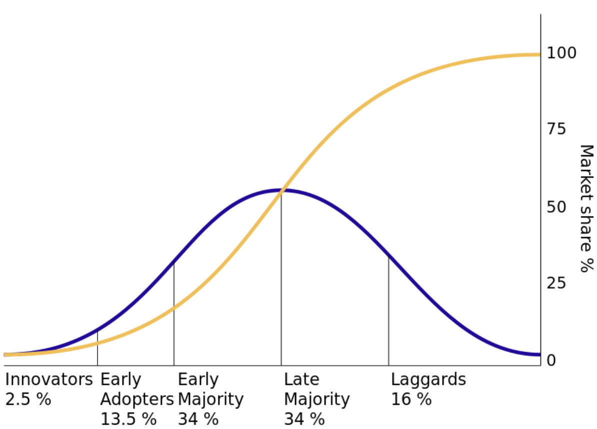


Figure 9.4: [Technology adoption user types](#) Image by [Rogers Everett](#), licensed under [Public domain, via Wikimedia Commons](#)

Rogers identified five (sections of the blue curve) specific types of technology adopters:

- **Innovators**: Innovators are the first individuals to adopt new technology. Innovators are willing to take risks, are the youngest in age, have the highest social class, have great financial liquidity, are very social, and have the closest contact with scientific sources and interaction with other innovators. Risk tolerance has them adopting technologies that may ultimately fail. Financial resources help absorb these failures (Rogers 1962 5th ed, p. 282).
- **Early adopters:** The early adopters adopt an innovation after a technology has been introduced and proven. These individuals have the highest degree of opinion leadership among the other adopter categories, which means that they can influence the largest majority's opinions. They are typically younger in age, have higher social status, more financial liquidity, more advanced education, and are more socially aware than later adopters. These people are more discrete in adoption choices than innovators and realize the judicious choice of adoption will help them maintain a central communication position (Rogers 1962 5th ed, p. 283).
- **Early majority**: Individuals in this category adopt an innovation after a varying degree of time. This time of adoption is significantly longer than the innovators and early adopters. This group tends to be slower in the adoption process, has above average social status, has contact with early adopters, and seldom holds opinion leadership positions in a system (Rogers 1962 5th ed, p. 283).
- **Late majority**: The late majority will adopt an innovation after the average member of the society. These individuals approach an innovation with a high degree of skepticism, have below-average social status, very little financial liquidity, contact others in the late majority and the early majority, and show very little opinion leadership.
- **Laggards**: Individuals in this category are the last to adopt an innovation. Unlike those in the previous categories, individuals in this category show no opinion leadership. These individuals typically have an aversion to change agents and tend to be advanced in age. Laggards typically tend to be focused on "traditions," are likely to have the lowest social status and the lowest financial liquidity, be the oldest of all other adopters, and be only in contact with family and close friends.

Organizations should apply this model when managing change, identifying innovators and early adopters first when rolling out new systems, then leveraging their experience for others. Change management techniques can facilitate this process.

Sidebar: Real life Example of Diffusion of Innovation Theory

Adoption of new technology within a college district is a great example of diffusion theory. The technology coordinators attend a conference to learn about the potential benefits of the new technology and its features in enhancing student engagement and understanding. They conduct research and consult with experts and explore case studies of other colleges (innovators) that have successfully implemented this technology. They conduct a pilot program with select faculty (early adopters) who then conduct demonstrations and workshops for faculty through which teaching methods and curriculum compatibility are evaluated. Factors such as ease of integration, cost, potential impact on student achievement are considered. The college invests in the new technology and faculty (large majority) start incorporating this new technology into their curriculum. Student actively engage and faculty receive support and guidance from the early adopters and technology coordinators. After several semesters of using this new technology, data shows improvement in student motivation, participation and understanding. The positive outcomes reinforce the decision to continue using this new technology and their success stories are shared with other colleges and districts thus diffusing this technology to the broader education communities.

Knowledge of the diffusion theory and the five types of technology users help provide additional insight into how to implement new information systems within an organization. For example, when rolling out a new system, IT may want to identify the innovators and early adopters within the organization and work with them first, then leverage their adoption to drive the implementation. The adoption model developed by Rogers provides valuable perspective into how users accept new information systems. Understanding these adoption patterns can inform strategies for change management and user involvement.

This process of diffusion of new ideas and technology can usually take months or years. But there are exceptions: the use of the internet in the 1990s and mobile devices in recent years to communicate, interact socially, access news and entertainment have spread more rapidly than possibly any other innovation in humankind's history.

9.7.2: Perspectives from Non-IT Departments

While IT professionals manage technology systems, other departments in an organization have important perspectives that should be incorporated. Groups like Sales, Marketing, Finance, and Operations are focused on business objectives and interacting with customers and partners. Their input on information systems requirements is crucial to ensure the technology solutions support the business goals. IT should foster partnerships across departments. Inputs from groups like Marketing and Operations will identify innovators and early adopters who can pilot and endorse new systems to support wider organizational adoption per Rogers' model.

9.7.3: References

Rogers, E. M. (1962). *Diffusion of innovations*. New York: Free Press

---

9.8: Summary

9.8.1: Summary

This chapter has reviewed the many different categories of individuals - from the front-line help-desk workers to system analysts to chief information officer(CIO) -who make up the people component of information systems. The world of information technology is changing so fast that new roles are being created all the time, and roles that have existed for decades are being phased out. That said, this chapter should have given you a good idea of the importance of the people component of information systems.

9.9: Study Questions

Study Question 9.9.1

Describe the role of a systems analyst.

Answer

The systems analyst works with business users to identify requirements for new systems. They document processes, specify system design, and create technical specifications for programmers.

Study Question 9.9.2

What are some of the different roles of a computer engineer?

Answer

The text covers these roles: hardware engineer, software engineer, systems engineer, and network engineer.

Study Question 9.9.3

What are the duties of a computer operator?

Answer

Computer operators oversee mainframe computers and data centers. They keep systems running, allocate resources, and maintain hardware/software.

Study Question 9.9.4

What does the CIO do?

Answer

The CIO aligns IT plans with business goals. This includes IT strategy, budgeting, staffing, and communications with senior leadership.

Study Question 9.9.5

Describe the job of a DBA.

Answer

The DBA manages organizational databases by ensuring their availability, security, recovery plans, and assisting users.

Study Question 9.9.6

Explain the point of having two different career paths in information systems.

Answer

The dual paths allow technical specialists to advance without taking on managerial roles. The two tracks are managerial and technical.

Study Question 9.9.7

What are the five types of information systems users?

Answer

The five types covered are innovators, early adopters, early majority, late majority, and laggards.

Study Question 9.9.8

Why would an organization outsource?

Answer

Reasons include lacking internal skills for a project or needing help with a system implementation. It reduces costs.

Study Question 9.9.9

What are some of the duties of a help desk analyst?

Answer

Help desk analysts provide frontline support to computer users in an organization. They assist with problems, answer questions, investigate issues, and escalate to more senior IT staff when needed.

Exercise 9.9.10

What does a computer trainer do?

Answer

A computer trainer conducts classes to teach people specific computer skills and how to use information systems. They help with the adoption of new systems.

Study Question 9.9.11

What is a programmer-analyst?

Answer

A programmer-analyst is a systems analyst who also creates the systems they design, combing the roles of analyst and programmer.

Study Question 9.9.12

What are some factors that influence how readily people adopt new technology?

Answer

The text discusses age, social status, financial resources, and contact with others as factors in the speed of adopting innovations.

Study Question 9.9.13

What roles focus on change management when new information systems are implemented?

Answer

The chapter mentions change management professionals who create plans and strategies to guide organizations through transitions to new systems.

Study Question \(\PageIndex{14\)

Why is change management important when introducing new information technology?

Answer

Change management helps employees impacted by new systems feel prepared and supported, leading to better adoption and outcomes.

Study Question 9.9.15

How can organizations support users during information systems changes?

Answer

Suggested approaches include communication plans, training programs, and user adoption strategies focused on understanding needs and getting buy-in.

Exercises

1. Which IT job would you like to have? Do some original research and write a two-page paper describing the duties of the job you are interested in.
2. Spend a few minutes on Dice or Monster to find IT jobs in your area. What are IT jobs currently available? Write up a two-page paper describing three jobs, their starting salary (if listed), and the skills and education needed for the job.
3. How is the IT function organized in your school or place of employment? Create an organization chart showing how the IT organization fits into your overall organization. Comment on how centralized or decentralized the IT function is.
4. What type of IT user are you? Take a look at the five types of technology adopters, and then write a one-page summary of where you think you fit in this model.
5. What processes at your organization rely on information systems?
6. Who are the primary users of IT systems in your workplace?
7. What upcoming IT initiatives are planned for your organization?
8. What IT skills are most important for your own role?
9. Who provides IT support in your workplace?
10. How could IT systems be improved at your organization?

CHAPTER OVERVIEW

10: Information Systems Development

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Explain the overall process of developing a new software application;
- Explain the differences between software development methodologies;
- Understand the different types of programming languages used to develop software;
- Understand some of the issues surrounding the development of mobile applications; and
- Identify the four primary implementation policies.

People build information systems for people's use. This chapter will look at different methods to manage an information system's development process, with special attention to software development, review mobile application development, and discuss end-user computing. We will look at key trade-offs that organizations face in making critical decisions to "build vs. buy or subscribe," the balancing act between scope, cost, and time while delivering a high-quality project and obtaining the buy-in from the users.

10.1: Introduction

When someone has an idea for a new function to be performed by a computer, how does that idea become a reality? If a company wants to implement a new business process and needs new hardware or software to support it, how do they go about making it happen? How do they decide whether to build their own solution or buy or subscribe to a solution available in the market?

This chapter will discuss the different methods of taking those ideas and bringing them to reality, a process known as information systems development.

10.2: Systems Development Life Cycle (SDLC) Model

Imagine you have been tasked with creating a new model of a car. Where would you start? You could design cool features and then jump right into building it. But what if some pieces don't work together? What if the target customer wants totally different features? A lot of research has been done in avoiding these and other problems and the solution is called the Systems Developement Life Cycle or SDLC.

SDLC was first developed in the 1960s to manage the large projects associated with corporate systems running on mainframes. It is a very structured process designed to manage large projects with many people's efforts, including technical, business, support professionals. These projects are often costly to build, and they have a large impact on the organization. A failed project or an incorrect business decision to pick a wrong project to fund can be a business or financial catastrophe for an organization.

SDLC is a model defining a process of a set of phases for planning, analysis, design, implementation, maintenance. Chapter 1 discusses that an information system (IS) includes hardware, software, database, networking, process, and people. SDLC has been used often to manage an IS project that may include one, some, or all of the elements of an IS. Let's walk through each of the five phases of an SDLC as depicted in Figure 10.2.1:

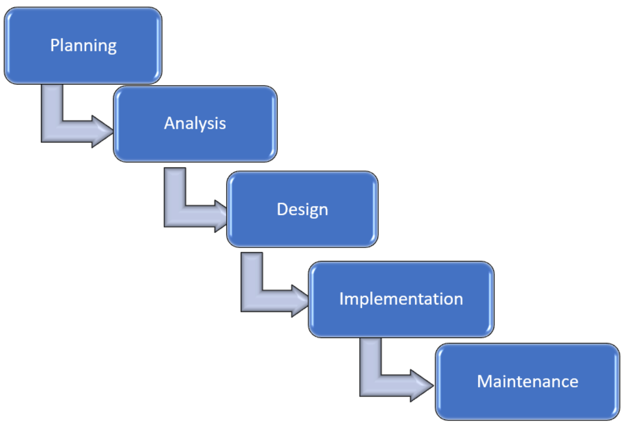


Figure 10.2.1: Software Development Lifecycle Model. Image by Ly-Huong Pham, Ph.D. is licensed under CC BY NC

1. **Planning**. In this phase, a request is initiated by someone who acts as a sponsor for this idea. A small team is assembled to conduct a preliminary assessment of the request's merit and feasibility. The objectives of this phase are:
    - To determine how the request fits with the company's strategy or business goals.
    - To conduct a feasibility analysis, which includes an analysis of the technical feasibility (is it possible to create this?), the economic feasibility (can we afford to do this?), and the legal feasibility (are we allowed to do this?).
    - To recommend a go/no go for the request. If it is a go, then a concept proposal is also produced for management to approve.
2. **Analysis**. Once the concept proposal is approved, the project is formalized with a new project team (including the previous phase). Using the concept proposal as the starting point, the project members work with different stakeholder groups to determine the new system's specific requirements. No programming or development is done in this step. The objectives of this phase are:
    - Identify and Interview key stakeholders.
    - Document key procedures
    - Develop the data requirements
    - To produce a system-requirements document as the result of this phase. This has the details to begin the design of the system.
3. **Design**. Once the system requirements are approved, the team may be reconfigured to bring in more members. This phase aims for the project team to take the system requirements document created in the previous phase and develop the specific technical details required for the system. The objectives are:
    - Translate the business requirements into specific technical requirement

- Design the user interface, database, data inputs and outputs, and reports
- Produce a system-design document as the result of this phase. . This document will have everything a programmer will need to create the system.

4. **Implementation**. Once a system design is approved, the software code finally gets written in the programming phase, and the development effort for other elements such as hardware also happens. The purpose is to create an initial working system. The objectives are:
    - Develop the software code, and other IS components. Using the system- design document as a guide, developers begin to code or develop all the IS project components.
    - Test the working system through a series of structured tests such as:
        - The first is a unit test, which tests individual parts of the code for errors or bugs.
        - Next is a system test, where the system's different components are tested to ensure that they work together properly.
        - Finally, the user-acceptance test allows those that will be using the software to test the system to ensure that it meets their standards.
        - Iteratively test any fixes again to address any bugs, errors, or problems found during testing.
        - Train the users
        - Provide documentation
        - Perform necessary conversions from any previous system to the new system.
        - Produce, as a result, the initial working system that meets the requirements laid out in the analysis phase and the design developed in the design phase.
5. **Maintenance**. This phase takes place once the implementation phase is complete. In this phase, the system must have a structured support process in place to:
    - Report bugs
    - Deploy bug fixes
    - Accept requests for new features
    - Evaluate the priorities of reported bugs or requested features to be implemented
    - Identify a predictable and regular schedule to release system updates and perform backups.
    - Dispose of data and anything else that is no longer needed

Organizations can combine or sub-divide these phases to fit their needs. For example, instead of one phase, Planning, an organization can choose to have two phases: Initiation, Concept; or splitting the implementation into two phases: implementation and testing.

Have a listen to this 5 minute video that introduces and reviews the multiple phases of Software Application Development Lifecycle.

10.2.1: Waterfall Model

One specific SDLC-based model is the Waterfall model, and the name is often thought to be the same as SDLC. It is used to manage software projects as depicted in Figure 10.2.2 with five phases: Requirements, Design, Implement, Verification, and Maintenance. This model stresses that each phase must be completed before the next one can begin (hence the name waterfall). For example, changes to the requirements are not allowed once the implementation phase has begun, or changes must be sought and approved to a change process. They may require the project to restart from the requirement phase since new requirements need to be approved, which may cause the design to be revised before the implementation phase can begin.

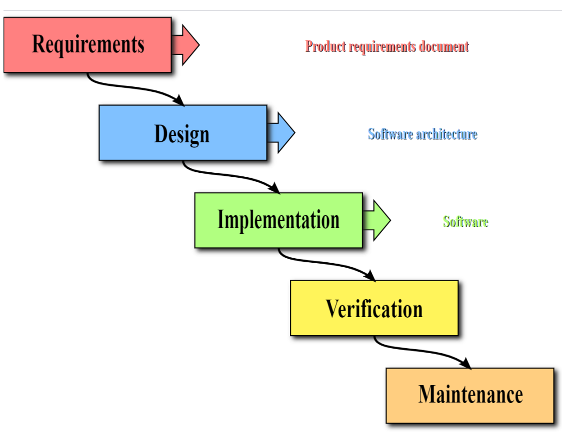


Figure 10.2.2 Waterfall Model of System Development. Image by Peter Kemp / Paul Smit is licensed CC BY 3.0

The waterfall model's structure has been criticized for being quite rigid and causing teams to be risk-averse to avoid going back to previous phases. However, there are benefits to such a structure too. Some advantages and disadvantages of SDLC and Waterfall are:

10.2.2: Advantages and Disadvantage of SDLC and Waterfall

Advantages	Disadvantages
The robust process to control and track changes to minimize the number of risks can derail the project unknowingly.	Take time to record everything, which leads to additional cost and time to the schedule.
Standard and transparent processes help the management of large teams.	Too much time spent attending meetings, seeking approval, etc. which lead to additional cost and time to the schedule.
Documentation reduces the risks of losing personnel, easier to add people to the project.	Some members do not like to spend time writing, leading to the additional time needed to complete a project.
Easier to trace a problem in the system to its root whenever errors are found, even after the project is completed.	It is difficult to incorporate changes or customers' feedback since the project has to go back to one or more previous phases, leading teams to become risk-averse.

Other models are developed over time to address these criticisms. We will discuss two other models: Rapid Application Development and Agile, as different approaches to SDLC.

10.2.3: Rapid Application Development (RAD)

Rapid application development (RAD) is a software development (or systems-development) methodology that focuses less on planning and incorporating changes on an ongoing basis. One alternative to heavyweight waterfall development is rapid application development (RAD), depicted in Figure 10.2.3. RAD emphasizes building a prototype quickly and iteratively based on user feedback instead of detailed specifications. After a brief planning phase, developers collaborate closely with users to shape the application. This allows faster iterations and accommodation of changing requirements compared to waterfall development. RAD works best for smaller, less complex applications rather than enterprise-wide systems. After several iterations of development, a final version is developed and implemented. Let's walk through the four phases in the RAD model as depicted in Figure 10.2.3.

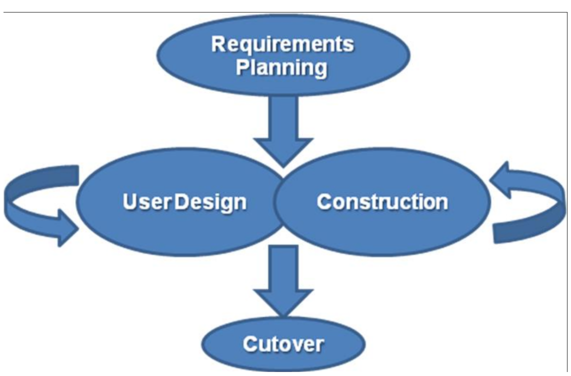


Figure 10.2.3 Image Rapid Application Development Model is licensed Public domain.

1. **Requirements Planning**. This phase is similar to the planning, analysis, and design phases of the SDLC.
2. **User Design**. In this phase, the users' representatives work with the system analysts, designers, and programmers to interactively create the system's design. One technique for working with all of these various stakeholders is the Joint Application Development (JAD) session. A JAD session gets all relevant users who interact with the systems from different perspectives, other key stakeholders, including developers, to have a structured discussion about the system's design. The objectives are for users to understand and adopt the working model and for the developers to understand how the system needs to work from the user's perspective to provide a positive user experience.

3. **Construction**. In the construction phase, the tasks are similar to SDLC's implementation phase. The developers continue to work interactively with the users to incorporate their feedback as they interact with the working model that is being developed. This is an interactive process, and changes can be made as developers are working on the program. This step is executed parallel with the User Design step in an iterative fashion until an acceptable version of the product is developed.
4. **Cutover**. This step is similar to some of the SDLC implementation phase tasks. The system goes live or is fully deployed. All steps required to move from the previous state to using the new system are completed here.

Compared to the SDLC or Waterfall model, the RAD methodology is much more compressed. Many of the SDLC steps are combined, and the focus is on user participation and iteration. This methodology is better suited for smaller projects and has the added advantage of giving users the ability to provide feedback throughout the process. SDLC requires more documentation and attention to detail and is well suited to large, resource-intensive projects. RAD is better suited for projects that are less resource-intensive and need to be developed quickly. Here are some of the advantages and disadvantages of RAD:

10.2.3.1: Advantages and Disadvantage of RAD

Advantages	**Disadvantages**
Increase quality due to the frequency of interacting with the users	Risks of weak implementation of features that are not visible to the users, such as security
Reduce risks of users' refusal to accept the finished product	Lack of control over the system changes due to a working version's fast turn-around to address users' issues.
Improve chances of on-time, on-budget completion as users update in real-time, avoiding surprises during development.	Lack of design since changes are being put in the system might unknowingly affect other parts of the system.
Increase interaction time between developers/experts and users	Scarce resources as developers are tied up, which could slow down other projects.
Best suited for small to medium size project teams	Difficult to scale up to large teams

10.2.4: Agile Development Methodologies

Agile methodologies are a group of methodologies that utilize incremental changes focusing on quality and attention to detail. Each increment is released in a specified period of time (called a time box), creating a regular release schedule with particular objectives. While considered a separate methodology from RAD, they share some of the same principles: iterative development, user interaction, and changeability. The agile methodologies are based on the "Agile Manifesto," first released in 2001.

The characteristics of agile methods include:

- small cross-functional teams that include development-team members and users;
- daily status meetings to discuss the current state of the project;
- short time-frame increments (from days to one or two weeks) for each change to be completed; and
- At the end of each iteration, a working project is completed to demonstrate to the stakeholders.

In essence, the Agile approach puts a higher value on tasks that promote interaction, build frequent working versions, customers/user collaboration, and quick response to change and less emphasis on processes and documentation. The agile methodologies' goal is to provide an iterative approach's flexibility while ensuring a quality product.

There are a variety of models that are built using Agile methodologies. One such example is the Scrum development model.

10.2.4.1: Scrum development model

This model is suited for small teams who work to produce a set of features within fixed-time interactions, such as two- to four weeks, called sprints. Let's walk through the four key elements of a Scrum model as depicted in Figure $10.2.4$

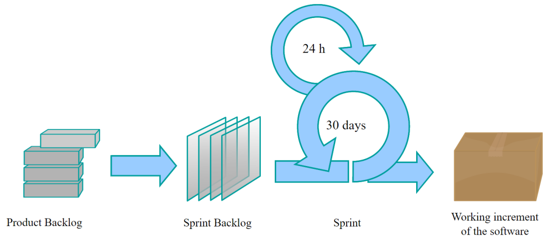


Figure 10.2.4: The Scrum project management method. Image by Lakeworks is licensed CC BY-SA 4.0

1. **Product backlog**. This is a detailed breakdown list of work to be done. All the work is prioritized based on criteria such as risks, dependencies, mission-critical, etc. Developers select their own tasks and self-organize to get the work done.
2. **Sprint backlog**. This is a list of the work to be done in the next sprint.
3. **Sprint**. This is a fixed time, such as 1-day, 2-weeks, or 4-weeks, as agreed by the team. A daily progress meeting is called a daily scrum, typically a short 10-15 minute meeting facilitated by a scrum master whose role is to remove roadblocks for the team.
4. **Working increment of the softwar**e. This is a working version that is incrementally built with the breakdown lists at the end of the sprints.

Use Case: Agile Methodology 10.2.1

ABC Company wanted to build a new customer portal for their website. How should they use an agile development methodology?

Solution

First, the team was assembled including developers, testers, a product manager, and user experience designer. Next, the product manager met with stakeholders and created a prioritized product backlog of required features for the portal.

The development team worked in 2 week sprints. Each sprint began with a planning session to select features to work on from the backlog. Developers then built these features collaboratively and testers performed continuous automated testing as code was written.

At the end of each sprint, a working increment of the portal was demonstrated to stakeholders who provided feedback. Feedback was incorporated into the product backlog to improve subsequent sprints.

After 5 sprints over 10 weeks, the initial customer portal was complete. It was launched as a beta version to gather additional user feedback for subsequent portal enhancement.

This agile approach with short iterative cycles, continuous testing, and user feedback allowed ABC Company to develop the customer portal faster and with greater quality than using traditional waterfall development.

10.2.5: Comparing Waterfall and Agile Methods

Here is a table comparing and contrasting Waterfall and Agile software development methodologies:

Comparing and contrasting Waterfall and Agile Methods

	Waterfall	Agile
Requirements	Gathered upfront	Evolve iteratively
Design	Upfront design	Just-in-time design
Documentation	Extensive	Working software over documentation

	Waterfall	Agile
User Feedback	After development	Continuous feedback
Development	Sequential phases	Iterative sprints
Testing	After development	Continuous testing
Changes	Changes cause rework	Embraces change

The table highlights the key differences:

- Waterfall emphasizes upfront planning, documentation and sequenced development phases
- Agile favors responding to change, user feedback, and iterative development

10.2.6: Lean Methodology

One last methodology we will discuss is a relatively new concept taken from the business bestseller The Lean Startup, by Eric Reis.

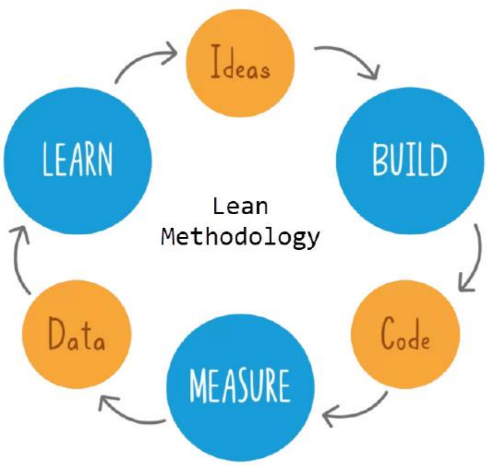


Figure 10.2.5: The Lean Methodology. Image by Tejal Desai-Naik is licensed under CC BY-4.0

This methodology focuses on taking an initial idea and developing a minimum viable product (MVP). The MVP is a working software application with just enough functionality to demonstrate the idea behind the project. Once the MVP is developed, it is given to potential users for review. Feedback on the MVP is generated in two forms: (1) direct observation and discussion with the users, and (2) usage statistics gathered from the software itself. Using these two forms of feedback, the team determines whether they should continue in the same direction or rethink the project's core idea, change the functions, or create a new MVP. This change in strategy is called a pivot. Several iterations of the MVP are developed, with new functions added each time based on the feedback, until a final product is completed.

The biggest difference between the lean methodology and the other methodologies is that the system's full set of requirements is unknown when the project is launched. The method focuses on establishing whether a business is viable by launching a product at the same time as gaining feedback. As each iteration of the project is released, the statistics and feedback gathered are used to determine the requirements. The aim being to reduce business risk and have a refined product or solution with a ready-made client base. The lean methodology works best in an entrepreneurial environment where a company is interested in determining if their idea for a software application is worth developing.

Sidebar: Dropbox - Lean startup success story

Dropbox is one of the most well-known lean startup success stories. This popular file transfer service was designed to send files between users which are too big to be sent as email attachments. Dropbox now has over 500 million users worldwide but it started life as a minimum viable product in form of a 3-minute screencast video by founder and CEO Drew Houston showing consumers what Dropbox could do.

It was targeted at a community of technology early adopters. Response to the video enabled Dropbox to test if there was demand for the product and, at the same time, capture an initial audience through a waiting list. The video helped drive subscribers so the dropbox team could begin the process of refining their product and align it with customer needs. In less than 18 months, Dropbox's list of registered users rose from 100,000 to more than 4 million!

10.2.7: Budgeting and Cost Estimation

When planning for a new software development project, estimating the overall budget and costs is an important first step. Organizations will want to factor in costs for elements such as:

- Labor - this is often the biggest cost, including salaries for software engineers, developers, project managers, analysts, testers, UI/UX designers and more. The number of team members and their hourly rates drive labor costs.
- Hardware/Infrastructure - any new servers, networks, hardware that may be needed, including cloud computing costs.
- Software licenses - the cost of any software development tools, operating systems, databases or other software needed.
- User training - the labor and material costs for training users on the new system.
- Facilities - if new office space is required for the project team.

These cost estimates are important for setting budgets to insure that sufficient resources are planned to avoid unplanned cost overruns.

10.2.8: References:

Manifesto for Agile Software Development (2001). Retrieved December 10, 2020, from http://agilemanifesto.org/

The Lean Startup. Retrieved on December 9, 2020, from http://theleanstartup.com/

10.3: Software Development

Many of the methodologies discussed above are used to manage software development since programming is complex, and sometimes errors are hard to detect. We learned in chapter 2 that software is created via programming, and programming is the process of creating a set of logical instructions for a digital device to follow using a programming language. The programming process is sometimes called “coding” because the syntax of a programming language is not in a form that everyone can understand – it is in “code.”

The process of developing good software is usually not as simple as sitting down and writing some code. True, sometimes a programmer can quickly write a short program to solve a need. But most of the time, the creation of software is a resource-intensive process that involves several different groups of people in an organization. In the following sections, we are going to review several different methodologies for software development.

Sidebar: The project management quality triangle

When developing software or any product or service, there is tension between the developers and the different stakeholder groups, such as management, users, and investors. When developing software, project managers must make tradeoffs between scope, schedule, and cost. This is illustrated by the project management quality triangle (Figure 10.3.1). For example, adding new features without adjusting timeline or resources will reduce quality. Understanding these constraints can help managers make wise tradeoffs when planning software projects.

Figure 10.3.1 illustrates the tension of the three requirements: time, cost, and quality that project managers need to make tradeoffs in. From how quickly the software can be developed (time), to how much money will be spent (cost), to how well it will be built (quality). The quality triangle is a simple concept. It states that you can only address two of the following: time, cost, and quality for any product or service being developed.

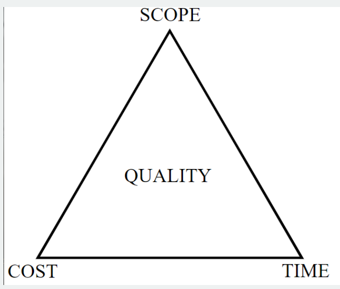


Figure 10.3.1: Project Management Quality Triangle. Image by Mapto is licensed Public domain

So what does it mean that you can only address two of the three? It means that the finished product's quality depends on the three variables: scope, schedule, and the allocated budget. Changes in any of these three variables affect the other two, hence, the quality.

For example, if a feature is added, but no additional time is added to the schedule to develop and test, the code's quality may suffer, even if more money is added. There are times when it is not even feasible to make the tradeoff. For example, adding more people to a project where members are so overwhelmed that they don’t have time to manage or train new people. Overall, this model helps us understand the tradeoffs we must make when developing new products and services.

10.3.1: Software Development Teams

Software development involves coordinators and specialists playing different roles, discussed in the earlier chapter, on the team:

- Project managers - oversee the overall project timeline, budget, resource planning, and cross-functional communication.
- Software developers/engineers - develop code and programs based on the specifications.
- Quality assurance testers - test the software to identify defects and ensure requirements are met.
- User experience (UX) designers - design intuitive and user-friendly interfaces.
- Business analysts - document business requirements that software should fulfill.
- End user representatives - provide ongoing feedback during development to ensure software meets needs.

Designing an optimal team is essential for a successful implementation.

10.3.2: Programming Languages

One of the important decisions that a project team needs to make is to decide which programming language(s) are to be used and associated tools in the development process. As mentioned in chapter 3, software developers create software using one of several programming languages. A programming language is a formal language that provides a way for a programmer to create structured code to communicate logic in a format that the computer hardware can execute. Over the past few decades, many different programming languages have evolved to meet many different needs.

There is no one way to categorize the languages. Still, they are often grouped by type (i.e., query, scripting), or chronologically by year when it was introduced (i.,e. Fortran was introduced in 1954s), by their "generation," by how it was translated to the machine code, or how it was executed. We will discuss a few categories in this chapter.

10.3.2.1: Generations of Programming Languages

Early languages were specific to the type of hardware that had to be programmed; each type of computer hardware had a different low-level programming language (in fact, even today, there are differences at the lower level, though higher-level programming languages now obscure them). In these early languages, precise instructions had to be entered line by line – a tedious process.

Some common characteristics are summarized below to illustrate some differences among these generations:

	First-generation (1GL)	Second-generation (2GL)	Third-generation (3GL)	Fourth-generation (4GL)	Fifth-generation (5GL)
Time introduced (est).	1940s or earlier	1950s	1950s-1970s	1970s-1990s	1980s-1900s
Instructions	They are made of binary numbers of 0s and 1s	Use a set of syntax that is readable by human and programmers	The syntax is more structured and is made up of more human-like language	The syntax is friendly to non-programmers	Still in progress.
Category	Machine dependent Machine code	Machine dependent Low level, Assembly Languages	Machine independent High Level	Machine independent High-level abstraction, Advanced 3GLs	Logic programming
Advantage	Very fast, no need for 'translation' to 0s and 1s	Code can be read and written by programmers easier than learning machine code	More machine-independent More friendly to programmers General-purpose	Easy to learn	May not need programmers to write programs
Disadvantage	Machine dependent, not portable	Must be converted to machine code, still machine-dependent	May go multiple steps to translate to machine code	More specialized	Still early in the adoption phase
Today's usage	If needed to interact with hardware directly such as drivers (i.e., USB driver)	If needed to interact with hardware directly such as drivers (i.e., USB driver)	Modern 3GLs are more commonly used. Early 3GLs are used to maintain existing business programs or scientific programs	Database, web development	Limited Visual tools, Artificial intelligence research

	First-generation (1GL)	Second-generation (2GL)	Third-generation (3GL)	Fourth-generation (4GL)	Fifth-generation (5GL)
Examples	Machine language	Assembly language	Early 3GLs: COBOL, Fortran Modern 3PLs: C, C++, Java, Javascript	Perl, PhP, Python, SQL, Ruby	Mercury, OPS5

Statista.com reported that by early 2020, Javascript was the most used language among developers worldwide. To see the complete list, please visit Statista.com for more details.

Examples of languages

First-generation language: machine code. In machine code, programming is done by directly setting actual ones and zeroes (the bits) using binary code. Here is an example program that adds 1234 and 4321 using machine language:

10111001	00000000
11010010	10100001
00000100	00000000
10001001	00000000
00001110	10001011
00000000	00011110
00000000	00011110
00000000	00000010
10111001	00000000
11100001	00000011
00010000	11000011
10001001	10100011
00001110	00000100
00000010	00000000

Second-generation language. Assembly language gives English-like phrases to the machine-code instructions, making it easier to program. An assembly-language program must be run through an assembler, which converts it into machine code. Here is an example program that adds 1234 and 4321 using assembly language:

MOV CX,1234 MOV DS:[0],CX MOV CX,4321 MOV AX,DS:[0]

MOV BX,DS:[2] ADD AX,BX

MOV DS:[4],AX

Third-generation languages are not specific to the type of hardware they run and are much more like spoken languages. Most third-generation languages must be compiled, a process that converts them into machine code. Well-known third-generation languages include BASIC, C, Pascal, and Java. Here is an example using BASIC:

A=1234 B=4321 C=A+B END

Fourth-generation languages are a class of programming tools that enable fast application development using intuitive interfaces and environments. Many times, a fourth-generation language has a particular purpose, such as database interaction or report-writing. These tools can be used by those with very little formal training in programming and allow for the quick development of applications and/or functionality. Examples of fourth-generation languages include Clipper, FOCUS, FoxPro, SQL, and SPSS.

Why would anyone want to program in a lower-level language when they require so much more work? The answer is similar to why some prefer to drive stick-shift automobiles instead of automatic transmission: control and efficiency. Lower-level languages, such as assembly language, are much more efficient and execute much more quickly. You have finer control over the hardware as well. Sometimes, a combination of higher- and lower-level languages is mixed together to get the best of both worlds: the programmer will create the overall structure and interface using a higher-level language but will use lower-level languages wherever in the program that requires more precision.

10.3.2.2: Compiled vs. Interpreted

Besides classifying a programming language based on its generation, it can also be classified as compiled or interpreted language. As we have learned, a computer language is written in a human-readable form. In a compiled language, the program code is translated into a machine-readable form called an executable that can be run on the hardware. Some well-known compiled languages include C, C++, and COBOL.

An interpreted language requires a runtime program to be installed to execute. This runtime program then interprets the program code line by line and runs it. Interpreted languages are generally easier to work with but are slower and require more system resources. Examples of popular interpreted languages include BASIC, PHP, PERL, and Python. The web languages such as HTML and Javascript would also be considered interpreted because they require a browser to run.

The Java programming language is an interesting exception to this classification, as it is actually a hybrid of the two. A program written in Java is partially compiled to create a program that can be understood by the Java Virtual Machine (JVM). Each type of operating system has its own JVM, which must be installed, allowing Java programs to run on many different types of operating systems.

10.3.2.3: Procedural vs. Object-Oriented

A procedural programming language is designed to allow a programmer to define a specific starting point for the program and then execute sequentially. All early programming languages worked this way. As user interfaces became more interactive and graphical, it made sense for programming languages to evolve to allow the user to define the program's flow. The object-oriented programming language is set up to define "objects" that can take certain actions based on user input. In other words, a procedural program focuses on the sequence of activities to be performed; an object-oriented program focuses on the different items being manipulated.

For example, in a human-resources system, an "EMPLOYEE" object would be needed. If the program needed to retrieve or set data regarding an employee, it would first create an employee object in the program and then set or retrieve the values needed. Every object has properties, which are descriptive fields associated with the object. In the example below, an employee object has the properties "Name," "Employee number," "Birthdate," and "Date of hire." An object also has "methods," which can take actions related to the object. In the example, there are two methods. The first is "ComputePay()," which will return the current amount owed to the employee. The second is "ListEmployees()," which will retrieve a list of employees who report to this employee.

Employee Object

Object: EMPLOYEE
First_Name Last_Name Employee_ID Birthdate Date_of_hire
ComputePay() ListEmployees()

10.3.3: Programming Tools

Another decision that needs to be made during the development of an IS is the set of tools needed to write programs. To write programs, programmers need tools to enter code, check for the code's syntax, and some method to translate their code into machine code. To be more efficient at programming, programmers use integrated tools such as an integrated development environment (IDE) or computer-aided software-engineering (CASE) tools.

10.3.3.1: Integrated Development Environment (IDE)

For most programming languages, an IDE can be used. An IDE provides various tools for the programmer, all in one place with a consistent user interface. IDE usually includes:

- an editor for writing the program that will color-code or highlight keywords from the programming language;
- a help system that gives detailed documentation regarding the programming language;
- a compiler/interpreter, which will allow the programmer to run the program;

- a debugging tool, which will provide the programmer details about the execution of the program to resolve problems in the code; and
- a check-in/check-out mechanism allows a team of programmers to work together on a project and not write over each other’s code changes.

Statista.com reports that 80% of software developers worldwide from 2018 and 2019 use a source code collaboration tool such as GitHub, 77% use a standalone IDE such as Eclipse, 69% use Microsoft Visual Studio. For a complete list, please visit statista.com.

10.3.3.2: Computer-aided software engineering (CASE) Tools

While an IDE provides several tools to assist the programmer in writing the program, the code still must be written. Computer-aided software engineering (CASE) tools allow a designer to develop software with little or no programming. Instead, the CASE tool writes the code for the designer. CASE tools come in many varieties, but their goal is to generate quality code based on the designer's input.

10.3.3.3: Build vs. Buy or Subscribe

When an organization decides that a new software program needs to be developed, they must determine if it makes more sense to build it themselves or purchase it from an outside company. This is the “build vs. buy” decision. This ‘buy’ decision now includes the option to subscribe instead of buying it outright.

Listen to Ramli John as he shared 3 factors you should consider to help you decide which option is best for you. (warning: video contains Appcues product marketing)

There are many advantages to purchasing software from an outside company. First, it is generally less expensive to purchase a software package than to build it. Second, when a software package is purchased, it is available much more quickly than if the package is built in-house. Third, companies or consumers pay a one-time price and get to keep the software for as long as the license allows and could be as long as you own it or even after the vendor stops supporting it. Software applications can take months or years to build; a purchased package can be up and running within a month. A purchased package has already been tested, and many of the bugs have already been worked out, and additional support contracts can be purchased. It is the role of a systems integrator to make various purchased systems and the existing systems at the organization work together.

There are also disadvantages to purchasing software. First, the same software you are using can be used by your competitors. If a company is trying to differentiate itself based on a business process in that purchased software, it will have a hard time doing so if its competitors use the same software. Another disadvantage to purchasing software is the process of customization. If you purchase a software package from a vendor and then customize it, you will have to manage those customizations every time the vendor provides an upgrade. With the rise of security and privacy, companies may lack the in-house expertise to respond quickly. Installing various updates and dealing with bugs encountered may also be a burden to IT staff and users. This can become an administrative headache.

A hybrid solution is to subscribe. Subscribe means that instead of selling products individually, vendors now offer a subscription model that the users can rent and pay periodically, such as monthly, yearly. The renting model has been used in many other industries such as movies, books and recently has moved into high tech industries. Companies and consumers can now subscribe to almost everything, as we discussed in earlier chapters, from additional storage in your email platforms such as Google Drive or Microsoft Onedrive, to software such as Quickbooks, Microsoft Office 365, to hosting and web support services such as Amazon AWS. Vendors benefit from converting one-time sales to recurring sales and increase customer loyalty. Customers benefit from the headache of installing updates, having the software support and updates taken care of automatically, knowing that the software continues to be updated with new features. A subscription model is now a prevalent option for both consumers and businesses.

Even if an organization determines to buy or subscribe, it still makes sense to go through many of the same analyses to compare the costs and benefits of building it themselves. This is an important decision that could have a long-term strategic impact on the organization.

✔ Use Case: Build vs. Buy 10.3.1

Company My Widgets is evaluating options for a new enterprise system to manage its supply chain and manufacturing operations. The COO has requested a build vs buy analysis.

Solution

1. Build Option: The IT department could develop a custom supply chain management system tailored to My Widgets' unique manufacturing workflows. They already have experience with the required technologies. This system would provide competitive advantages from proprietary processes. However, initial development is estimated at 18 months with ongoing maintenance.
2. Buy Option: Several vendors offer supply chain management software, such as SAP and Oracle. The systems provide standard functionality that covers 70% of My Widgets' needs. They could be implemented in 6 months but would require custom integrations. Vendor costs are $1M for licenses and support.

In this scenario, the company must weigh factors like competitive advantage, development costs, maintenance, and speed-to-implementation. While building provides customization, buying could allow faster rollout and leverage vendor expertise. Engaging users and mapping processes to packaged capabilities is essential in the decision-making process.

10.3.4: Web Services

Chapter 3 stated that the move to cloud computing has allowed software to be looked at as a service. One option companies have these days to license functions provided by other companies instead of writing the code themselves. These are called web services, and they can greatly simplify the addition of functionality to a website.

For example, suppose a company wishes to provide a map showing the location of someone who has called their support line. By utilizing Google Maps API web services, they can build a Google Map right into their application. Or a shoe company could make it easier for its retailers to sell shoes online by providing a shoe-size web service that the retailers could embed right into their website.

Web services can blur the lines between “build vs. buy.” Companies can choose to build a software application themselves but then purchase functionality from vendors to supplement their system.

10.3.5: End-User Computing or Shadow IT

In many organizations, application development is not limited to the programmers and analysts in the information-technology department. Especially in larger organizations, other departments develop their own department-specific applications. The people who build these are not necessarily trained in programming or application development, but they tend to be adept with computers. A person, for example, who is skilled in a particular software package, such as a spreadsheet or database package, may be called upon to build smaller applications for use by his or her own department. This phenomenon is referred to as ***end-user development***, or ***end-user computing***, or ***Shadow IT***.

Shadow IT is the use of IT-related hardware or software by a department or individual without the knowledge of the IT or security group within the organization. It can encompass cloud services, software, and hardware.

Some examples of shadow IT applications and cloud based services include:

- Productivity tools such as Asana and Trello
- Cloud storage, file-sharing and document-editing applications such as Google Drive, Dropbox, Google Docs
- Communication and messaging apps such as Skype, Slack, Whatsapp, Telegram, as well as personal email accounts.

End-user computing can have many advantages for an organization. First, it brings the development of applications closer to those who will use them. Because IT departments are sometimes quite backlogged, it also provides a means to have software created more quickly. Many organizations encourage end-user computing to reduce the strain on the IT department. for example, Excel can be used to create a customer-facing application that depicts dynamic views into different investment scenarios. An end-user development like this can help customers easily view, comprehend and determine their preferred course of action.

End-user computing does have its disadvantages as well. If departments within an organization are developing their own applications, the organization may end up with several applications that perform similar functions, which is inefficient since it duplicated effort. Sometimes, these different versions of the same application provide different results, bringing confusion when departments interact. These applications are often developed by someone with little or no formal training in programming. In these cases, the software developed can have problems that have to be resolved by the IT department. Shadow IT can also pose significant security risks. Because the IT team is unaware of shadow IT, it doesn't monitor these assets, or address their vulnerabilities. End-user computing can be beneficial to an organization, but it should be managed. The IT department should set guidelines and provide tools for the departments who want to create their own solutions.

Communication between departments will go a long way towards the successful use of end-user computing.

10.3.6: Mobile Platforms and Tools

There are a wide variety of development tools available for building mobile applications on different platforms:

- iOS apps are built using Swift or Objective-C languages and Xcode IDE, along with Apple's software development kit (SDK).
- Android apps are built using Java or Kotlin, along with Android Studio IDE and Android SDK.
- Cross-platform apps use frameworks like Xamarin, React Native, Flutter to allow development in languages like C# and JavaScript.
- Web apps use standard web development tools like HTML, CSS, JavaScript.

Understanding the different tools for different mobile platforms helps inform the build vs buy decision for organizations.

Sidebar: Building a Mobile App

Software development typically includes building applications to run on desktops, servers, or mainframes. However, the web's commercialization has created additional software development categories such as web design, content development, web server. Web-related development effort for the internet is now called web development. Earlier web development activities include building websites to support businesses or to build e-commerce systems and have made technologies such as HTML very popular with web designers and programming languages such as Perl, Python, Java popular for programmers. Pre-packaged websites are now available for consumers to purchase without learning HTML or hiring a web designer. For example, entrepreneurs who want to start a bakery business can now buy a pre-build website with a shopping cart, all ready to start a business without incurring costly expenses to build it themselves.

With the rise of mobile phones, a new type of software development called mobile app development came into being. Statista.com forecasts that Mobile apps revenues will increase significantly from $98B in 2014 to over $935B by 2023. This means that the need for mobile app developers has also increased.

In many ways, building an application for a mobile device is the same as building an application for a traditional computer. Understanding the application requirements, designing the interface, working with users – all of these steps still need to be carried out. The decision process to pick the right programming languages and tools remains the same.

However, there are specific differences that programmers must consider in building apps for mobile devices. They are:

- The user interface must vary to adapt to different screen size
- The use of fingers as pointers or to type in text instead of keyboard and mouse on the desktop
- Specific requirements from the OS vendor must be met for the app to be included in each store (i.e., Apple's App Store or Android's Play Store)
- The integration with the desktop or the cloud to synch up data
- Tight integration with other built-in hardware such as cameras, biometric or motion sensors.
- Less available memory, storage space, and processing power

Mobile apps are now available for just about everything and continue to grow.

10.3.7: Risks of End-User Computing

While end-user computing can provide organizations with more flexibility, there are also risks to consider:

- Unsupported apps - Apps developed by end users may not follow official development and documentation processes. This makes them harder to maintain when issues arise.
- Integration problems - End-user apps may not properly integrate with existing systems and databases. This can lead to data inconsistencies.
- Data discrepancies - With multiple departments creating their own apps, data can end up fragmented across siloed systems. The canonical source of truth is lost.
- Security vulnerabilities - Apps created outside official IT processes may not undergo proper security testing, leaving them open to cyberthreats.

To minimize risks from end-user computing, organizations should have IT oversight including:

- Published standards - Provide guidelines for end users on preferred programming languages, databases, etc.
- Code reviews - Require code reviews of end user apps to catch issues early.
- Change management - Formalize a process for requesting new end user apps and changes.
- Security testing - Test end user code for vulnerabilities before deployment.

With proper IT change management and governance, organizations can take advantage of end user computing benefits while reducing associated risks.

10.3.8: Security and Privacy in Software Development

While security applies to the entire software lifecycle, many key considerations need to be addressed up front during development. When developing new software applications, security and privacy need to be considered from the initial design phases:

- Secure design - Architect the application with security principles in mind from the start using best practices like encryption, least privilege access, and input validation.
- Data protection - Implement controls like encryption and tokenization to protect sensitive data in transit and at rest. Follow industry data security standards.
- Access controls - Limit user access with role-based permissions and multi-factor authentication. Maintain detailed logs for auditing.
- Patching - Ensure a patching roadmap is in place to quickly roll out new patches for security vulnerabilities as they arise.
- Testing - Perform extensive security testing activities like risk assessments, penetration testing, and code reviews to identify vulnerabilities.
- Compliance - Consider regulatory and industry-specific requirements like HIPAA and PCI DSS early in the process.

Making security and privacy a priority during software design, development, testing, and deployment reduces risk and instills trust.

10.3.9: Software Testing Methodologies

While testing does come before implementation, it is tightly aligned to development methodologies and software creation and the testing strategies should be part of the development methodologies and software creation. Some key testing methods include:

- Unit testing - Tests individual units of code like functions to make sure they work as intended. Confirms the smallest components operate correctly.
- Integration testing - Verifies that different modules and interfaces connect and interact properly. Makes sure components work together.
- System testing - Validates the entire system meets requirements. Tests the fully integrated system.
- User acceptance testing (UAT) - Real users test the software to validate it meets business needs and provides the expected user experience.
- Load testing - Checks application performance under expected user loads and identifies capacity limits.
- Security testing - Validates controls against vulnerabilities like exploits, data leaks, unauthorized access.

Managers should understand the purpose of each testing methodology to insure that the project meets the expected quality from the customers or users and are taken account in the budget planning.

10.3.10: Global Software Development

Many software projects today involve global teams with members distributed across multiple timezones and geographic regions. Effective collaboration is crucial for success and needs to be part of the planning of the development project. Considerations include:

- Communication - With remote team members, invest in tools for communication like Slack, Zoom, and email to bridge distance gaps.
- Collaboration - Use project management platforms like JIRA or Trello to coordinate tasks and status across locations. Version control with Git enables code sharing.
- Scheduling - Overlap team members working hours so collaboration can happen live. Schedule calls respecting time zones.
- Culture - Recognize cultural differences in communication styles and needs. Bridge language barriers.
- Onboarding - Train remote members on processes and tools. Create documentation assets for consistency.
- Bonding - Foster connections between remote members with team gatherings or visits if possible. Build relationships and trust.

With an intentional strategy and process for how to collaborate gobablly, the project will decrease the risk of failure during the implementation phase.

10.3.10.1: References:

Javascript was the most used language among developers worldwide (2020). Retrieved December 10, 2020, from Satistica.com

Google Maps Platform Documentation. Retrieved December 10, 2020, from https://developers.google.com/maps/documentation

Programming/development tools used by software developers worldwide from 2018 and 2019 (2020). Retrieved December 10, 2020, from Statista.com

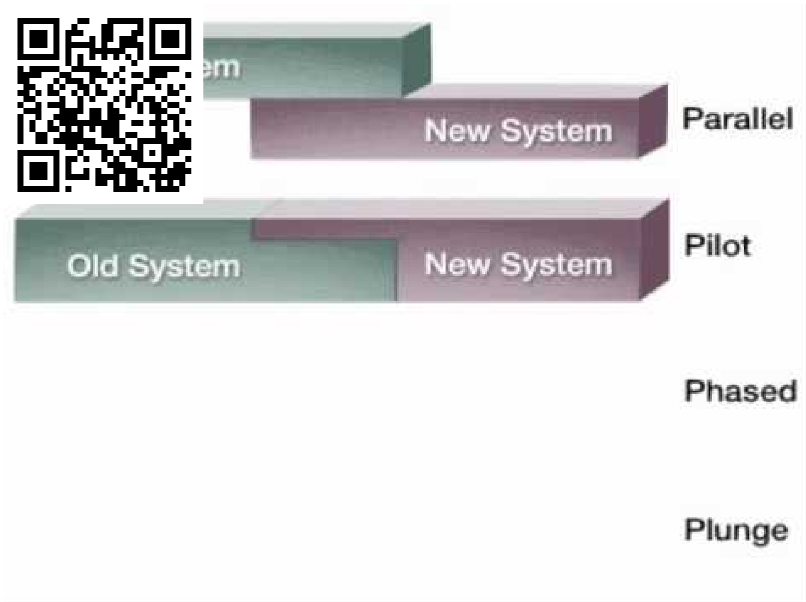
Worldwide mobile app revenues in 2014 to 2023 (2010.) Retrieved December 10, 2020, from Statista.com

Shadow IT. IBM Topics. https://www.ibm.com/topics

10.4: Implementation Methodologies

Once a new system is developed (or purchased), the organization must determine the best method for implementing it. Convincing a group of people to learn and use a new system can be a challenging process. Using the new software and the business processes it gives rise to can have far-reaching effects within the organization.

There are several different methodologies or phases an organization can adopt to implement a new system. Four of the most popular are listed below. Here's a video that gives a brief overview of Implementation methodologies



- **Direct cutover (or plunge)**. In the direct-cutover implementation methodology, the organization selects a particular date that the old system will not be used anymore. On that date, the users begin using the new system, and the old system is unavailable. The advantages of using this methodology are that it is speedy and the least expensive. However, this method is the riskiest as well. If the new system has an operational problem or is not properly prepared, it could prove disastrous for the organization.
- **Pilot implementation**. In this methodology, a subset of the organization (called a pilot group) starts using the new system before the rest of the organization. This has a smaller impact on the company and allows the support team to focus on a smaller group of individuals.
- **Parallel operation**. With the parallel operation, the old and new systems are used simultaneously for a limited period of time. This method is the least risky because the old system is still being used while the new system is essentially being tested. However, this is the most expensive methodology since work is duplicated and support is needed for both systems in full.
- **Phased implementation**. In a phased implementation, different functions of the new application are used as functions from the old system are turned off. This approach allows an organization to move from one system to another slowly.

These implementation methodologies depend on the complexity and importance of the old and new systems.

10.4.1: Change Management

As new systems are brought online, and old systems are phased out, it becomes important to manage how change is implemented. Change should never be introduced in a vacuum. The organization should be sure to communicate proposed changes before they happen and plan to minimize the impact of the change that will occur after implementation. Training and incorporating users' feedback are critical to increasing user's acceptance of the new system. Without gaining the user's acceptance, the risk of failure is very high. We discussed in a prior chapter about Change management given that it is a critical component of IT oversight.

Use case: Change Management 10.4.1

Acme Inc. recently implemented a new cloud-based enterprise resource planning (ERP) system to manage finances, inventory, and manufacturing. How should they they follow a change management process?

Solution

They followed these change management practices:

- Communication - One month before launch, the CIO sent emails and held town halls explaining the new ERP and why it was needed.
- Training - All users went through online and in-person training on the new ERP before and after launch. Quick reference guides were also distributed.
- User involvement - Key user representatives were part of the ERP selection and provided input on configurations.
- Support - For the first month, on-site experts from the vendor helped employees and answered questions. The help desk was also bolstered.
- Feedback - Users were surveyed two weeks after launch about their experiences. Enhancements were developed to address issues.
- Transition time - The old and new ERP systems ran in parallel for two weeks during launch before completely switching over.

By taking these steps, Acme Inc ensured a smooth transition to the new system by increasing user adoption.

10.4.2: Maintenance

Once a new system has been introduced, it enters the maintenance phase. In this phase, the system is in production and is being used by the organization. While the system is no longer actively being developed, changes need to be made when bugs are found, or new features are requested. During the maintenance phase, IT management must ensure that the system continues to stay aligned with business priorities, has a clear process to accept requests, problem reports, deploy updates to ensure user's satisfaction with continuous improvements in the product's quality.

Ongoing maintenance is required, including:

- Bug fixes - As bugs are discovered, they must be prioritized and fixed via patches. A structured process for bug reporting, triage, and resolution should be in place.
- Feature requests - Users will request new features over time. Each request should be evaluated and prioritized by business value.
- Testing - Any patches, bug fixes, or new features need to be tested before deployment to production.
- Upgrades - Vendor supplied updates and upgrades to fix vulnerabilities or add new functionality need to be evaluated and rolled out.
- Sunset planning - Eventually, systems need to be retired. Planning ahead for sunsetting legacy systems is key.

To manage these activities, organizations should have defined processes for triaging requests, fixing issues, testing changes, and releasing updates. Regular schedules for upgrades and bug fix rollouts should be established and communicated to users.

With the rise of privacy concerns, many companies now add policies about maintaining their customers' data or data collected during the project. Policies such as when to dispose of, how to dispose of, where to store are just a few examples.

10.4.3: Release Management

Once software development is complete, there are ongoing processes for deploying updates:

- Release planning - Evaluates features, bundles them into releases, and sets a rollout schedule.
- Release testing - Testing of new increments before deployment to production environments.
- Rollout - Transferring updates from the test environment and making them live for users.
- Monitoring - Tracking application performance and issues after updates are released.

Organizations need to have a structured release process that ensures changes are properly tested and deployed and to communicate with customers to help with their own planning when to receive and install the company's updates and releases.

10.5: Summary

Developing an information system is a complex process requiring close management of costs, timelines, and development teams. Following a structured systems development lifecycle (SDLC) process helps manage risk and deliver high quality solutions. Programming languages and tools continue to rapidly evolve, requiring developers to continuously learn new skills.

Software development involves much more than just coding. Cross-functional teams must collaborate to turn requirements into working software. Agile methods encourage constant user feedback and embrace changing requirements. Involving users throughout the development process improves software quality and user adoption.

Organizations must weigh factors like resources, timelines, and customization needs when deciding whether to build, buy, or subscribe to software. Security and compliance should be priorities early in development. Maintenance keeps systems aligned with evolving business needs after deployment.

End user computing outside of IT departments can improve agility but requires oversight. Effective change management and training helps drive user adoption of new systems. Global collaboration tools now enable software teams to work together effectively across locations and time zones.

By following best practices in software development, maintenance, and implementation, organizations can deliver solutions that are on time, on budget, and tailored to their business needs.

10.6: Study Questions

? Study Question 10.6.1

What are the steps in the SDLC methodology?

Answer

The steps in SDLC are planning, analysis, design, implementation, and maintenance.

? Study Question 10.6.2

What is RAD software development?

Answer

RAD is a development methodology focused on quickly building a prototype and iterating based on user feedback instead of detailed specifications.

? Study Question 10.6.3

What is the Waterfall model?

Answer

The Waterfall model is an SDLC-based model with sequential phases of requirements, design, implementation, testing, and maintenance.

? Study Question 10.6.4

What makes the lean methodology unique?

Answer

The lean methodology is unique in its focus on launching a minimum viable product quickly and using user feedback to iteratively modify it.

? Study Question 10.6.5

What is the difference between the Waterfall and Agile models?

Answer

Waterfall uses sequential phases while agile utilizes iterative sprints and continuous user feedback.

? Study Question 10.6.6

What is a sprint?

Answer

A sprint is a short, fixed time period in agile development during which specific features are implemented.

? Study Question 10.6.7

What are three differences between second-generation and third-generation languages?

Answer

Three differences are: 2GLs are low-level/machine code, 3GLs are closer to human language, 3GLs are portable across platform.

? Study Question 10.6.8

Why would an organization consider building its own software application if it is cheaper to buy one?

Answer

Reasons to build vs buy include greater customization, competitive advantage, and keeping intellectual property in-house.

? Study Question 10.6.9

What is the difference between the pilot implementation methodology and the parallel implementation methodology?

Answer

Pilot rolls out to a subset of users first, while parallel runs new and old systems concurrently for everyone.

? Study Question 10.6.10

What are the differences between compiled programming languages and interpreted programming languages?

Answer

Compiled languages are converted to machine code before execution. Interpreted languages are executed line-by-line by an interpreter program.

? Study Question 10.6.11

What is change management?

Answer

Change management is the process of managing user adoption when introducing a new system through training, support, and communication.

? Study Question 10.6.12

What are the four different implementation methodologies?

Answer

Direct cutover, pilot, parallel, and phased are four implementation methodologies.

10.6.1: Exercises

1. Which software-development methodology would be best if an organization needed to develop a software tool for a small group of users in the marketing department? Why? Which implementation methodology should they use? Why?
2. Doing your own research, find three programming languages and categorize them in these areas: generation, compiled vs. interpreted, procedural vs. object-oriented.
3. Some argue that HTML is not a programming language. Doing your own research, find three arguments for why it is not a programming language and three arguments for why it is.
4. Read more about responsive design using the link given in the text. Provide the links to three websites that use responsive design and explain how they demonstrate responsive-design behavior.
5. Discuss advantages and disadvantages of buy vs build.
6. Research the criteria and cost to put a mobile app into Apple's App Store. Write a report.
7. Consider Google Docs or Google Sheets. What end user application - add on would you make it more productive or convenient for your use?
8. Research to find out what elements to use to estimate the cost to build an app. Write a report.
9. Go to a job site and find a software developer job description. What are the required qualifications and skills?
10. Install and try a simple new software application, from a credible source, on your computer or phone. Document your experience going through the implementation and adoption process.
11. Sign up for a free trial of an online software service like project management, email marketing, or accounting. Evaluate their onboarding and training process for new users.
12. Observe someone who doesn't have a technical background use a new software tool. Note any difficulties they encounter and where the product could be more user friendly.

CHAPTER OVERVIEW

11: Information Systems, Globalization, and Inequality

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Explain the concept of globalization;
- Describe the role of information technology in globalization;
- Identify the issues experienced by firms as they face a global economy; and
- Define the digital divide and explain Nielsen's three stages of the digital divide.

The rapid rise of the Internet has made it easier than ever to do business worldwide. This chapter will look at the impact that the Internet is having on the globalization of business. Firms will need to manage challenges and leverage opportunities due to globalization and digitalization. It will discuss the digital divide concept, what steps have been taken to date to alleviate it, and what more needs to be done.

11.1: Introduction

In this chapter, we will look at how the Internet has opened the world to globalization. We will look at where it began and fast forward to where we are today. We will review the influences of man, machine, and technology enabling globalization. It is now just as simple to communicate with someone on the other side of the world as to talk to someone next door. In this chapter, we will look at the implications of globalization and its impact on the world.

What Is Globalization?

Globalization is found in economics and refers to the integration of goods, services, and culture among the people and nations of the world. Globalization has accelerated since the turn of the 18th century due to mass improvements in transportation and technology. Globalization has its roots as far back as an exploration of finding the New World. Globalization creates world markets. Places once limited to only providing goods and services to the immediate area now have open access to other countries worldwide. The expansion of global markets has increased economic activities in the exchange of goods, services, and funds, which has created global markets that are now readily feasible. Today, people's ease of connectivity has accelerated the speed of globalization. People no longer have to sail for a year to share goods or services.

Fig. 11.1 Globalization in Handshake, Hands, Laptop, Monitor. Image by Gerd Altmann is licensed CC BY-SA 2.0

The Internet has connected nations. From its initial beginnings in the United States in the 1970s to the development of the World Wide Web, it has crept into home use with the introduction of the personal computer in the 1980s. The 90s then introduced social networks and e-commerce of today; the Internet has continued to increase the integration between countries, making globalization a fact of life for citizens worldwide. The Internet is truly a worldwide phenomenon. By Q2 of 2022, approximately 5.4 billion people, or more than half of the world's population, use the Internet. The growth from 2000 to 2023 is about 1392%! For more details and to explore each region interactively, please view the data at internetworldstats.com.

WORLD INTERNET USAGE AND POPULATION STATISTICS 2023 Year Estimates						
World Regions	Population (2022 Est.)	Population % of World	Internet Users 31 Dec 2021	Penetration Rate (% Pop.)	Growth 2000-2023	Internet World %
Africa	1,394,588,547	17.6 %	601,940,784	43.2 %	13,233 %	11.2 %
Asia	4,352,169,960	54.9 %	2,916,890,209	67.0 %	2,452 %	54.2 %
Europe	837,472,045	10.6 %	747,214,734	89.2 %	611 %	13.9 %
Latin America / Carib.	664,099,841	8.4 %	534,526,057	80.5 %	2,858 %	9.9 %
North America	372,555,585	4.7 %	347,916,694	93.4 %	222 %	6.5 %
Middle East	268,302,801	3.4 %	206,760,743	77.1 %	6,194 %	3.8 %
Oceania / Australia	43,602,955	0.5 %	30,549,185	70.1 %	301 %	0.6 %
WORLD TOTAL	7,932,791,734	100.0 %	5,385,798,406	67.9 %	1,392 %	100.0 %

NOTES: (1) Internet Usage and World Population Statistics estimates are for June 30, 2022. (2) CLICK on each world region name for detailed regional usage information. (3) Demographic (Population) numbers are based on data from the United Nations Population Division. (4) Internet usage information comes from data published by Nielsen Online, by the International Telecommunications Union, by GfK, by local ICT Regulators and other reliable sources. (5) For definitions, navigation help and disclaimers, please refer to the Website Surfing Guide. (6) The information from this website may be cited, giving the due credit to www.internetworldstats.com.

Fig 11.2 - World Internet Usage and Population Statistics. Source: https://internetworldstats.com/stats.htm

The Network Society

1996 social-sciences researcher Manuel Castells published The Rise of the Network Society. He identified new ways to organize economic activity around the networks the latest telecommunication technologies provided. This unique, global economic activity was different from the past because "it is an economy with the capacity to work as a unit in real-time on a planetary scale." (Castells, 2000) We are now in this network society where we are all connected on a global scale.

The World Is Flat

In Thomas Friedman's seminal book, The World Is Flat (Friedman, 2005), he unpacks the personal computer, the Internet, and communication software's impact on business, specifically globalization. He begins the book by defining the three eras of globalization:

- "Globalization 1.0″ occurred from 1492 until about 1800. In this era, globalization was centered around countries. It was about how much horsepower, wind, and steam power a country had and how creatively it was deployed. The world shrank from size "large" to size "medium."
- "Globalization 2.0″ occurred from about 1800 until 2000, interrupted only by the two World Wars. In this era, the dynamic force driving change was multinational companies. The world shrank from size "medium" to size "small."
- "Globalization 3.0″ is our current era, beginning in the year 2000. The convergence of the personal computer, fiber-optic Internet connections, and software has created a "flat-world platform" that allows small groups and even individuals to go global. The world has shrunk from size "small" to size "tiny."

According to Friedman (2005), this third era of globalization was brought about, in many respects, by information technology. Some of the specific technologies he lists include:

- The graphical user interface for the personal computer was popularized in the late 1980s. Before the graphical user interface, using a computer was relatively complex. By making the personal computer something that anyone could use, it became commonplace very quickly. Friedman points out that this digital storage of content made people much more productive and, as the Internet evolved, made it simpler to communicate content worldwide.
- The build-out of the Internet infrastructure during the dot-com boom during the late 1990s. During the late 1990s, telecommunications companies laid thousands of miles of fiber-optic cable worldwide, turning network communications into a commodity. At the same time, the Internet protocols, such as SMTP (e-mail), HTML (web pages), and TCP/IP (network communications), became standards that were available for free and used by everyone.

- The introduction of software to automate and integrate business processes. As the Internet continued to grow and become the dominant form of communication, it became essential to build on the standards developed earlier so that the websites and applications running on the Internet would work well together. Friedman calls this "workflow software," which allows people to work together more efficiently and allows different software packages and databases to integrate easily. Examples include payment-processing systems and shipping calculators.

These three technologies came together in the late 1990s to create a "platform for global collaboration." Once these technologies were in place, they continued to evolve. Friedman also points out a couple more technologies that have contributed to the flat-world platform – the open-source movement (see Chapter 10) and the advent of mobile technologies.

Example - Expedia 11.1.1

Expedia's travel booking company provides an example of a business that expanded globally thanks to the Internet and information systems.

Solution

Founded in 1996 just as the Internet was gaining mainstream traction, Expedia leveraged the connectivity of the Web to allow travelers to easily search for and book flights, hotels, rental cars, and more.

Given the Internet's borderless nature, Expedia could instantly provide booking services worldwide. Today, it operates local sites in over 70 countries and has grown into one of the largest online travel agencies.

The World Is Flat was published in 2005. Since then, we have seen even more growth in information technologies contributing to global collaborations. We will discuss current and future trends in chapter 13.

References

Castells, Manuel (2000). The Rise of the Network Society (2nd ed.). Blackwell Publishers, Inc., Cambridge, MA, USA.

Friedman, T. L. (2005). The world is flat: A brief history of the twenty-first century. New York: Farrar, Straus, and Giroux.

Q2 2022 Internet usage. Retrieved August 1, 2023, from internetworlstats.com.

11.2: The Global Firm

The Global Firm

What do Apple, Coca-Cola, Amazon, and Toyota have in common?

They are all successful global companies. A multinational corporation, also known as a global company, is coined from the base term' global,' which means all arworldwideakes sense to assume that a global company is a company that does business in at least one country other than the country where it originated.

The new era of globalization allows any business to become international. By accessing this new platform of technologies or networks, Castells' vision (Castells, 2000) of working as a unit in real-time on a planetary scale can be a reality. He believed the collective could benefit society. Some of the advantages of this include the following:

- **Access to expertise and labor around the world**. Organizations are no longer limited by viable candidates locally and can now hire people from the global labor pool. This also allows organizations to pay a lower labor cost for the same work based on the prevailing wage in different countries.
- **Operate 24 hours a day**. With employees in different time zones worldwide, an organization can operate around the clock, handing off work on projects from one part of the world to another. Businesses can also keep their digital storefront (their website) constant time.
- **Access to a larger market for firm products**. Once a product is sold online, it is available from a worldwide consumer base. Even if a company's products do not appeal beyond its own country's borders, being online has also made the product more visible to consumers within that country.
- **Achieve a diversity of the market**. It helps companies to stabilize their overall revenue sources. The company could experience a gain in revenues in one country and be down the other side of the world, which will help stabilize its revenues.
- **Gain more exposure to foreign investment opportunities.** Globalization helps companies become more familiar with opportunities in the new areas they are expanding into.

Fun Fact: Coca-Cola - From a startup to a global company

All contemporary global companies once had been mere startups. Coca-Cola was once a drugstore in Atlanta, Georgia. On May 8, 1886, Dr. John Pemberton brought his perfected syrup to Jacobs' Pharmacy in downtown Atlanta, where the first glass of Coca-Cola was poured. By World War II, Coca-Cola was 50 years old and had proudly maintained its price at 5 cents to enable many people to afford the beverage. The company would sell its drink to U.S. soldiers worldwide for 5 cents a bottle, but no more. Coca-Cola now sells its beverages in more than 200 countries. The Coca-Cola Company sells its popular fizzy drinks such as Coke, Fanta, Sprite, and some 3,800 other products, including soy-based beverages enriched with vitamins. The Coca-Cola Company also sells juices, iced teas, bottled water, and more. One of the reasons Coca-Cola has seen such monumental success in nearly every country in which it has established itself is that it never had a standardized view of all countries. The company will ensure it only provides products that fit the local community's tastes and culture.

To fully take advantage of these new capabilities, companies must understand that there are also challenges in dealing with employees, customers from different cultures, and other countries' economies. Some of these challenges include:

- **Infrastructure differences**. Each country has its own infrastructure, many of which are not the same quality as the U.S. infrastructure. Americans are currently getting around 135 Mbps of download speed and 52 Mbps of upload speed through their fixed broadband connections — good for eighth in the world and around double the global average. For every South Korea (16 average speed), there is an Egypt (0.83 MBps) or an India (0.82 MBps). A business cannot depend on every country having the same Internet speeds. See the sidebar called "How Does My Internet Speed Compare?"
- **Labor laws and regulations**. Different countries (including the United States) have different laws and regulations. A company that wants to hire employees from other countries must understand the various rules and concerns.
- **Legal restrictions**. Many countries restrict what can be sold or how to advertise a product. A business needs to understand what is allowed. For example, in Germany, it is illegal to sell anything Nazi-related; in China, it is illegal to put anything sexually suggestive online.
- **Language, customs, and preferences**. Every country has its own (or several) unique culture(s), which a business must consider when trying to market a product. Additionally, different countries have different preferences. For example, in some

parts of the world, people prefer french fries with mayonnaise instead of ketchup; in other regions, specific hand gestures (such as the thumbs-up) are offensive.

- **International shipping**. Promptly shipping products between countries can be challenging. Inconsistent address formats, dishonest customs agents, and prohibitive shipping costs are all factors that must be considered when trying to deliver products internationally.
- **Volatility of currency**. This could occur when you are buying or selling goods; the currency has significant fluctuations in value when converting to a different country's currency, such as the euro, yen, and dollar.

The Challenges of Technology Infrastructure Abroad

When expanding operations to a new country, companies must carefully evaluate the on-the-ground realities of the technology infrastructure they will encounter. Factors like average Internet speeds, reliability of electricity, and access to technical support will impact performance. For example:

- Internet speeds may be significantly slower than what a company is used to. Peru averages 22 Mbps, while Taiwan sees 85 Mbps.
- Power outages may be more frequent, disrupting operations and forcing reliance on generators. Outages averaged 4.5 hours per month in India vs. 1.5 hours in France.
- Technical support resources may be less readily available. Singapore has one I.T. support personnel for every 90 residents, while Honduras has one for every 3,000.

Up to speed on these infrastructure differences will allow companies to set realistic expectations and develop workarounds. Finding local telecom partners to provide redundancy for Internet and electricity can mitigate risks. This knowledge can help to facilitate a smoother expansion process.

? Exercise - Supporting Global Operations 11.2.1

ShutterQuick (a fictitious company) is a US-based company that produces high-end electronic camera shutters. They want to expand internationally, specifically Brazil and Indonesia. What should they consider to evaluate the technology infrastructure in potential new markets to support the global operations?

Answer

As they looked to expand internationally, they carefully evaluated the technology infrastructure in potential new markets.

They found average Internet speeds of 25 Mbps in Brazil, suitable for normal operations. But electricity reliability was a concern, with average power outages occurring nearly three hours per month. ShutterQuick addressed this by working with a local partner to set up generator backups for their facilities.

In Indonesia, ShutterQuick was attracted by the low engineering labor costs. But technical support was scarcer, with only one I.T. support person for every 5,000 residents on average. ShutterQuick overcame this by hiring and training local support teams to service their office's needs.

ShutterQuicks successfully tailored its strategies by proactively understanding infrastructure conditions, allowing it to build thriving operations in new countries. Factoring in on-the-ground realities before expanding sets companies up for global success.

Because of these challenges, many businesses choose not to expand globally for labor or customers. Whether a company has its website or relies on a third party, such as Amazon or eBay, the question of whether to globalize must be carefully considered.

Globalization has changed dramatically in the last several decades. It has seen positive development, with associated costs and benefits, such as organizations have seen their fortune changed and progress and modernization are brought into various parts of the world. However, its benefits are not necessarily evenly distributed across the globe. With the global pandemic of 2020 (COVID-19), globalization is now viewed by many as risks to the national supply chain of goods and services, job losses, increased inequality, and health risks. It is expected that globalization post-Covid will need to mitigate these risks to move to a more balanced approach between independence and integration between countries (Kobrin, 2020).

Sidebar: How does my Internet Speed Compare?

Internet speed varies by geography, such as states and countries, as reported by Statista.com. For example, as of April 2023, Singapore's internet speed is ~242 Mbps, while Romania's is ~174 Mbps. Please visit Statista.com for more details.

Statista.com also reported that as of June 2020, over 42% of U.S. households did not know the down and speed of their household internet service. The download speed varies from 10 Mbps or less to over 100 Mbps. There are several free tools that you can use to test your household internet upload and download speed, such as the app speed test, a free download (as of this writing).

References

Castells, Manuel (2000). The Rise of the Network Society (2nd ed.). Blackwell Publishers Inc., Cambridge, MA, USA.

Kobrin, S.J (2020). How globalization became a thing that goes bump in the night. J Int Bus Policy 3, 280–286. https://doi.og/10.1057/s42214-020-00060-y

Statista. (2020). Household internet download speed for adults in the United States as of June 2020. Retrieved December 5, 2020, from Statista.com.

Statista. (2023). Countries with the fastest average fixed broadband internet speeds as of April 2023 (in Mbps). Retrieved August 1, 2023, from Statista.com.

LaMarco, N (2018) November 5). *What is a Global Corperation?* Retrieved August 1, 2023 from smallbusiness.chron.com.

11.3: The Digital Divide

The Digital Divide

As the Internet continues to make inroads across the world, it also creates a separation between those with access to this global network and those without access. This separation, called the "digital divide," is of great concern. Kilburn (2005) summarizes this concern in his article Crossroads:

Adopted by the ACM Council in 1992, the ACM Code of Ethics and Professional Conduct focuses on issues involving the Digital Divide that could prevent specific categories of people - those from low-income households, senior citizens, single-parent children, the undereducated, minorities, and residents of rural areas — from receiving adequate access to the wide variety of resources offered by computer technology. This Code of Ethics positions the use of computers as a fundamental ethical consideration: "In a fair society, all individuals would have equal opportunity to participate in, or benefit from, the use of computer resources regardless of race, sex, religion, age, disability, national origin, or other similar factors." The article discusses the digital divide in various forms and analyzes reasons for the growing inequality in people's access to Internet services. It also describes how society can bridge the digital divide: the social gap between information "haves" and "have-nots."

Have a look at this infographic (Xanthios, 2017), which was created to educate students about the main groups that are digitally divided.

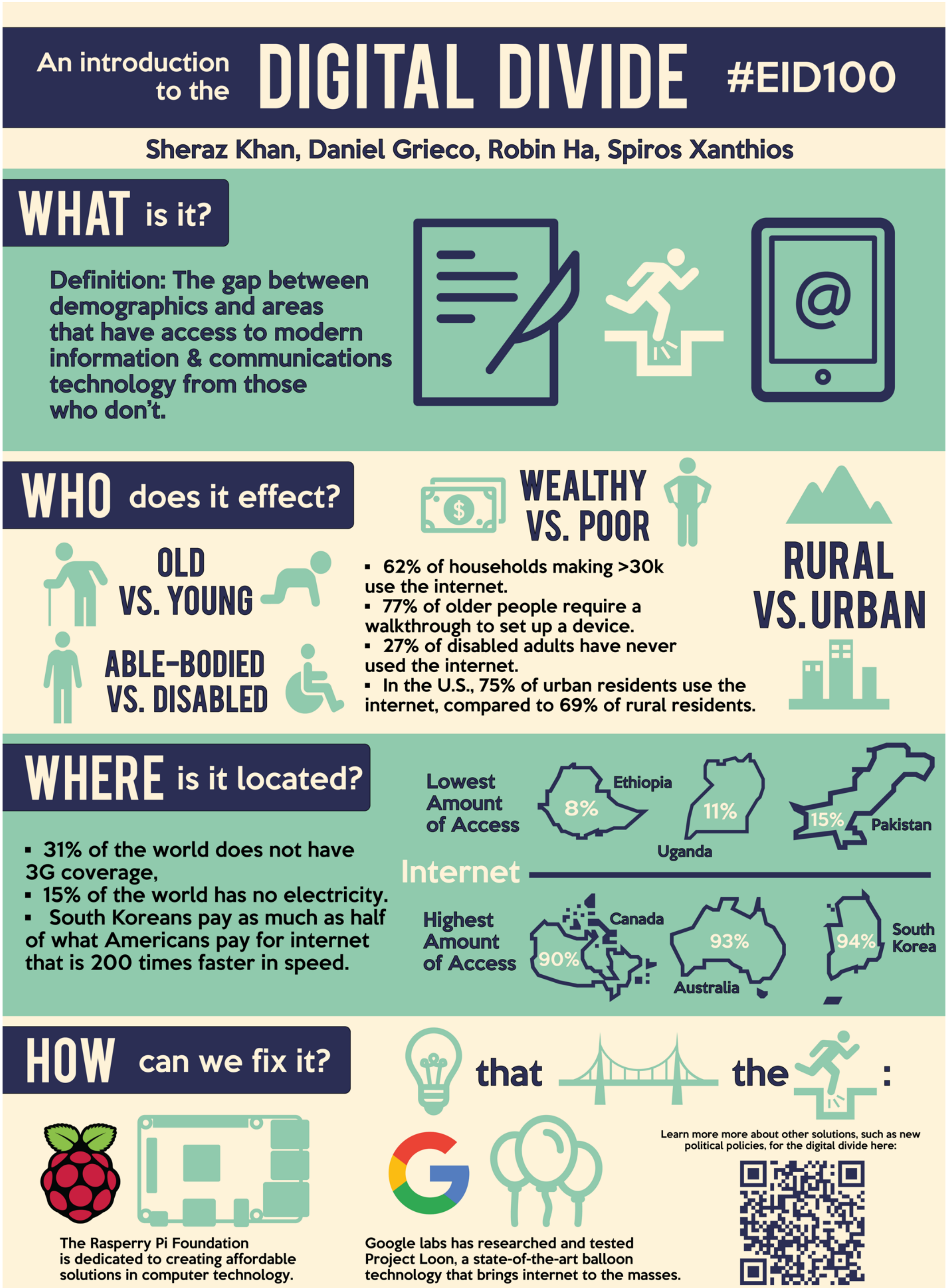

An introduction to the
DIGITAL DIVIDE
#EID100
Sheraz Khan, Daniel Grieco, Robin Ha, Spiros Xanthios
WHAT is it?
Definition: The gap between demographics and areas that have access to modern information & communications technology from those who don't.
WHO does it effect?
OLD VS. YOUNG
ABLE-BODIED VS. DISABLED
WEALTHY VS. POOR
▪ 62% of households making >30k use the internet.
▪ 77% of older people require a walkthrough to set up a device.
▪ 27% of disabled adults have never used the internet.
▪ In the U.S., 75% of urban residents use the internet, compared to 69% of rural residents.
RURAL VS. URBAN
WHERE is it located?
▪ 31% of the world does not have 3G coverage,
▪ 15% of the world has no electricity.
▪ South Koreans pay as much as half of what Americans pay for internet that is 200 times faster in speed.
Lowest Amount of Access
8%
Ethiopia
11%
Uganda
15%
Pakistan
Internet
Highest Amount of Access
90%
Canada
93%
Australia
94%
South Korea
HOW can we fix it?
that
the
:
The Rasperry Pi Foundation is dedicated to creating affordable solutions in computer technology.
Google labs has researched and tested Project Loon, a state-of-the-art balloon technology that brings internet to the masses.
Learn more more about other solutions, such as new political policies, for the digital divide here:

Figure 11.3.1: An introduction to digital divide by Xanthios, S retrieved from https://medium.com/@spirosx/an-introduction-to-the-digital-divide-33dc670f8c16.

The digital divide is categorized into three stages: the economic divide, the usability divide, and the empowerment divide (Nielson, 2006)

- **The economic divide** is usually called the digital divide: some people can afford a computer and Internet access while others cannot. Because of Moore's Law (see Chapter 2), the price of hardware has continued to drop, and, at this point, we can now access digital technologies, such as smartphones, for very little. This fact, Nielsen asserts, means that the economic divide is a moot point for all intents and purposes, and we should not focus our resources on solving it.
- **The usability divide** concerns that "technology remains so complicated that many people couldn't use a computer even if they got one for free." And even for those who can use a computer, accessing all the benefits of having one is beyond their understanding. Included in this group are those with low literacy and seniors. According to Nielsen, we know how to help these users, but we are not doing it because there is little profit.
- **The empowerment divide** is the most difficult to solve. It is concerned with how we use technology to empower ourselves. Very few users genuinely understand the power that digital technologies can give them. In his article, Nielsen explains that his (and others) research has shown that very few users contribute content to the Internet, use advanced search, or even distinguish paid search ads from organic search results. Many people do not see themselves in online spaces and don't feel they can inhabit those spaces without help and training - they are not ready for it. They do not have sufficient skills, understanding, and trust in the process or system to interact with the technology. Thus, they will limit what they can do online by accepting their computer's default settings and not understanding how they can truly be empowered.

Understanding the digital divide using these three stages provides an approach to developing solutions and monitoring our progress in bridging the digital divide gap.

The Digital Divide Between Geographies

The digital divide refers to the gulf between those with ready access to modern information and communications technology and those without. This divide can occur between countries and regions, cities, or even neighborhoods nearby. There may be pockets with little or no reliable Internet access in many US cities, while high-speed broadband is ubiquitous just a few miles away.

As of January 2023, Statista.com reports there were five billion Internet users worldwide, with China leading at 1.05 billion Internet users, more than three times the US's, with about 311 million Internet users. It also reported in 2023 that about 89% of Europeans have access to the Internet compared to 40% of the African population.

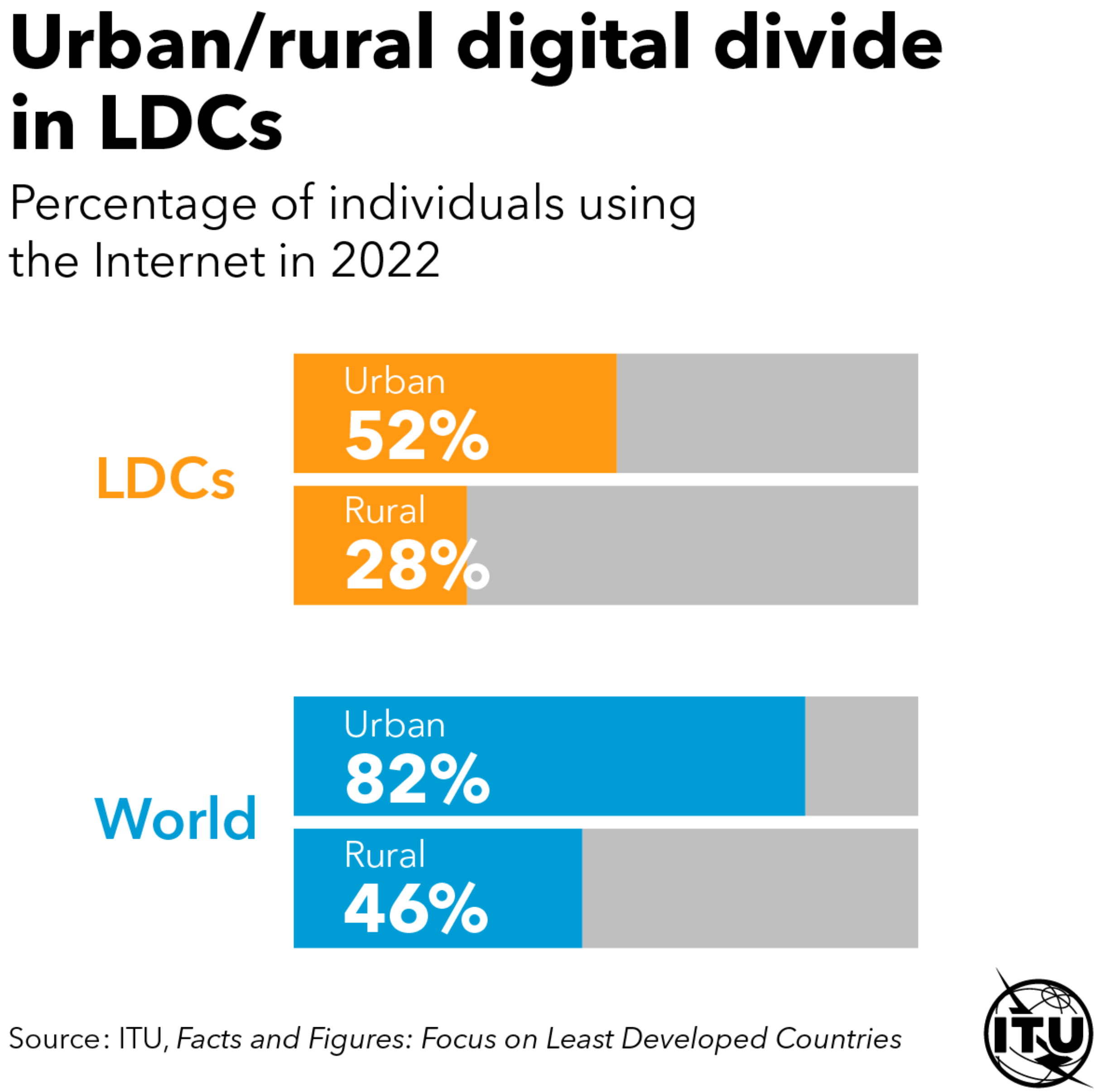


Figure $11.3.2$: People online in Least Developed Countries in 2022, source: ITU Facts and figure

The reasons for these disparities can include factors like lower income levels, lack of technology infrastructure investment, and fewer educational opportunities. But the result is many groups being cut off from the benefits of digital connectivity, which in today's world are crucial for access to jobs, government services, healthcare, Education, and more. Bridging this geographical digital divide requires understanding where it exists and why.

The Rural-Urban Digital Divide in the US

The digital divide can occur between countries, regions, or even neighborhoods. There are pockets with little or no Internet access in many US cities, while high-speed broadband is standard just a few miles away.

According to data from the Federal Communications Commission (FCC) at the end of 2019, a substantial gap exists between rural and urban Americans' access to fixed broadband internet. 17% of people living in rural areas lacked access to download speeds of at least 25 megabits per second and upload speeds of at least three megabits per second. This compares to only 1% of Americans in urban areas that lacked access to this 25/3 Mbps high-speed broadband standard. Even when high-speed broadband internet is technically available in an area, many people still lack access due to affordability issues and a lack of digital skills. According to FCC data, around 31% of Americans have access to broadband speeds of at least 25/3 Mbps. However, they have not subscribed to those available services. Lower-income households are less likely to have a home broadband subscription, even if the fast internet option exists where they live. In other words, the cost of broadband and lack of digital abilities present additional barriers beyond just availability. Simply offering broadband in a community does not mean everyone can use it. In other words, those living in rural parts of the country are significantly less likely to have high-speed Internet available in their homes, exacerbating the rural-urban digital divide.

Due to the social distance or lockdown mandates, the COVID-19 pandemic has made Internet access an essential requirement and has spotlighted this issue globally.

? Exercise - FCC National Broadband Map 11.3.3

Go to https://broadbandmap.fcc.gov/home#/

Type in an address and press enter

Answer

You should see a brief report about the broadband and the providers of that address. Take a screenshot and share it with the class discussion.

Challenges and efforts to bridge the Digital Divide gap

Solutions to the digital divide have had mixed success over the years. Initial efforts focused on providing internet access and computing devices with some degree of success. However, providing Internet access and computing devices is insufficient to bring accurate Internet access to a country, region, or neighborhood.

The World Bank and International Monetary Fund (IMF), in their annual meeting in 2020, brought together global leaders and private innovators to discuss how to bridge the digital gap globally. Three challenges were identified:

1. Lack of infrastructure remains a significant barrier to connectivity
2. Greater collaboration is needed between the public and private sectors
3. Education and training to help connect people in underserved communities

In June 2020, the UN Secretary-General stated that the Digital Divide is now a Matter of Life and Death' amid the COVID-19 Crisis and called on global leaders for global cooperation to meet the goal: every person has safe and affordable access to the Internet by 2030.

With this challenge being acute due to the global pandemic of 2020 (COVID-19), many leaders have increased their investment to bridge this gap in their countries. For example, the IMF reported that countries like Kenya, Ghana, Rwanda, and Tanzania had made significant progress using mobile to connect their citizens to financial systems (IMF, 2020). Many states in the United States have increased their funding through public or private partnerships, such as the California Closing the Divide initiative (CA dept of Education, 2020).

Continued global investment to bridge this gap remains a critical need for the global world, both during and post-global pandemic.

> **Sidebar: Using Gaming to Bridge the Digital Divide**
>
> Paul Kim, the Assistant Dean and Chief Technology Officer of the Stanford Graduate School of Education, designed a project to address the digital divide for children in developing countries (Kim et al., 2011.) In their project, the researchers wanted to understand if children can adopt and teach themselves mobile learning technology without help from teachers or other adults and the processes and factors involved in this phenomenon. The researchers developed a portable device called TeacherMate, which contained a game designed to help children learn math. The unique part of this research was that the researchers interacted directly with the children; they did not channel the mobile devices through the teachers or the schools. Another essential factor to consider: to understand the context of the children's educational environment, the researchers began the project by working with parents and local nonprofits six months before their visit. While the results of this research are too detailed to go into here, it can be said that the researchers found that children can adopt and teach themselves mobile learning technologies.
>
> What makes this research so interesting when thinking about the digital divide is that the researchers found that, to be effective, they had to customize their technology and tailor their implementation to the specific group they were trying to reach. One of their conclusions stated the following:
>
> Considering the rapid advancement of technology today, mobile learning options for future projects will only increase. Consequently, researchers must continue to investigate their impact; we believe there is a specific need for more in-depth studies on ICT [information and communication technology] design variations to meet different localities' challenges. To read more about Dr. Kim's project, locate the paper referenced in the list of references.

References

ACM (2020). ACM Code of Ethics and Professional Conduct. Retrieved from acm.org, December 5, 2020.

Digital Divide 'a Matter of Life and Death' amid COVID-19 Crisis, Secretary-General Warns Virtual Meeting, Stressing Universal Connectivity Key for Health, Development. Retrieved from un.org, November 1, 2020.

Kiburn, Kim (2005). Challenges in HCI: Digital divide. Crossroads 12, 2 (December 2005), 2-2.

Kim, P., Buckner, E., Makany, T., & Kim, H. (2011). *A comparative analysis of a game-based mobile learning model in socioeconomic communities of India*. International Journal of Educational Development. doi:10.1016/j.ijedudev.2011.05.008.

Urban/rural digital divide in LDCs. Retrieved from itu.com, August 2023

National Strategy Needed to Guide Federal Efforts to Reduce Digital Divide Report (May 2022.) Retrieved from US Government Accountability Office, August 1, 2023.

Nielsen, J (2006). *Digital Divide: The 3 Stages*. Retrieved November 1, 2020, from http://www.nngroup.com/articles/digital-divide-the-three-stages/.

Statista. (2023). Internet usage in the United States. Retrieved from statista.com, April 2023.

Statista. (2023). Countries with the fastest average fixed broadband internet speeds as of April 2023*(in Mbps)*. Retrieved from statista.com, April 2023.

Statista. (2023). Internet penetration rate in rural and urban areas 2022, by region. Retrieved April 2023. Retrieved from statista.com, April 2023.

Xanthios, S (2017, April 7). *An Introduction to the Digital Divide*. Retrieved August 2023 from Medium.

11.4: Summary

Summary

Information technology has been a driving force behind globalization, transforming how business is conducted worldwide. As Castells and Friedman observed, digital tools now allow people and organizations to collaborate across borders as never before.

Businesses have leveraged these technologies to expand their operations globally. They have gained access to more labor pools, suppliers, and a worldwide world. Information systems have enabled 24/7 operations by linking employees across time zones. However, these global connections have also introduced challenges. Companies must now navigate varying regulations, cultural preferences, and infrastructure reliability between countries. Marketing, product development, and HR processes require localization for diverse international audiences.

While some organizations operate globally, many lack access to digital tools and networks. Nielsen's three-stage model describes that the digital divide persists due to economic, usability, and empowerment gaps. The COVID-19 pandemic underscored these inequalities, with the UN declaring the digital divide a matter of life and death. Ongoing efforts from both public and private sectors seek to address it.

This chapter explores both the opportunities and ethical complications presented by information systems' role in globalization and connectivity. These issues will continue shaping how technology progresses worldwide.

11.5: Study Questions

? Study Question 11.5.1

What does the term globalization mean?

Answer

Globalization refers to the integration of goods, services, and culture among the people and nations of the world.

? Study Question 11.5.2

What are the three areas of globalization?

Answer

The three eras of globalization according to Friedman are:

- Globalization 1.0 from 1492-1800 centered around countries
- Globalization 2.0 from 1800-2000 driven by multinational companies
- Globalization 3.0 our current era enabled by information technology

? Study Question 11.5.3

Which technologies have had the biggest effect on globalization?

Answer

Key technologies that have driven globalization include the graphical user interface for personal computers, the build-out of the Internet infrastructure, and workflow software for automation and integration.

? Study Question 11.5.4

What are some of the advantages brought about by globalization?

Answer

Advantages of globalization include access to more labor pools, the ability to operate 24/7 across time zones, expanded markets for products worldwide, diversity in markets, and exposure to more investment opportunities.

? Study Question 11.5.5

What are the disadvantages of globalization?

Answer

Disadvantages include having to deal with varying infrastructure, regulations, languages, customs, shipping challenges, and currency volatility between different countries.

? Study Question 11.5.6

What does the term digital divide mean?

Answer

The digital divide refers to the gap between those who have access and ability to use modern information and communication technologies and those who do not.

Study Question 11.5.7

What are Jakob Nielsen’s three stages of the digital divide?

Answer

Nielsen's three stages are:

- Economic divide: Access to technology based on affordability
- Usability divide: Ability to use technology even with access
- Empowerment divide: Understanding how to fully leverage technology.

Study Question 11.5.8

Which country has the highest number of Internet Users

Answer

As of April 2023, China has the highest Internet users

Study Question 11.5.9

What are the effects of the global pandemic on the digital divide?

Answer

The pandemic made digital access an essential service, highlighting gaps for remote work, education, healthcare, etc. It prompted increased investment and global cooperation to bridge the digital divide.

Study Question 11.5.10

How can information systems help a business expand its operations globally? Provide at least 2 examples of how technology can assist global growth.

Answer

Collaboration software such as Zoom, cloud-based systems, websites, e-commerce

Study Question 11.5.11

What is an example of a product that failed to expand globally? Explain some of the potential reasons it was not successful internationally.

Answer

Name a few after doing a quick Internet search.

Exercise 11.5.12

Two ways tech companies can help empower more global users

Answer

Discuss your ideas.

Exercises

1. Compare the concept of Friedman's "Globalization 3.0″ with Nielsen's empowerment stage of the digital divide.
2. Do some original research to determine some of the US company's regulations before doing business in one of the following countries: China, Mexico, Iran, and India.
3. Go to speedtest.net to determine your Internet speed. Compare your speed at home to the Internet speed at two other locations, such as your local coffee shop, school, place of employment. Write up a one-page summary that compares these locations.
4. Write a report to assess Nielson's three stages based on your today's experience.
5. Go to this website https://www.ntia.doc.gov/data/digital-nation-data-explorer#sel=internetUser&disp=map or search for "Digital Nation Data Explorer" to locate it. Report the internet usage in your state and compare it with your own experience
6. Give one example of the digital divide and describe what you would do to address it.
7. How the research conducted by Manuel Castells influences globalization.
8. Find a news article about a company expanding or withdrawing business operations in another country. What challenges did they face?
9. Interview 2 people from different generations about their comfort with technology. How could the empowerment divide apply?
10. Compare internet access between two neighborhoods, one lower-income and one higher-income. What factors contribute to any divides?
11. Find an example of a global nonprofit using technology to address social issues. How are they leveraging IT?
12. Interview someone who immigrated to your country about how technology helps them connect with their home country. What platforms and tools do they use?

CHAPTER OVERVIEW

12: The Ethical and Legal Implications of Information System

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe what the term information systems ethics means;
- Explain what a code of ethics is and describe the advantages and disadvantages;
- Define the term intellectual property and explain the protections provided by copyright, patent, and trademark
- Describe what Creative Commons is and be able to identify what the different licenses mean.
- Describe the challenges that information technology brings to individual privacy.

The rapid changes in all the components of information systems in the past few decades have brought a broad array of new capabilities and powers to governments, organizations, and individuals alike. This chapter will discuss the effects that these new capabilities have had and the legal and regulatory changes that have been put in place in response, and what ethical issues organizations and IT communities need to consider in using or developing emerging solutions and services that regulations are not fully developed.

12.1: Introduction

Information systems have had an impact far beyond the world of business. In the past four decades, technology has fundamentally altered our lives: from the way we work, how we play to how we communicate, and how we fight wars. Mobile phones track us as we shop at stores and go to work. Algorithms based on consumer data allow firms to sell us products that they think we need or want. New technologies create new situations that we have never dealt with before. They can threaten individual autonomy, violate privacy rights, and can also be morally contentious. How do we handle the new capabilities that these devices empower us with? What new laws are going to be needed to protect us from ourselves and others? This chapter will kick off with a discussion of the impact of information systems on how we behave (ethics). This will be followed by the new legal structures being put in place, focusing on intellectual property and privacy.

12.1.1: Information Systems Ethics

The term ethics is defined as "a set of moral principles" or "the principles of conduct governing an individual or a group." Since the dawn of civilization, the study of ethics and its impact has fascinated humankind. But what do ethics have to do with information systems? Let's listen to Professor Gorbatai in this video on What is Digital Ethics?

The introduction of new technology can have a profound effect on human behavior. New technologies give us capabilities that we did not have before, which create environments and situations that have not been specifically addressed in ethical terms. Those who master new technologies gain new power; those who cannot master them may lose power. In 1913, Henry Ford implemented the first moving assembly line to create his Model T cars. While this was a great step forward technologically (and economically), the assembly line reduced human beings' value in the production process. The development of the atomic bomb concentrated unimaginable power in the hands of one government, which then had to wrestle with the decision to use it. Today's digital technologies have created new categories of ethical dilemmas.

For example, the ability to anonymously make perfect copies of digital music has tempted many music fans to download copyrighted music for their own use without making payment to the music's owner. Many of those who would never have walked into a music store and stolen a CD find themselves with dozens of illegally downloaded albums.

Digital technologies have given us the ability to aggregate information from multiple sources to create profiles of people. What would have taken weeks of work in the past can now be done in seconds, allowing private organizations and governments to know more about individuals than at any time in history. This information has value but also chips away at the privacy of consumers and citizens.

Communication technologies like social media(Facebook, Twitter, Instagram, LinkedIn, internet blogs) give so many people access to so much information that it's getting harder and harder to tell what's real and what's fake. Its widespread use has blurred the line between professional, personal, and private. Employers now have access to information that has traditionally been considered private and personal, giving rise to new legal and ethical ramifications.

Some technologies like self-driving vehicles(drones), artificial intelligence, the digital genome, and additive manufacturing methods(GMO) are transitioning into a new phase, becoming more widely used or incorporated into consumer goods, requiring new ethical and regulatory guidelines.

12.1.1.1: Code of Ethics

One method for navigating new ethical waters is a code of ethics. A code of ethics is a document that outlines a set of acceptable behaviors for a professional or social group; generally, it is agreed to by all members of the group. The document details different actions that are considered appropriate and inappropriate.

A good example of a code of ethics is the Code of Ethics and Professional Conduct of the Association for Computing Machinery, an organization of computing professionals that includes educators, researchers, and practitioners. Here is an excerpt from the preamble:

Computing professionals' actions change the world. To act responsibly, they should reflect upon the wider impacts of their work, consistently supporting the public good. The ACM Code of Ethics and Professional Conduct ("the Code") expresses the profession's conscience. Additionally, the Code serves as a basis for remediation when violations occur. The Code includes principles formulated as statements of responsibility based on the understanding that the public good is always the primary consideration. Each principle is supplemented by guidelines, which provide explanations to assist computing professionals in understanding and applying the principle.

Section 1 outlines fundamental ethical principles that form the basis for the remainder of the Code. Section 2 addresses additional, more specific considerations of professional responsibility. Section 3 guides individuals who have a leadership role, whether in the workplace or a volunteer professional capacity. Commitment to ethical conduct is required of every ACM member, and principles involving compliance with the Code are given in Section 4.

In the ACM's code, you will find many straightforward ethical instructions, such as the admonition to be honest and trustworthy. But because this is also an organization of professionals that focuses on computing, there are more specific admonitions that relate directly to information technology:

Sidebar: Why everyone in Tech should care about code of ethics?

Listen to this interesting video by Dr. Bo Brinkman, part of the Integrity Project series by ACM Ethics.

One of the major advantages of creating a code of ethics is clarifying the acceptable standards of behavior for a professional group. The varied backgrounds and experiences of the members of a group lead to various ideas regarding what is acceptable behavior. While to many the guidelines may seem obvious, having these items detailed provides clarity and consistency. Explicitly stating standards communicates the common guidelines to everyone in a clear manner.

Having a code of ethics can also have some drawbacks. First of all, a code of ethics does not have legal authority; in other words, breaking a code of ethics is not a crime in itself. So what happens if someone violates one of the guidelines? Many codes of ethics include a section that describes how such situations will be handled. In many cases, repeated violations of the code result in expulsion from the group.

In the case of ACM: "Adherence of professionals to a code of ethics is largely a voluntary matter. However, if a member does not follow this code by engaging in gross misconduct, membership in ACM may be terminated." Expulsion from ACM may not impact many individuals since membership in ACM is usually not a requirement for employment. However, expulsion from other organizations, such as a state bar organization or medical board, could carry a huge impact.

Another possible disadvantage of a code of ethics is that there is always a chance that important issues will arise that are not specifically addressed in the code. Technology is changing exponentially, and advances in artificial intelligence mean new ethical issues related to machines. The code of ethics might not be updated often enough to keep up with all of the changes. However, a good code of ethics is written in a broad enough fashion that it can address the ethical issues of potential technology changes. In contrast, the organization behind the code makes revisions.

Finally, a code of ethics could also be a disadvantage because it may not entirely reflect the ethics or morals of every member of the group. Organizations with a diverse membership may have internal conflicts as to what is acceptable behavior. For example, there may be a difference of opinion on the consumption of alcoholic beverages at company events. In such cases, the organization must choose the importance of addressing a specific behavior in the code.

Example

Self-driving car technology has created new ethical dilemmas, such as how to program autonomous vehicles to make decisions in emergency scenarios. For example, should a self-driving car prioritize the safety of its own passengers over pedestrians?

Sidebar: Acceptable Use Policies (AUP)

Many organizations that provide technology services to a group of constituents or the public require an acceptable use policy (AUP) before those services can be accessed. Like a code of ethics, it is a set of rules applied by the organization that outlines what users may or may not do while using the organization's services. Usually, the policy requires some acknowledgment that the rules are well understood, including potential violations. An everyday example of this is the terms of service that must be agreed to before using the public Wi-Fi at Starbucks, McDonald's, or even a university. An AUP is an important document as it demonstrates due diligence of the organization's security and protection of sensitive data, which protects the organization from legal actions. Here is an example of an acceptable use policy from Virginia Tech.

Just as with a code of ethics, these acceptable use policies specify what is allowed and what is not allowed. Again, while some of the items listed are obvious to most, others are not so obvious:

- "Borrowing" someone else's login ID and password are prohibited.
- Using the provided access for commercial purposes, such as hosting your own business website, is not allowed.
- Sending out unsolicited emails to a large group of people is prohibited.

Also, as with codes of ethics, violations of these policies have various consequences. In most cases, such as with Wi-Fi, violating the acceptable use policy will mean that you will lose your access to the resource. While losing access to Wi-Fi at Starbucks may not have a lasting impact, a university student getting banned from the university's Wi-Fi (or possibly all network resources) could greatly impact their education and their future. From Code to Culture: Operating Ethically

12.1.2: From Code to Culture: Operating Ethically

The rapid emergence of advanced artificial intelligence technologies like chatbots and language models has created new ethical challenges. Systems like ChatGPT demonstrate impressive conversational abilities and knowledge, but also high potential risks around misinformation, privacy, and job disruption. As these technologies become more sophisticated and ubiquitous, clear ethical principles are needed to guide responsible development and use.

Organizations leveraging AI should proactively create codes of ethics covering issues like transparency, accountability, mitigating bias, and aligning with human values. Individuals interacting with language models would also benefit from developing their own code to consciously evaluate when and how to use these powerful tools responsibly. Some key reasons include avoiding the spread of harmful content, properly attributing information sources, considering implications for human roles, and being honest about a system's capabilities. Establishing ethical foundations will help maximize benefits and minimize risks as intelligent algorithms grow more advanced.

While having a code of ethics provides guidance on acceptable conduct, organizations need to take additional steps to truly embed ethical awareness into the corporate culture. Developing a comprehensive ethics program requires ongoing commitment from leadership along with inclusion of stakeholders at all levels. Here are some best practices for bringing ethics principles to life:

- Involve a diverse committee in shaping the code and framework to reflect varied perspectives. Include members across departments, tenures, demographics, etc.
- Connect the guiding values directly to the organization's purpose and mission. The principles should tie logically to the core goals.
- Communicate the code in multiple formats including training, evaluations, signage, workshops, and more. Use many channels for maximum impact.
- Make following the guidelines an element considered in performance reviews and promotions. Leaders should exemplify the expected behaviors.
- Establish safe reporting procedures for suspected violations and protect those who come forward responsibly.
- Respond to breaches with consistent, measured discipline to reinforce accountability. The consequences should fit the offense.
- Assess comprehension and implementation of the code through surveys, audits, and other mechanisms. Identify areas for improvement.
- Schedule periodic reviews by the ethics advisory committee to update the program based on changing needs.

- Consider external validation through certifications like the Ethics & Compliance Initiative to formally benchmark efforts.

Embedding ethics awareness requires patience and concerted effort. But organizations that invest in a culture of integrity reap significant rewards in trust, reputation, and productivity. A robust ethics program brings principles to life.

12.1.3: References

ACM Code of Ethics. *Preamble*. Retrieved November 10, 2020, from https://www.acm.org/code-of-ethics.

- No one should enter or use another’s computer system, software, or data files without permission. One must always have appropriate approval before using system resources, including communication ports, file space, other system peripherals, and computer time.
- Designing or implementing systems that deliberately or inadvertently demean individuals or groups is ethically unacceptable.
- Organizational leaders are responsible for ensuring that computer systems enhance, not degrade, working life quality. When implementing a computer system, organizations must consider all workers' personal and professional development, physical safety, and human dignity. Appropriate human-computer ergonomic standards should be considered in system design and the workplace.

12.2: Intellectual Property

One of the domains that digital technologies have deeply impacted is the domain of intellectual property. Digital technologies have driven a rise in new intellectual property claims and made it much more difficult to defend intellectual property.

Merriam-Webster Dictionary defines Intellectual property as “property (as an idea, invention, or process) that derives from the work of the mind or intellect. This could include song lyrics, a computer program, a new type of toaster, or even a sculpture.

Practically speaking, it is challenging to protect an idea. Instead, intellectual property laws are written to protect the tangible results of an idea. In other words, just coming up with a song in your head is not protected, but if you write it down, it can be protected.

Protection of intellectual property is important because it gives people an incentive to be creative. Innovators with great ideas will be more likely to pursue those ideas if they clearly understand how they will benefit. In the US Constitution, Article 8, Section 8, the authors saw fit to recognize the importance of protecting creative works:

Congress shall have the power... To promote the Progress of Science and useful Arts by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries.

An important point to note here is the “limited time” qualification. While protecting intellectual property is important because of its incentives, it is also necessary to limit the amount of benefit that can be received and allow the results of ideas to become part of the public domain.

Outside of the US, intellectual property protections vary. You can find out more about a specific country’s intellectual property laws by visiting the World Intellectual Property Organization.

There are many intellectual property types such as copyrights, patents, trademarks, industrial design rights, plant variety rights, and trade secrets. In the following sections, we will review three of the best-known intellectual property protection: copyright, patent, and trademark.

12.2.1: Copyright

Copyright is the protection given to songs, movies, books, computer software, architecture, and other creative works, usually for a limited time. An artist can, for example, sue if his painting is copied and sold on T-shirts without permission. A coder can sue if another Web developer verbatim takes her code. Any work that has an “author” can be copyrighted. It covers both published and unpublished work. Under the terms of copyright, the author of the work controls what can be done with the work, including:

- Who can make copies of the work?
- Who can create derivative works from the original work?
- Who can perform the work publicly?
- Who can display the work publicly?
- Who can distribute the work?

Often, work is not owned by an individual but is instead owned by a publisher with whom the original author has an agreement. In return for the rights to the work, the publisher will market and distribute the work and then pay the original author a portion of the proceeds.

Copyright protection lasts for the life of the original author plus seventy years. In the case of a copyrighted work owned by a publisher or another third party, the protection lasts for ninety-five years from the original creation date. For works created before 1978, the protections vary slightly. You can see the full details on copyright protections by reviewing the Copyright Basics document available at the US Copyright Office’s website. See also the sidebar “History of Copyright Law.”

Example:

The author of a book about Dr. Seuss sought to reproduce several Dr. Seuss images under fair use doctrine to analyze the imagery. However, the company that owns the Dr. Seuss intellectual property sued for copyright infringement and won, preventing use of the images.

12.2.2: Obtaining Copyright Protection

In the United States, copyright is obtained by the simple act of creating the original work. In other words, when an author writes down that song, makes that film, or designs that program, he or she automatically has the copyright. However, it is advisable to register for a copyright with the US Copyright Office for a work that will be used commercially. A registered copyright is needed to bring legal action against someone who has used a work without permission.

12.2.3: First Sale Doctrine

If an artist creates a painting and sells it to a collector who then, for whatever reason, proceeds to destroy it, does the original artist have any recourse? What if the collector, instead of destroying it, begins making copies of it and sells them? Is this allowed?

The protections that copyright law extends to creators have an important limitation. The first sale doctrine is a part of copyright law that addresses this, as shown below:

The first sale doctrine, codified at 17 U.S.C. § 109, provides that an individual who knowingly purchases a copy of a copyrighted work from the copyright holder receives the right to sell, display or otherwise dispose of that particular copy, notwithstanding the interests of the copyright owner.

So, in our examples, the copyright owner has no recourse if the collector destroys her artwork. But the collector does not have the right to make copies of the artwork.

12.2.4: Fair Use

Another important provision within copyright law is that of fair use. Fair use is a limitation on copyright law that allows for protected works without prior authorization in specific cases. For example, if a teacher wanted to discuss a current event in her class, she could pass out copies of a copyrighted news story to her students without first getting permission. Fair use allows a student to quote a small portion of a copyrighted work in a research paper.

Unfortunately, the specific guidelines for what is considered fair use and what constitutes copyright violation are not well defined. Fair use is a well-known and respected concept and will only be challenged when copyright holders feel that their work's integrity or market value is being threatened. The following four factors are considered when determining if something constitutes fair use 9 :

- The purpose and character of the use, including whether such use is of commercial nature or is for nonprofit educational purposes;
- The nature of the copyrighted work;
- The amount and substantiality of the portion used concerning the copyrighted work as a whole;
- The effect of the use upon the potential market for, or value of, the copyrighted work.

If you are ever considering using a copyrighted work as part of something you are creating, you may be able to do so under fair use. However, it is always best to check with the copyright owner to ensure you are staying within your rights and not infringing upon theirs.

Sidebar: The History of Copyright Law

As noted above, current copyright law grants copyright protection for seventy years after the author's death or ninety-five years from the date of creation for a work created for hire. But it was not always this way.

The first US copyright law, which only protected books, maps, and charts, protected for only 14 years with a renewable term of 14 years. Over time, copyright law was revised to grant protections to other forms of creative expressions, such as photography and motion pictures. Congress also saw fit to extend the length of the protections, as shown in the chart below. Today, copyright has become big business, with many businesses relying on copyright-protected works for their income.

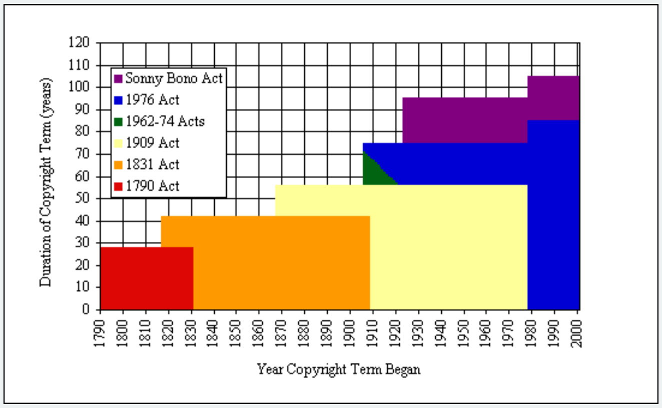


Figure 12.2.1: Expansion of U.S. Copyright act by Tom Bell licensed CC-BY-SA 3.0

Many now think that the protections last too long. The Sonny Bono Copyright Term Extension Act 1998 has been nicknamed the "Mickey Mouse Protection Act," as it was enacted just in time to protect the copyright on the Walt Disney Company's Mickey Mouse character. It extended copyright terms to the life of the author plus 70 years. Because of this term extension, many works from the 1920s and 1930s were still protected by copyright and could not enter the public domain until 2019 or later. Mickey Mouse will not be in the public domain until 2024.

12.2.5: References

ACM Code of Ethics. *Preamble*. Retrieved November 10, 2020, from https://www.acm.org/code-of-ethics.

US copyright. *Copyright basics*. Retrieved November 10, 2020, from https://www.copyright.gov/.

US copyright. *More information on fair use*. Retrieved from https://www.copyright.gov/fair-use/more-info.html.

12.3: The Digital Millennium Copyright Act

As digital technologies have changed what it means to create, copy, and distribute media, a policy vacuum has been created. In 1998, the US Congress passed the Digital Millennium Copyright Act (DMCA), which extended copyright law to consider digital technologies, while limiting the liability of the providers of online services for copyright infringement by their users. An anti-piracy statute makes it illegal to duplicate digital copyrighted works and sell or freely distribute them. Two of the best-known provisions from the DMCA are the anti-circumvention provision and the "safe harbor" provision.

- The anti-circumvention provision makes it illegal to create technology to circumvent technology that has been put in place to protect a copyrighted work. This provision includes the creation of the technology and the publishing of information that describes how to do it. While this provision does allow for some exceptions, it has become quite controversial and has led to a movement to have it modified.
- The "safe harbor" provision limits online service providers' liability when someone using their services commits copyright infringement. This provision allows YouTube, for example, not to be held liable when someone posts a clip from a copyrighted movie. The provision does require the online service provider to take action when they are notified of the violation (a "takedown" notice). For an example of how takedown works, here's how YouTube handles these requests: YouTube Copyright Infringement Notification.

Here's a video overview of DMCA by CopyrightAlliance:

Many think that the DMCA goes too far and ends up limiting our freedom of speech. The Electronic Frontier Foundation (EFF) is at the forefront of this battle. For example, in discussing the anti-circumvention provision, the EFF states:

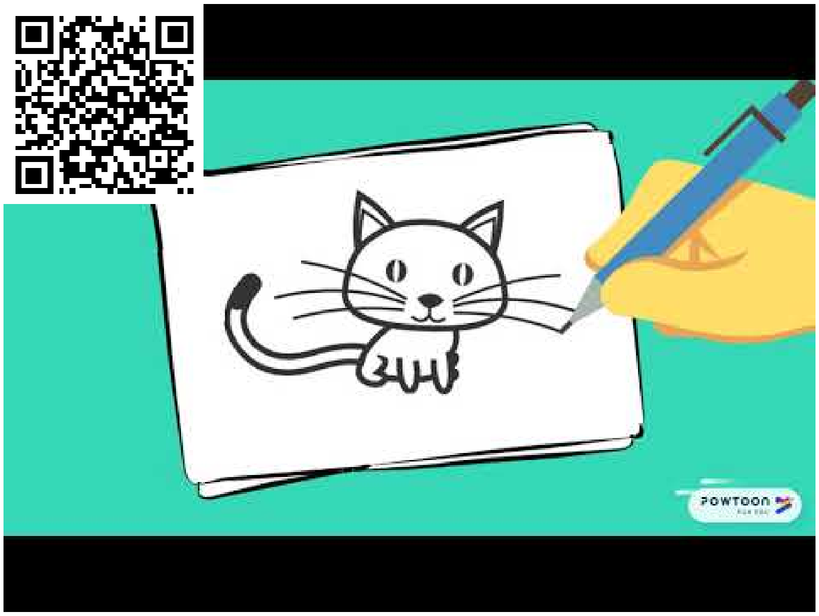
Yet, the DMCA has become a serious threat that jeopardizes fair use, impedes competition and innovation, chills free expression and scientific research, and interferes with computer intrusion laws. If you circumvent DRM [digital rights management] locks for non-infringing fair uses or create the tools to do so, you might be on the receiving end of a lawsuit.

12.3.1: Creative Commons

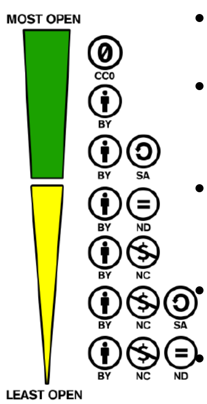
In chapter 2, we learned about open-source software. Open-source software has few or no copyright restrictions; the software creators publish their code and make their software available for others to use and distribute for free. This is great for software, but what about other forms of copyrighted works? If an artist or writer wants to make their works available, how can they go about doing so while still protecting their work integrity? Creative Commons is the solution to this problem.

Creative Commons is an international nonprofit organization that provides legal tools for artists and authors around the world. The tools offered to make it simple to license artistic or literary work for others to use or distribute consistently with the creator's intentions. Creative Commons licenses are indicated with the symbol CC . It is important to note that Creative Commons and the public domain are not the same. When something is in the public domain, it has absolutely no restrictions on its use or distribution. Works whose copyrights have expired, for example, are in the public domain.

Watch this video by U of G Library that introduces creative commons licensing to make copyright easier to understand.



By using a Creative Commons license, creators can control the use of their work while still making it widely accessible. By attaching a Creative Commons license to their work, a legally binding license is created. Creators can choose from the following six licenses with varying permissions from the least open to the most open license:



- **CCO**: allows creators to give up their copyright and put their works into the worldwide public domain. It allows others to distribute, remix, adapt and build upon in any medium or format with no conditions.
- **CC BY**: This is the least restrictive license. It lets others distribute, remix, adapt, and build upon the original work, in any medium or format, even commercially, as long as they give the author credit (attribution) for the original work.
- **CC-BY-SA**: This license restricts the distribution of the work via the “share-alike” clause. This means that others can freely distribute, remix, adapt and build upon the work, but they must give credit to the original author, and they must share using the same Creative Commons license.
- **CC-BY-NC**: NC stands for “non-commercial.” This license is the same as CC-BY but adds that no one can make money with this work - non-commercial purposes only.
- **CC-BY-NC-SA**: This license allows others to distribute, remix, adapt, and build upon the original work for non-commercial purposes, but they must give credit to the original author and share using the same license.
- **CC-BY-NC-ND**: This license is the same as CC-BY-NC and adds the ND restriction, which means that no derivative works may be made from the original.

Figure 12.3.1: Creative Commons licenses icons created by Creative Commons licensed under CC BY 4.0

This OER text book has been written under the Creative Commons license CC-BY. More than half a billion licensed works exist on the Web free for students and teachers to use, build upon, and share. Understanding the Creative Commons licenses and copyrights is important for making sure you're a respectful digital citizen.

Example 12.3.1

How well do you understand CC licensing? Suppose you find the following black and white image.

You would like to color it and then use it. Which licenses should the image have that allows you to do that?

CC BY

CC BY-SA

CC BY NC

CC BY-NC-SA

CC-BY-NC-ND

Solution

All except CC BY-NC-ND which does not allow derivative work. Coloring the image is considered a derivative work.

12.3.2: Patent

Another important form of intellectual property protection is the patent. A patent creates protection for someone who invents a new product or process. The definition of invention is quite broad and covers many different fields. Here are some examples of items receiving patents:

- circuit designs in semiconductors
- prescription drug formulas
- firearms
- locks
- plumbing
- engines
- coating processes and
- business processes.

Once a patent is granted, it provides the inventors with protection from others infringing on their patent. A patent holder has the right to "exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States for a limited time in exchange for public disclosure of the invention when the patent is granted."

As with copyright, patent protection lasts for a limited period of time before the invention or process enters the public domain. In the US, a patent lasts twenty years. This is why generic drugs are available to replace brand-name drugs after twenty years.

> **Example**
>
> In 1935, a patent application was submitted for a board game called Monopoly. The Patent Office initially rejected it, stating that the game was too similar to previous games. However, after appeal, a patent was eventually granted in 1935, protecting this now famous board game.

12.3.3: Obtaining Patent Protection

Unlike copyright, a patent is not automatically granted when someone has an interesting idea and writes it down. In most countries, a patent application must be submitted to a government patent office. A patent will only be granted if the invention or process being submitted meets certain conditions:

- It must be original. The invention being submitted must not have been submitted before.
- It must be non-obvious. You cannot patent something that anyone could think of. For example, you could not put a pencil on a chair and try to get a patent for a pencil-holding chair.
- It must be useful. The invention being submitted must serve some purpose or have some use that would be desired.

The United States Patent and Trademark Office(USPTO) is the federal agency that grants U.S patents and registering trademarks. It reviews patent applications to ensure that the item being submitted meets these requirements. This is not an easy job: USPTO processes more than 600,000 patent applications and grants upwards of 300,000 patents each year. It took 75 years to issue the first million patents. The last million patents took only three years to issue; digital technologies drive much of this innovation.

The cost of preparing and filing a patent application can vary dramatically based on such factors as the technology of the invention, the skill and experience of the attorney or agent preparing the application, and the involvement of the inventor in the process. Simple mechanical patent applications can be prepared for less than 10,000 dollars in many cases, while some drug related applications might exceed $30,000 or 40,000 dollars to prepare and file. Patents are not inexpensive, so why should companies get patents? Patents provide a competitive advantage by

- enabling limited monopolies for their owners
- protect the invention from leaving the business - ex-employees, customers, competitors cannot market their own competing products
- and provide a tangible measure of research and product development output.

> **Sidebar: What is a Patent Troll?**
>
> The advent of digital technologies has led to a large increase in patent filings and, therefore, many patents being granted. Once a patent is granted, it is up to the patent owner to enforce it; if someone is found to be using the invention without permission, the patent holder has the right to sue to force that person to stop and collect damages.
>
> The rise in patents has led to a new form of profiteering called patent trolling. A patent troll is a person or organization who gains the rights to a patent but does not actually make the invention that the patent protects. Instead, the patent troll searches for illegally using the invention in some way and sues them. In many cases, the infringement being alleged is questionable at best. For example, companies have been sued for using Wi-Fi or for scanning documents, technologies that have been on the market for many years.
>
> Recently, the US government has begun taking action against patent trolls. Several pieces of legislation are working their way through Congress that will, if enacted, limit the ability of patent trolls to threaten innovation. You can learn a lot more about patent trolls by listening to a detailed investigation titled *When Patents Attack* conducted by the radio program This American Life.

12.3.4: Trademark

A trademark is a word, phrase, logo, shape, or sound that identifies a source of goods or services. For example, the Nike “Swoosh,” the Facebook “f,” and Apple’s apple (with a bite taken out of it) Kleenex(facial tissue brand) are all trademarked. The concept behind trademarks is to protect the consumer. Imagine going to the local shopping center to purchase a specific item from a specific store and finding that there are several stores all with the same name!

Two types of trademarks exist – a common-law trademark and a registered trademark. As with copyright, an organization will automatically receive a trademark if a word, phrase, or logo is being used in the normal course of business (subject to some restrictions, discussed below). A common-law trademark is designated by placing “TM” next to the trademark. A registered trademark has been examined, approved, and registered with the trademark office, such as the Patent and Trademark Office in the US. A registered trademark has the circle-R (®) placed next to the trademark.

While most any word, phrase, logo, shape, or sound can be trademarked, there are a few limitations.

A trademark will not hold up legally if it meets one or more of the following conditions:

1. The trademark is likely to confuse with a mark in a registration or prior application.
2. The trademark is merely descriptive for the goods/services. For example, trying to register the trademark “blue” for a blue product you sell will not pass muster.
3. The trademark is a geographic term.
4. The trademark is a surname. You will not be allowed to trademark “Smith’s Bookstore.”
5. The trademark is ornamental as applied to the goods. For example, a repeating flower pattern that is a design on a plate cannot be trademarked.

As long as an organization uses its trademark and defends it against infringement, the protection afforded by it does not expire. Thus, many organizations defend their trademark against other companies whose branding even only slightly copies their trademark. For example, Chick-fil-A has trademarked the phrase “Eat Mor Chikin” and has vigorously defended it against a small business using the slogan “Eat More Kale.” Coca-Cola has trademarked its bottle's contour shape and will bring legal action against any company using a bottle design similar to theirs. As an example of trademarks that have been diluted and have now lost their protection in the US are “aspirin” (originally trademarked by Bayer), “escalator” (originally trademarked by Otis), and “yo-yo” (originally trademarked by Duncan).

Sidebar: What is the difference between Copyright, Trademark, and Patent?

Each of the legal rights Copyright, Trademark and Patent provides a person or company with the ability to exploit or protect a particular form of intellectual property. While patents tend to be very distinct from the other two categories, how copyright and trademark are distinguished can often be difficult for people to understand. This video compares Copyright vs. Trademark vs. Patent

Examples: Lost Protection

Examples of trademarks that lost protection due to becoming widely used generic terms include aspirin, escalator, and yo-yo. All were originally protected brand names that are now just common names for the related products.

12.3.5: Information Systems and Intellectual Property

The rise of information systems has forced us to rethink how we deal with intellectual property. From the increase in patent applications swamping the government’s patent office to the new laws that must be put in place to enforce copyright protection, digital technologies have impacted our behavior.

12.3.6: Privacy

The term privacy has many definitions, but privacy will mean the ability to control information about oneself for our purposes. Our ability to maintain our privacy has eroded substantially in the past decades due to information systems.

12.3.6.1: Personally Identifiable Information(PII)

Information about a person that can uniquely establish that person’s identity is called personally identifiable information, or PII. This is a broad category that includes information such as:

- name;
- social security number;
- date of birth;
- place of birth;
- mother‘s maiden name;
- biometric records (fingerprint, face, etc.);
- medical records;
- educational records;
- financial information; and
- employment information.

Organizations that collect PII are responsible for protecting it. The Department of Commerce recommends that “organizations minimize the use, collection, and retention of PII to what is strictly necessary to accomplish their business purpose and mission.” They go on to state that “the likelihood of harm caused by a breach involving PII is greatly reduced if an organization minimizes the amount of PII it uses, collects, and stores.” 4 Organizations that do not protect PII can face penalties, lawsuits, and loss of business. In the US, most states now have laws requiring organizations that have had security breaches related to PII to notify potential victims, as does the European Union.

Just because companies are required to protect your information does not mean they are restricted from sharing it. In the US, companies can share your information without your explicit consent (see sidebar below), though not all do so. The FTC urges companies that collect PII to create a privacy policy and post it on their website. California requires a privacy policy for any website that does business with a resident of the state.

While the US's privacy laws seek to balance consumer protection with promoting commerce, in the European Union, privacy is considered a fundamental right that outweighs the interests of commerce. This has led to much stricter privacy protection in the EU and makes commerce more difficult between the US and the EU.

Example: Facebook

Facebook faced a $5 billion penalty in 2019 for failing to protect user privacy after the Cambridge Analytica scandal revealed the private data of millions of users had been misused without consent.

12.3.7: Non-Obvious Relationship Awareness (NORA)

Digital technologies have given us many new capabilities that simplify and expedite the collection of personal information. Every time we come into contact with digital technologies, information about us is being made available. From our location to our web-surfing habits, our criminal record, to our credit report, we are constantly being monitored. This information can then be aggregated to create profiles of every one of us. While much of the information collected was available in the past, collecting it and combining it took time and effort. Today, detailed information about us is available for purchase from different companies. Even information not categorized as PII can be aggregated so that an individual can be identified.

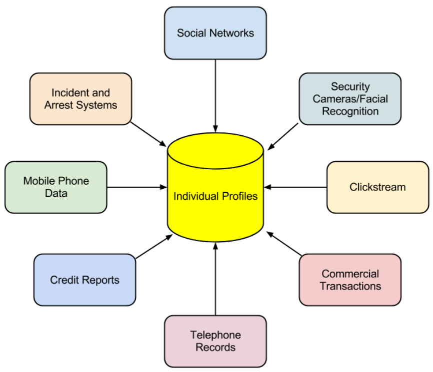


Figure $12.3.2$ Non-obvious relationship awareness(NORA). Image by David Bourgeois, Ph.D. is licensed CC-By-NC-SA 4.0

First commercialized by big casinos looking to find cheaters, NORA is used by both government agencies and private organizations, and it is big business. In some settings, NORA can bring many benefits, such as in law enforcement. By identifying potential criminals more quickly, crimes can be solved more quickly or even prevented before they happen. But these advantages come at a price: our privacy.

Example: NORA

NORA technology allowed law enforcement to identify an anonymous serial killer in Louisiana known as the Riddler, who had sent cryptic notes to police. By analyzing writing samples through NORA, a suspect was identified.

12.3.8: Restrictions on Data Collecting

Information privacy or data protection laws provide legal guidelines for obtaining, using, and storing data about its citizens. The European Union has had the General Data Protection Regulation(GDPR) in force since 2018. The US does not have a comprehensive information privacy law but has adopted sectoral laws. 9

12.3.8.1: Children's Online Privacy Protection Act (COPPA)

Websites collecting information from children under the age of thirteen are required to comply with the Children's Online Privacy Protection Act (COPPA), which is enforced by the Federal Trade Commission (FTC). To comply with COPPA, organizations must make a good-faith effort to determine the age of those accessing their websites. If users are under thirteen years old, they must obtain parental consent before collecting any information.

Note

In 2022, T-Mobile paid $19 million to settle claims it violated COPPA by selling location data from children's phones to third party companies, failing to obtain parental consent.

12.3.8.2: Family Educational Rights and Privacy Act (FERPA)

The Family Educational Rights and Privacy Act (FERPA) is a US law that protects student education records' privacy. In brief, this law specifies that parents have a right to their child's educational information until they reach either the age of eighteen or begin attending school beyond the high school level. At that point, control of the information is given to the child. While this law is not specifically about the digital collection of information on the Internet, the educational institutions collecting student information are at a higher risk for disclosing it improperly because of digital technologies. This became especially apparent during the Covid-19 pandemic when all face-to-face classes at educational institutions transitioned to online classes. Institutions need to have policies in place that protect student privacy during video meetings and recordings.

12.3.8.3: Health Insurance Portability and Accountability Act (HIPAA)

The Health Insurance Portability and Accountability Act of 1996 (HIPAA) is the law that specifically singles out records related to health care as a special class of personally identifiable information. This law gives patients specific rights to control their medical records, requires health care providers and others who maintain this information to get specific permission to share it, and imposes penalties on the institutions that breach this trust. Since much of this information is now shared via electronic medical records, the protection of those systems becomes paramount.

If you key in the data in the US, you own the right to store and use it even if the data was collected without permission except regulated by laws and rules such as above. Very few states recognize an individual's right to privacy; California is the exception. The California Online Privacy Protection Act of 2003(OPPA) requires operators of commercial websites or online services that collect personal information on California residents through a website to post a privacy policy on the site conspicuously.

Sidebar: Do Not Track

When it comes to getting permission to share personal information, the US and the EU have different approaches. In the US, the "opt-out" model is prevalent; in this model, the default agreement is that you have agreed to share your information with the organization and explicitly tell them that you do not want your information shared. No laws prohibit sharing your data (beyond some specific categories of data, such as medical records). In the European Union, the "opt-in" model is required to be the default. In this case, you must give your explicit permission before an organization can share your information.

To combat this sharing of information, the Do Not Track initiative was created. As its creators explain 3 :

Do Not Track is a technology and policy proposal that enables users to opt-out of tracking by websites they do not visit, including analytics services, advertising networks, and social platforms. At present, few of these third parties offer a reliable tracking opt-out, and tools for blocking them are neither user-friendly nor comprehensive. Much like the popular Do Not Call registry, Do Not Track provides users with a single, simple, persistent choice to opt-out of third-party web tracking.

12.3.9: References

EFF. *Unintended consequences - 16 years under DCMA (2014*). Retrieved November 10, 2020, from https://www.eff.org/wp/unintended-consequences-16-years-under-dmca

EFF. *Do not track*. Retrieved November 10, 2020, from http://donottrack.us/

Guide to Protecting the Confidentiality of Personally Identifiable Information (PII). National Institute of Standards and Technology. US Department of Commerce Special Publication 800-122. http://csrc.nist.gov/publications/nistpubs/800-122/sp800-122.pdf

US Patent and Trademark Office, *"What is a patent?"* Retrieved November 10, 2020, from www.uspto.gov/patents/

12.4: Summary

The exponential advancement of information technology in recent decades has introduced innovative new capabilities, along with complex ethical and legal implications. Digital tools have fundamentally changed how individuals and organizations create, distribute, and consume content.

To adapt to these changes, new rules, regulations, and cultural norms continue to evolve. We've seen how intellectual property protections have been extended into the digital realm, through copyright for creative works, patents for inventions, and trademarks for branding. Obtaining and defending these protections has become big business. However, doctrines like fair use and Creative Commons licensing allow more open access and sharing of intellectual property as well.

Privacy has also been impacted as personal data can be effortlessly copied and transmitted globally. Information that previously required painstaking compilation to connect can now be easily aggregated and analyzed using technology like NORA. Legal protections aim to restrict this, such as HIPAA, FERPA, and COPPA, but challenges remain.

As capabilities like artificial intelligence develop, new complex questions will continue to emerge around ethics, privacy, and appropriate regulation. Maintaining technology's benefits while minimizing harm will require thoughtful analysis from businesses, lawmakers, and society. This chapter provided background on navigating the ethical and legal implications of our increasingly high-tech world.

12.5: Study Questions

? Study Question 12.5.1

What does the term information systems ethics mean?

Answer

Information systems ethics refers to the moral principles and rules of conduct that apply to the development and use of computer systems and technology. It deals with ethical issues that arise due to the capabilities that information systems provide.

? Study Question 12.5.2

What is a code of ethics? What is one advantage and one disadvantage of a code of ethics?

Answer

A code of ethics is a document that outlines acceptable behaviors for members of a group, often professionals in a field. One advantage is that it clarifies acceptable standards of conduct. A disadvantage is that it may not cover every ethical situation that arises.

? Study Question 12.5.3

What does the term intellectual property mean? Give an example.

Answer

Intellectual property refers to creations of the mind that have commercial value and are protected by law from unauthorized use by others. Examples include trademarks, copyrights, and patents.

? Study Question 12.5.4

What protections are provided by a copyright? How do you obtain one?

Answer

A copyright protects original creative works like books, movies, and artwork from being copied or reproduced without permission. Copyright is obtained automatically when the work is fixed in a tangible form.

? Study Question12.5.5

What is fair use?

Answer

Fair use is a legal exemption that allows limited use of copyrighted material without permission for purposes such as education, commentary, and news reporting.

Study Question 12.5.6

What does a trademark protect? How do you obtain one?

Answer

A trademark protects words, phrases, logos or other identifiers that distinguish a good or service in commerce. Trademark rights are obtained by using the mark in commerce.

Study Question 12.5.7

What does the term personally identifiable information mean?

Answer

Personally identifiable information (PII) refers to data that can uniquely identify an individual, such as name, social security number, biometric data, and medical records.

Study Question 12.5.8

What protections are provided by HIPAA, COPPA, and FERPA?

Answer

HIPAA protects privacy of medical information, COPPA protects kids' privacy online, and FERPA protects privacy of student educational records.

Study Question 12.5.9

How would you explain the concept of NORA?

Answer

NORA stands for non-obvious relationship awareness. It refers to using technology to identify individuals by combining non-sensitive data from multiple sources to build detailed profiles.

Study Question 12.5.10

What are the ethical implications of artificial intelligence?

Answer

AI raises issues like inherent bias, transparency and accountability, potential job loss, and privacy concerns that organizations must weigh ethically.

Study Question 12.5.11

How does technology impact workplace monitoring?

Answer

Technology enables extensive employee monitoring, raising questions about privacy and appropriate use by employers. Clear policies are needed to address issues like surveillance and data collection.

? Study Question 12.5.12

How does copyright law balance the rights of a creator with the benefits of their work entering the public domain?

Answer

Copyright law aims to balance incentivizing creativity by protecting works for a period of time, while also ensuring works eventually enter the public domain for broader use. Protections are limited in duration, and doctrines like fair use allow some rights for the public. This attempts to serve both the original creator and society as a whole.

12.5.1: Exercises

1. Interview someone who works in cybersecurity. What ethical dilemmas have they encountered in their work?
2. Find a recent news article about a data breach or privacy violation. What could the company have done better?
3. Compare the privacy policies of 3 popular websites. What differences do you notice?
4. Find 5 copyrighted images online and evaluate what would be considered fair use.
5. Listen to a podcast episode covering issues related to technology ethics. What did you learn?
6. Review your social media privacy settings. What changes would better protect your privacy?
7. Find a code of ethics for a professional organization related to technology and review their key principles. Which do you think are most important?
8. Interview someone who has patented an invention. What was the process like?
9. Try to trademark a common word or phrase. What happens?
10. Take an online privacy quiz. Share some tips you learned.
11. Find a case where fair use protected the use of copyrighted material. What was the situation?
12. Compare privacy laws between the US and another country. What differences did you find?

12.6: Future Trends in Information Systems

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe future trends in information systems.

This final chapter will present an overview or advances of some of the new or recently introduced technologies. From wearable technology, virtual reality, Internet of Things, quantum computing to artificial intelligence, this chapter will provide a look forward to what the next few years will bring to potentially transform how we learn, communicate, do business, work, and play.

00: Front Matter

This page was auto-generated because a user created a sub-page to this page.

TABLE OF CONTENTS

SECTION OVERVIEW

13.1: Patent Basics

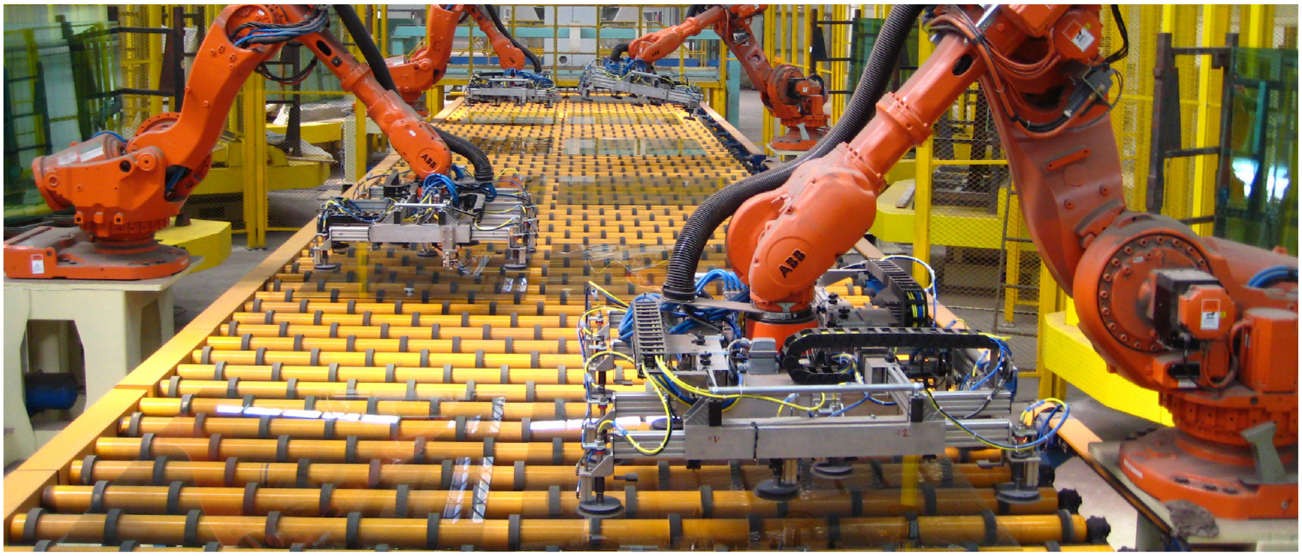


Figure **1.1** (credit: modification of work “Float Glass Unloading” by ICAPlants/wikimedia.org, CC BY 3.0)

13.1.1: The Foundations of Patent Protection

Learning Objectives

After completing this section, you will be able to

- Describe the philosophical logic behind granting patents.
- Describe the role of patents in fostering invention.

Do Patents Really Promote Innovation?

Before reading this section, please watch the overview video below covering the usefulness of patents - how ironic that a system for granting exclusive rights to inventors is the greatest vehicle for knowledge-sharing and technology transfer ever devised by human beings.


X000001
July 31, 1790

The United States.

To all to whom these Presents shall come. Greeting.

Whereas Samuel Hopkins of the City of Philadelphia and State of Pensylvania hath discovered an Improvement, not known or used before such Discovery, in the making of Pot ash and Pearl ash by a new Apparatus and Process; that is to say, in the making of Pearl ash 1st. by burning the raw Ashes in a Furnace, 2d. by dissolving and boiling them when so burnt in Water, 3d. by drawing off and settling the Ley, and 4th. by boiling the Ley into Salts which then are the true Pearl ash; and also in the making of Pot ash by fluxing the Pearl ash so made as aforesaid; which Operation of burning the raw Ashes in a Furnace, preparatory to their Dissolution and boiling in Water, is new, leaves little Residuum, and produces a much greater Quantity of Salt: These are therefore in pursuance of the Act, entituled "An Act to promote the Progress of useful Arts", to grant to the said Samuel Hopkins, his Heirs, Administrators and Assigns, for the Term of fourteen Years, the sole and exclusive Right and Liberty of using, and vending to others the said Discovery, of burning the raw Ashes previous to their being dissolved and boiled in Water, according to the true Intent and Meaning of the Act aforesaid. In Testimony whereof I have caused these Letters to be made patent, and the Seal of the United States to be hereunto affixed

...hundred & Ninety.

Wikimedia Commons /

What Is A Patent?

A **patent** is an **intellectual property** right granted by the government of a nation to an inventor that gives them the exclusive right to the invention for up to 20 years, in exchange for disclosing the details of the new technology to society for its ultimate benefit.

In the United States, a **patent** is a legal instrument in the form of a document issued by the United States Patent and Trademark Office (USPTO). It gives the inventor of any new, useful, and non-obvious machine, process, manufacture, or composition of matter the right "to exclude others from making, using, offering for sale, or selling the invention throughout the United States or importing the invention into the United States" for a limited time in exchange for public disclosure of the invention.[i] A U.S. patent is only recognized domestically, and cannot be enforced in another country.

History of Patents in the United States

The legal foundation for U.S. intellectual property rights was laid by the Founders in 1787, in the very first Article of the U.S. Constitution, which outlined the precepts of our democratic society. In Article 1, Section 8, Clause 8 of the Constitution, Congress was given the authority to "promote the progress of Science and useful Arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries".[ii]

America was the first country in the world to enshrine intellectual property rights in its national constitution. And the Founders did this quite deliberately, says B. Zorina Khan, an economic historian at Bowdoin College whose book, The Democratization of Invention: Patents and Copyrights in American Economic Development, was awarded the Alice Hanson Jones Prize for an outstanding work in economic history.[iii] “To the men who gathered in Philadelphia to ‘promote the general welfare,’” Khan wrote, “it was self-evident that ideas, industrial and cultural inventions, and democratic values were integrally related. American democratic institutions would ensure that rewards accrued to the deserving based on [merit] rather than on the arbitrary basis of class, patronage, or privilege.”

Indeed, the Founders viewed intellectual property rights as vital to the new nation’s economic survival. As George Washington himself stated in his first annual address to Congress in 1790, “The advancement of agriculture, commerce, and manufactures by all proper means will not, I trust, need recommendation. But I cannot forbear intimating to you the expediency of giving effectual encouragement to the introduction of new and useful inventions.”

The question is, with all the challenges they faced, why did the Founders think it so crucial to create a strong intellectual property system? Their reasons were both universal—i.e., applying to all societies—and also very particular to America’s revolutionary experience.

"Bargain" Theory vs. "Natural Rights" Theory

Every society that affirms intellectual property rights offers two justifications for doing so: the **bargain or contract theory** and the **natural rights theory**.

"Bargain" Theory

The “bargain” theory starts with the commonsense premise that people will be encouraged to invent new products and services that benefit society if they are likely to profit by doing so. The U.S. Constitution thus offers inventors a bargain: If you invent something useful—e.g., a cotton gin in 1794 that boosted agricultural production a hundredfold, or a semiconductor 163 years later that sparked the creation of a trillion-dollar new industry and millions of jobs—then the Constitution and statutes say that, as a quid pro quo, you can have the exclusive right to that invention for a “limited time,” after which it goes into the public domain and belongs to society.

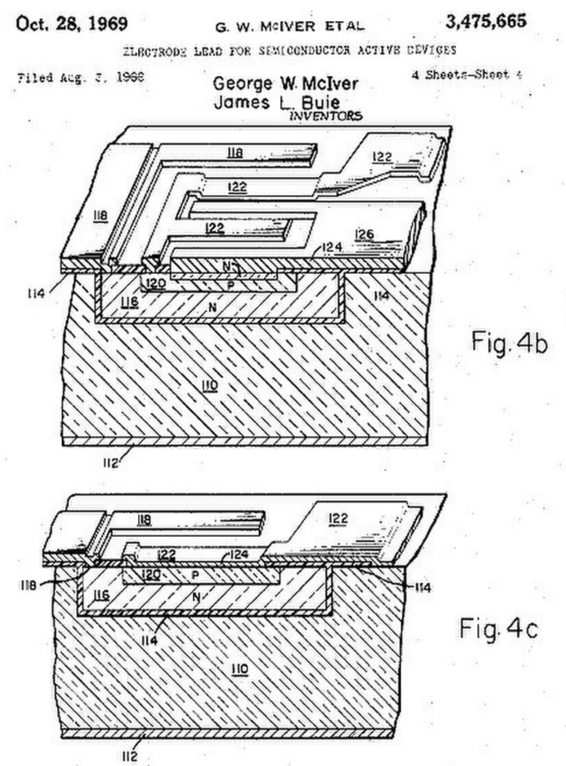


Figure 1.1.2 Patent for an electrode lead for semiconductor devices (credit: US Patent Office via Wikimedia Commons / Public Domain)

There is something so simple yet economically potent about this concept. As Abraham Lincoln—America’s only presidential patentee (No. 6469 for a device to lift boats over shoals)—noted, the beauty of the patent system is that it “added the fuel of interest to the fire of genius.”

"Natural Rights" Theory

The “natural rights” theory, meanwhile, invokes another commonsense premise that most of us instinctively hold to be true: that the product of mental labor is by all rights the property of its creator, no less than the product of physical labor is the property of its creator (or of the person who purchases it from that creator). This is what Daniel Webster was referring to when he said, “The American Constitution does not attempt to give an inventor a right to their invention, or an author a right to his composition; it recognizes an original, pre-existing, inherent right of property in such invention or composition.”

This right is not absolute, of course, and inventors’ inherent rights may at times be circumscribed by national security or other concerns. But in exchange for disclosing to the public the nature and details of the invention, the Constitution authorizes the government to enforce the inventor’s exclusive property right to that invention for a limited time.

Two important public policy goals are thus served. The inherent property rights of inventors and authors to their creations are protected, thereby helping to ensure that the wellsprings of creation and productivity do not dry up for lack of incentive. And yet the benefits derived from these inventions and creations are ultimately harnessed to the public good through disclosure, thus promoting the progress of the nation and “the general welfare” of its citizens.

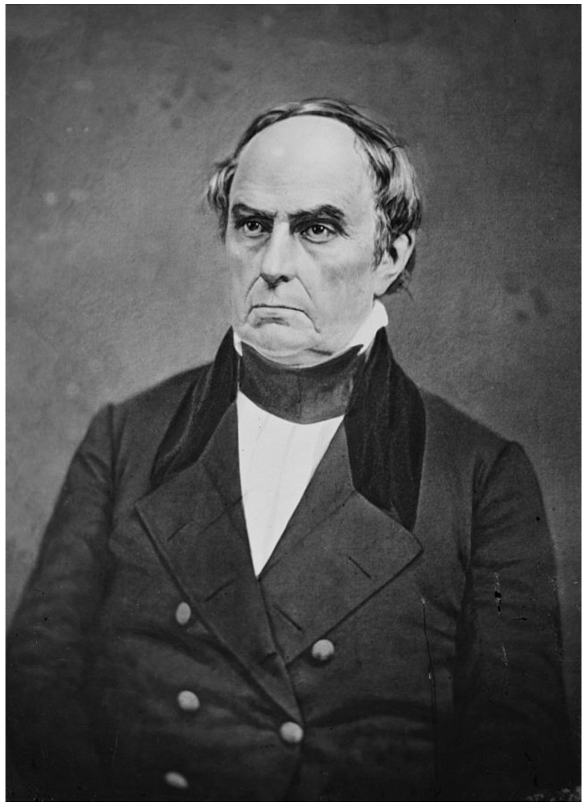


Figure 1.1.3 Daniel Webster, an American lawyer and statesman (Credit: Wikipedia / Public Domain)

How Patents Foster Innovation

To help understand why patent rights not only encourage inventors but also promote the wider diffusion of new technology for the benefit of society, economic historians Naomi Lamoreaux and the late Kenneth Sokoloff suggested the following thought experiment:

Imagine a world in which there was no patent system to guarantee inventors property rights to their discoveries. In such a world, inventors would have every incentive to be secretive and to guard jealously their discoveries from competitors [because those discoveries] could, of course, be copied with impunity. “By contrast, in a world where property rights in invention were protected, the situation would be very different. Inventors would now feel free to promote their discoveries as widely as possible so as to maximize returns either from commercializing their ideas themselves or from [licensing] rights to the idea to others. The protections offered by the patent system would thus be an important stimulus to the exchange of technological information in and of themselves. Moreover, it is likely that the cross -fertilization that resulted from these information flows would be a potent stimulus to technological change. [iv]

It’s more than just “likely.” Extensive research in the United States and other nations shows that patents have served as a powerful stimulant to technological knowledge sharing. A 2006 survey published by the French economists Francois Leveque and Yann Meniere, for example, found that 88 percent of U.S., European, and Japanese businesses rely upon the information disclosed in patents to keep up with technology advances and direct their own R&D efforts.[v]

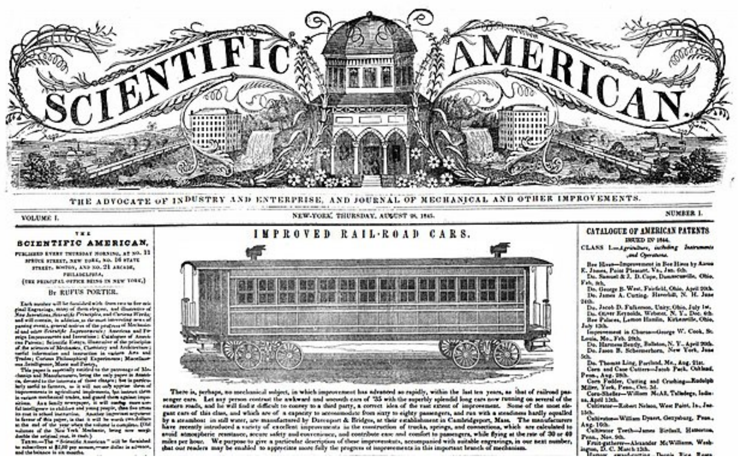
Patents Don't Block Innovation, They Promote It

From the earliest days of the United States, patent and legal records show how inventors (including Thomas Edison) regularly kept abreast of developments in their fields. They did this by studying patent descriptions published by both the USPTO as well as by industry publications such as Scientific American, which was founded in 1845 by Munn and Company, the leading patent agency of the nineteenth century, expressly to spread new technological knowledge and facilitate the buying and selling of patents. For example, Elias E. Reis—inventor of a number of devices to exploit the heat generated by electrical currents—reported that when he read in the Official Gazette in 1886 about a patent issued to Elihu Thomson for a new method of electric welding, "there immediately opened up to my mind a field of new applications to which I saw I could apply my system of producing heat in large quantities."[vi] In many industries, specialized journals kept readers informed about new patents of interest.

In fact, new research in 2012 discovered that rather than blocking development, Thomas Edison's seminal 1880 incandescent lamp patent (No. 223,898) actually "stimulated downstream development work" that resulted in "new technologies of commercial significance [including] the Tesla coil, hermetically sealed connectors, chemical vapor deposition process, tungsten lamp filaments and phosphorescent lighting that led to today's fluorescent lamps."[vii]

Even the word "patent" signifies its social purpose of disclosure. It is derived from the Latin patent meaning "open," and is the present participle of "pate¯re," meaning "to stand wide open."

This explains the origin of the term "letters patent" ("letters that lie open"), which refer to the patent documents issued by the English Crown. These were not closed with a seal but were instead kept open, with the seal hanging at the bottom, notifying all not to infringe upon the patent.


SCIENTIFIC AMERICAN.

THE ADVOCATE OF INDUSTRY AND ENTERPRISE, AND JOURNAL OF MECHANICAL AND OTHER IMPROVEMENTS.

VOLUME I. NEW-YORK, THURSDAY, AUGUST 28, 1845. NUMBER 1.

THE SCIENTIFIC AMERICAN.

IMPROVED RAIL-ROAD CARS.

CATALOGUE OF AMERICAN PATENTS

Figure 1.1.4: Front page of the first "Scientific American" issue, August 8, 1845. (credit: modification of work by Scientific American via Wikimedia Commons / Public Domain)

As with any economic and legal instrument, patents have the potential to slow innovation if their grant of exclusive rights is too broad. But the overwhelming preponderance of economic research and real-world experience demonstrate that, on balance, intellectual property rights tend to stimulate invention, economic growth, and the diffusion of new technological knowledge in every country where they exist.

This fact by itself, however, does not explain why the U.S. patent system became a model for much of the world. To understand why it did—and how it helped build the most successful economy in the history of the world—we must examine the revolutionary design of the U.S. patent system itself and the ways in which it overcame the weaknesses of earlier patent systems.

Footnotes

- i United States Patent and Trademark Office. (2012, January 26). Patents. Retrieved from www.uspto.gov/patents/index.jsp
- ii U.S. Constitution Arr. 1, § 8
- iii B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development*, 1790-1920, Cambridge University Press, 2005.
- iv Naomi R. Lamoreaux and Kenneth L. Sokoloff, *"Inventors, Firms, and the Market for Technology: U.S. Manufacturing in the Late Nineteenth and Early Twentieth Centuries,"*Historical Paper 98, National Bureau of Economic Research, Cambridge, Mass., 1997.
- v Francois Leveque and Yann Meniere, "Patents and Innovation: Friends or Foes?" CERNA (Centre d'economie industrielle Ecole Nationale Superieure des Mines de Paris), December, 2006.
- vi See "Record of Elias E. Reis," 8, *Thomson v. Reis*, case 13,971, box 1,845, Interference Case Files, 1836-1905, Records of the Patent Office, Record Group 241, National Archives, courtesy of B. Zorina Khan.

- vii Ron D. Katznelson, “Inventing Around Edison’s Incandescent Lamp Patent: Evidence of Patents’ Role in Stimulating Downstream Development,” May, 2012, derived from: http://works.bepress.com/cgi/viewcon...xt=rkatznelson

13.1.2: Patent-Eligible Inventions

Learning Objectives

After completing this section, you will be able to

- Identify the characteristics of a patentable invention.
- Understand what is not patentable and why.

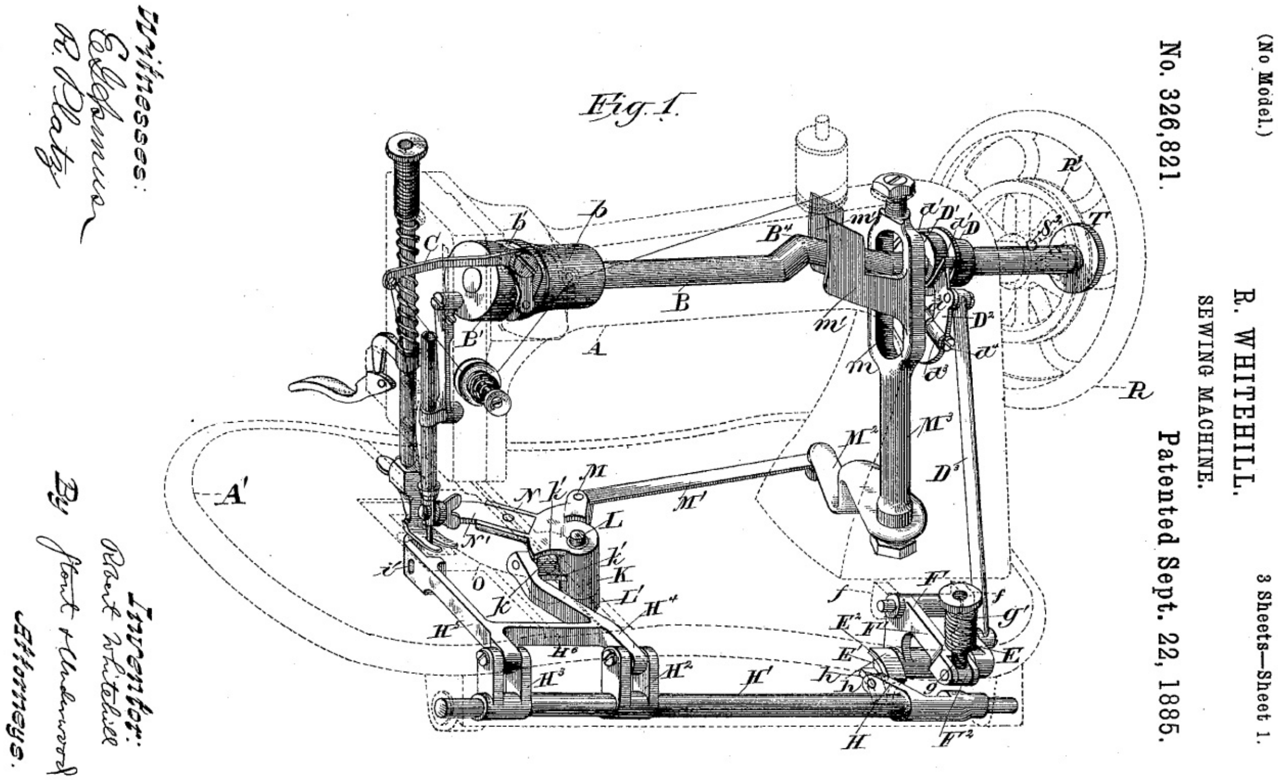


Figure 1.6.1 USPTO Patent No. 326821 for a sewing machine. (credit: USPTO via Wikimedia Commons / Public domain)

What, Exactly, Can You Patent?

Title 35 of the United States Code (the Patent Act) allows anyone who invents or discovers any new, nonobvious, and useful machine, manufacture, process, or composition of matter—or who makes an improvement of any of the above—to obtain a patent.[xliii]

These four kinds of patentable inventions fall into one of two categories: They are products or processes.[xliv]

Product or Process?

Products are physical things—whether they be machines (a new type of robotic welder), manufactures (an artificial knee made of titanium), or compositions of matter (a new chemical “superglue” for binding materials together). In this photo, Elon Musk observes the robotic arms in the Tesla Motors factory. Specialized manufacturing equipment like this are patentable products.

Processes (or methods), on the other hand, are a means to an end—either a means of doing something new (being able to pay for purchases directly from your smartphone), or a new way of doing something old (using “pinch, swipe, and zoom” gestures on a touchscreen, rather than clicking drop-down menus, to manipulate text, music, and images on a smartphone).

You Cannot Patent Ideas

All patented inventions fit into one of these four categories: machine, manufacture, process, or composition of matter. But not everything that fits in one of these four categories can be patented. And the most important reason why one thing is patentable and another is not lies in the difference between ideas and applications.

You cannot patent an idea for a better mousetrap—not unless it can be developed into a new, non-obvious, and useful machine, manufacture, process, or composition of matter that can actually accomplish the task. You may have a genius idea for faster-than-light travel, but that will not get you a patent unless you can outline how to develop a tangible process or device for actually doing so, in which case you can seek to patent it.

Put another way, “talk is cheap” when it comes to securing a patent. The U.S. Patent and Trademark Office offers no judgment as to the wisdom or desirability of any particular invention—patent No. 2,882,858 for a bird diaper is certainly proof of that. But it absolutely will insist that every invention include a tangible device or process for achieving its intended purpose before it deems the invention worthy of a patent.

Mathematical Formulas Not Patentable

There are other discoveries that fall into the broad category of abstract ideas and are thus unpatentable. You cannot patent a mathematical formula. You cannot patent a law of nature, such as Einstein’s E=MC2 . And you cannot patent natural phenomena like electricity (discovered by William Gilbert in 1600) or the Higgs particle that gives all matter its mass (discovered by researchers at the Large Hadron Collider on July 4, 2012). These all exist independently of human intervention, whether we have discovered them or formulated their rules yet or not, and must be freely available to all of humanity for its understanding and betterment.

To restate the distinction, you cannot patent electromagnetism but you can patent a telegraph that uses electromagnetism to communicate rapidly over great distances, as Samuel Morse did in 1840 with patent no. 1647. And although you cannot patent light waves, you can patent a fiber optic wire that employs light waves to communicate even more rapidly and over greater distances, as Corning Glass researchers did in 1970 with patent no. 3,711,262.

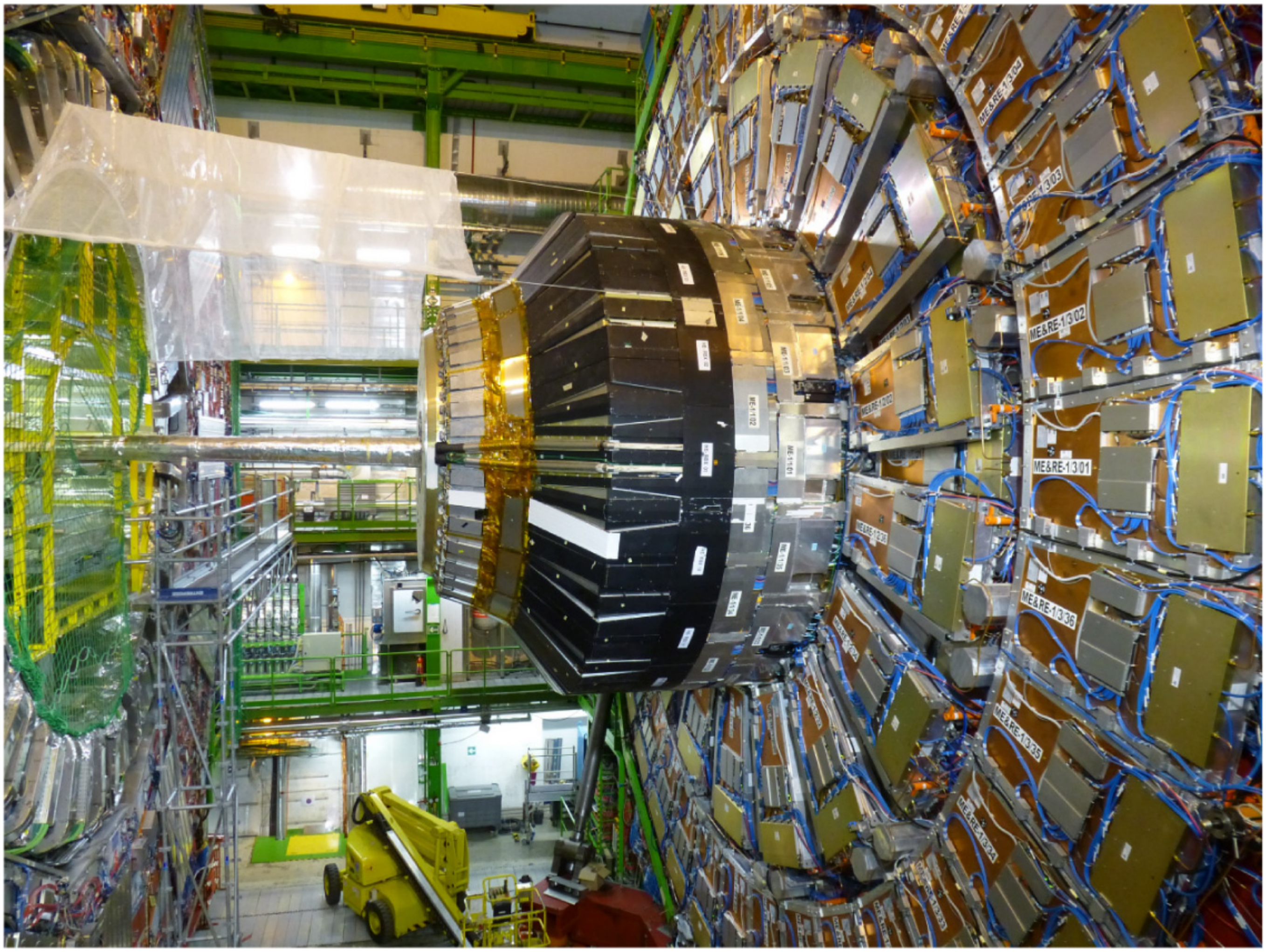


Figure 1.6.2 Portion of the Large Hadron Collider. (credit: Photograph by Luigi Selmi via flickr / CC BY 2.0)

Can You Patent Computer Software?

The boundary between ideas and applications might seem clear, but it has become blurred since the advent of computer technology 40 years ago, especially regarding the patentability of software.

To learn more, watch this video from PBS Digital Studios about the first software patent ever awarded and to learn a bit about the debate around software patentability.

Mixed Verdicts on Software Patentability

The federal courts and the U.S. Supreme Court have tried to clarify the limits of patentability in the computer age. Three Supreme Court cases in particular—often called the "patent-eligibility trilogy"—reveal the evolution of its thinking about software patentability. In 1972, the Supreme Court held in *Gottschalk v. Benson* that an algorithm in a computer program—in this case, a mathematical procedure executed electronically that was similar to long division with paper and pencil—was in and of itself not patentable. Phenomena of nature, mental processes, and abstract intellectual concepts are the basic tools of scientific and technical research, the court noted, and therefore could not be patented lest it foreclose others from using the algorithm and thereby stifle rather than promote technological progress. Granting a patent in this case, the court said, would be analogous to having granted Samuel Morse a patent covering all possible uses of electromagnetism in communications, rather than for the specific method and apparatus he actually invented.

The court made a point of saying, however, that its decision did not mean that computer software could not be patented—only that software whose only useful characteristic was an abstract algorithm could not be patented.

The Supreme Court further refined its thinking on software patentability in the 1978 case *Parker v. Flook*. Unlike the attempt to patent all uses of an algorithm in the Benson case, here the use of a software algorithm was limited to a specific application—setting off an alarm during the catalytic chemical conversion of hydrocarbons. This was a specific and tangible use of an algorithm, but the Court still ruled the software unpatentable because it felt the application itself was not inventive.

But once again, the Court left the door open: "Even though a phenomenon of nature or mathematical formula may be well known, an inventive application ... may be patented."

Three years later, the Supreme Court made its third attempt to define the patent-eligibility of software. In *Diamond v. Diehr* , the Court ruled that although algorithms by themselves are not patentable, a software program that used algorithms to govern the molding of raw synthetic rubber into cured precision products was in fact patentable because it involved "transforming or reducing an article to a different state or thing."

The Software Picture Blurs Even More

Taken together, the three rulings appeared for a time to arrive finally at a coherent definition of software patentability—namely, that although algorithms by themselves are abstract concepts and therefore unpatentable, software programs may be patented if they employ algorithms to produce a tangible and inventive or transformative result. This view was further augmented by a 1998 U.S. Court of Appeals for the Federal Circuit decision in *State Street Bank v. Signature Financial Group*, which extended software patentability to software-enabled methods of doing business so long as these produced a "useful, concrete, and tangible result."

But this definitional equilibrium was not to last. The "useful, concrete, and tangible result" test in *State Street Bank* was rejected ten years later by the same court in *In re Bilski*, which upheld the USPTO's denial of a patent for a method of hedging risk in commodities trading. The court instead offered a "machine or transformation" test, which allows a software program or business method to be patented only if it is implemented on a specific machine to achieve a special purpose that is novel, nonobvious, and useful; it transforms an article from one thing or state to another.

But in its review of *Bilski v. Kappos* , the Supreme Court ruled that while the "machine or transformation" test was useful, it was not the only test for patentability. In addition to the "machine or transformation" test, the court decreed (rather vaguely) that any future test should be "grounded in the examples and concepts" expressed in its original "patent-eligibility trilogy" of opinions. They thus reaffirmed that business methods may indeed be patentable.

Finally, a "Pretty Clear" Message

While businesses and the courts were trying to figure out what the other tests for patentability might be, the Supreme Court provided further input with its March 2012 decision in *Mayo Collaborative Services v. Prometheus Laboratories* . Here, the court ruled that a process enabling physicians to correlate blood test results with medication levels to achieve the most appropriate dosages was ineligible for patent protection."

But then in June of 2014, The Supreme Court issued what may prove to be its most consequential decision on the patentability of software in the 33 years since *Diamond v. Diehr*. In *Alice v. CLS Bank*, the Court ruled that taking some activity that people have been doing for centuries—in this case, holding funds in escrow until a transaction is completed—and then merely "doing it through a computer" did not turn this age-old activity into a patentable new invention.

At first, many observers believed that the effects of the *Alice v. CLS Bank* ruling would be very limited. Only the patent in the suit was invalidated, after all, not all software patents. What's more, the abstract reasoning of the court in its decision did not provide clarity on how the ruling may or may not apply to other kinds of software patents—for example, the sort of software used in manufacturing that was ruled patentable in the 1981 *Diamond v. Diehr* case.

But by October of 2014, a series of lower court decisions applying the new *Alice v. CLS Bank* standard had invalidated 13 additional software patents. As technology policy journalist Timothy B. Lee noted, "The courts are sending a pretty clear message: you can't take a commonplace human activity, do it with a computer, and call that a patentable invention."

> *"The courts are sending a pretty clear message: you can't take a commonplace human activity, do it with a computer, and call that a patentable invention."*
>
> *-Timothy B. Lee, technology policy journalist*

How far reaching will the impact of *Alice v. CLS Bank* be? “This doesn’t necessarily mean that all software patents are in danger,” Lee noted, because the patents involved “were particularly vulnerable to challenge under the new *Alice* precedent. But it does mean that the pendulum of patent law is clearly swinging in an anti-[software] patent direction.”

Overcoming the Alice Paradox

By late 2015, however, it was clear that the *Alice* ruling was having an impact not only on patent law, but also on the innovation process itself within corporate America.

As John Cronin, a former top inventor at IBM and now the CEO of the innovation-on-demand firm ipCreate, observes: “The highest-value products and services today—the ones that increasingly drive margins in business—involve cloud computing, Big Data, machine learning, connectivity, mobility and location-based services, and on-demand and anything-as-a-service software applications and business processes. But ironically, these high-value innovations are also the most difficult to patent nowadays as a result of the Supreme Court’s *Alice* decision.”

Cronin calls this the “*Alice* Paradox,” and it has left many in-house patent groups struggling for a solution. One thing is clear: To be patentable nowadays, software has to take a genuinely-inventive step and either trigger an action, employ a device, or in some other way produce a tangible transformative result.

In addition, smart companies are trying to address patentability issues involving software and business processes much earlier in the innovation cycle, before huge investments are made in R&D that may turn out to be not patentable.

Overall, addressing the “*Alice* Paradox” will be critical for many companies because patenting clearly adds value to a new product or service. In a groundbreaking joint study from Carnegie Mellon University, Georgia Institute of Technology, and Duke University entitled “R&D and the Patent Premium,” economists found that “the patent premium for innovations that were patented is substantial. Firms earn on average a 50% premium over the no patenting case, ranging from 60% in the health-related industries to 40% in electronics.”[xlv]

The Debate on Software Continues

The debate over the dividing line between patentable versus unpatentable computer software-related inventions continues—in corporate R&D labs and in the courts.

However, there are some who don’t believe that software and business methods should be patented under any conditions. They argue first of all that software is different from other industries—more iterative and more incremental, with each advance building upon thousands of previous advances. Therefore, their thinking goes, software should not be entitled to patents that ought to be more properly reserved for truly breakthrough or revolutionary inventions.

There are two problems with this argument. First, as anyone in the semiconductor, chemical, or medical device industries can attest, innovation is no more iterative, incremental, or cumulative in software than is innovation in many other industries. Indeed, there are probably just as many or more patents for incremental semiconductor inventions that build modestly upon earlier work as there are patents for incremental software inventions that do the same.

Figure 1.6.3 An Apple Macintosh Mouse M0100 Beige from 1984 (left), and an Apple Magic Mouse from 2009 (right) (credit: Photograph by reneko via flickr / CC BY 2.0)

As patent scholar and veteran practitioner Paul Janicke of the University of Houston put it, “There really are no breakthrough inventions—at least not in the sense imagined by these critics. Everything moves one step at a time. In fact, every time I thought I encountered a large leap, it turned out that I didn’t know the full extent of the prior art.”

The second problem with their logic is that the Founding Fathers specifically designed the patent system to encourage precisely this kind of incremental invention, so that ordinary people—using only the basic technical skills possessed by most citizens—could participate in rapidly developing the economy from the ground up. This was a very different approach than that of elitist European patent systems of the day, and it produced results that the rest of the world very soon came to envy (see “Section 1.5: What the U.S. Patent System Wrought”).

As the October 21, 1876, issue of Scientific American noted, “In the aggregate the little things—which in England or the continent would not or could not be patented—probably add more to the wealth and wellbeing of the community … than the great things do.” Or to quote Thomas Jefferson himself: “A smaller [invention], applicable to our daily concerns, is infinitely more valuable than the greatest which can only be used for great objects.”[xlvi] Any uncertainty over the validity of incremental patenting was removed once and for all by the Patent Act of 1952. Consistent with the Founders’ intentions, U.S. law now explicitly holds that patent eligibility is not restricted solely to revolutionary inventions or “flash of genius” discoveries, but also includes more iterative advances in the state of the technological art so long as these meet the requisite novelty, nonobviousness, and utility criteria.

Evidence Shows Software Patents Don’t Hinder Innovation

Another argument made by critics of software patenting is that patents stifle innovation and foster monopolization in the software industry. Research, however, suggests that this is decidedly not the case.[xlvii] If anything, in fact, the software industry has become even more innovative, more diversified, and more start-up friendly since patenting became common in the 1990s. You need only look at the huge proliferation of highly innovative start-ups in today’s social media and apps software fields to see just how erroneous the claim is that software patents stifle innovation. Or consider for a moment the fate of the Blackberry, once dominant but within the space of a couple of years superseded by more innovative competing smartphone makers.

Finally, some critics insist that the intangible nature of software ought to disqualify it from patentability. But as noted earlier, the Supreme Court has affirmed repeatedly that although abstract concepts cannot be patented, software that employs algorithms to produce a tangible and inventive result—e.g., software that governs the molding of raw synthetic rubber into cured precision products—may be patented.

It's also helpful to view this issue in a larger context. Forty years ago, 80 percent of the market value of all public companies resided in their tangible physical assets—their plant, equipment, and raw materials. In today's Knowledge Economy, however, it is intangible assets—intellectual property—that make up 80 percent of the market value of public companies.[xlviii]

Indeed, the entire history of economic progress on our planet may be described as one long climb by humanity up the ladder of abstraction—from brute force to the subtle use of energy, from wealth derived from tangible resources and industrial machinery to wealth derived from ever-more ingenious ways to deploy that energy and those resources. It seems only logical, therefore, to expect that invention itself should follow a similar trajectory—from the realm of the tangible to the realm of the intangible.

Ironically, the debate over patents for software, business methods, and other intangible inventions is nowhere more heated than on the Internet, itself an intangible realm in which "virtual" businesses launched with little more than hope and electrons (e.g., Facebook) are creating real and substantial wealth in the form of new products, new services, new jobs, and new economic growth for society. Yet strangely, those who have no trouble accepting the Internet as the intangible fruit of information age invention seem to get stuck in industrial age conceptions of what should and should not be patentable.

Odd perhaps, but not surprising. The expansion of patentable subject matter into new and more intangible realms has always met with resistance. Patents involving the use of electricity were condemned 140 years ago, as were biotechnology patents 30 years ago, and of course software patents when they began to appear in large numbers 20 years ago. In each case, critics warned that these new kinds of patents would hold back further scientific discovery and innovation. Yet in each case, innovation and discovery actually intensified and their benefits to society multiplied.

When Gene-Related Inventions Are Patentable

A similar resistance is also developing toward gene-related patents. These began to be issued in significant numbers after the Supreme Court's 1980 ruling in *Diamond v. Chakrabarty*, which upheld the first patent on a newly-created living organism—a bacterium for digesting crude oil in oil spills. Since then, patents have been granted for isolated gene sequences, but so far only on those with known functions and not on naturally occurring genes in humans or other organisms. Patents have also been granted for gene sequences used in diagnostic testing, and on gene sequences that have been altered to make them more useful in a specific application.

In March of 2010, however, a federal district court judge ruled in the case of Myriad Genetics that even isolated DNA is fundamentally the same as naturally- occurring DNA and is therefore ineligible for patenting. His ruling was reversed by the U.S. Court of Appeals for the Federal Circuit in July, 2011. But the Supreme Court then set aside that decision and directed the appeals court to once again review the case in light of its March, 2012 Prometheus decision. On August 16, 2012, however, the U.S. Court of Appeals for the Federal Circuit once again reaffirmed Myriad's right to patent the isolated genes BCRA1 and BCRA2, which are involved in most inherited forms of breast and ovarian cancer.

On June 13, 2013, however, the U.S. Supreme Court finally determined in a unanimous decision that a naturally occurring DNA segment is a product of nature and cannot be patented merely because it has been isolated, thereby invalidating Myriad's patents on the BRCA1 and BRCA2 genes. The Court did rule, however, that the manipulation of a gene to create something not found in nature—such as a strand of synthetically-produced complementary DNA (cDNA)—could still be eligible for patent protection.

To the average citizen—and perhaps to many patent lawyers as well—all this legal hairsplitting over the limits of patentability in the computer age must seem a bit like the debates in medieval times over how many angels can dance on the head of a pin. But two critical points must be borne in mind regarding these debates.

First, no matter what anyone thinks the limits of patentability in an ideal world ought to be, out in the real world where we actually live, software, business method, and gene patents are multi- billion-dollar facts of life that businesses ignore only at their peril.

Second, whatever confusion may exist today, the debates over patentability in the computer age will almost certainly be resolved eventually to most people's satisfaction, just as all previous debates over patentability have. For if nothing else, the two hundred year-plus history of the courts and the patent office demonstrate a remarkable ability on the part of these institutions to adapt to the challenges posed by new technologies and new economic conditions.

Footnotes

- xliii 35 U.S.C § 101.
- xliv Arthur R. Millerand Michael H. Davis,*Intellectual Property: Patents, Trademarks, and Copyright in a Nutshell*. (5th ed., p. 25). St. Paul MN: West Publishing Co., 2007.
- xlv Ashish Arora, Marco Ceccagnoli, and Wesley M. Cohen, "*R&D and the Patent Premium*," Science Direct, International Journal of Industrial Organization Issue 26, 2008.
- xlvi From Jefferson's letter to George Fleming in 1815, excerpt from *The Jefferson Cyclopedia*, courtesy of B. Zorina Khan.
- xlvii Robert Merges, "*Patents, Entry and Growth in The Software Industry*," University of California at Berkeley School of Law, Berkeley, California, 2006. Retrieved from: http://papers.ssrn.com/sol3/papers.c...ract_id=926204
- xlviii Op. cit., Ocean Tomo.

SECTION OVERVIEW

13.2: Copyright Basics

Figure 3.0.1: (credit: modification of work “Copyright symbol under magnifying glass” by Marco Verch/flikr.com, CC BY 2.0)

13.2.1: The Basics of Copyright

Learning Objectives

After completing this section, you will be able to

- Understand the theoretical and legal underpinnings of copyright.
- Appreciate the important differences between copyrights and patents.

Figure 3.1.1: (credit: Wikimedia Commons / CC BY-SA 3.0)

A copyright is an intellectual property right granted by a government to the author of an original literary, dramatic, musical, artistic, or other eligible creative work that gives them the exclusive right to control how the work is published, reproduced, performed, or displayed—as well as whether or not derivative works (e.g., a movie version of a novel) may be produced.

In the United States, the legal foundation for copyright is set forth, along with that for patents, in Article 1, Section 8, Clause 8 of the U.S. Constitution. This clause gives Congress the authority to "promote the progress of Science and useful Arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."[i]

Congress and the courts have interpreted the terms "authors" and "writings" very broadly so as to include the creators of a wide variety of artistic and intellectual works. Title 17 of the United States Code authorizes the grant of a copyright to the authors of "original works of authorship"—including literary works, dramatic works, choreographic works, graphic works, audiovisual works, sound recordings, and architectural works. In most cases, a copyright lasts for the life of the author plus 70 years.

How to Obtain a Copyright

In America, the copyright system is administered by the U.S. Copyright Office, which is part of the Library of Congress and maintains a registry of copyrighted works. Interestingly, registration is not required to obtain a copyright. It is automatically granted to an author at the moment of creation—i.e., as soon as the work is expressed in a tangible form that allows it to be seen or copied, such as being written on paper or on a computer, or recorded as video or audio. Registration is only required if a copyright holder wants to initiate a copyright infringement suit in federal court.

Copyrights vs. Patents

Unlike the case with patents, the United States never developed an examination system for determining whether or not a creative work merits copyright protection. That's because while the validity of an invention can be evaluated fairly objectively based on its utility, novelty, and non- obviousness, the merit of any cultural work is a far more subjective affair, as demonstrated by the frequency with which publishers reject novels that later go on to become literary classics.

What the patent and copyright systems share, however, is the recognition that unless the inherent property rights of inventors and authors to their creations are protected, the wellsprings of creation and productivity would be negatively affected by the reduced incentive. Both systems also share the public policy goal of marshaling the benefits of individual creativity—whether technological, as in the case of inventions, or cultural, as in literary works—to the public good so that these promote the progress of the nation and the "general welfare" of its citizens.

How to promote that general welfare, however, was approached very differently by the Founders in the case of patents than it was with copyright.

Figure 3.1.2: A portrait of Supreme Court Justice Henry Baldwin. (credit: modification of work by Wikimedia Commons / Public Domain)

The explicit intention of patent law, explained Supreme Court Justice Henry Baldwin in*Whitney v. Emmett* (1831), was "to benefit the inventor, in the belief that maximizing individual welfare leads to maximum social welfare." Inventors, after all, created tools that enabled the new nation to free itself from dependency on foreign imports and develop industries of its own. Whatever incentives were needed to prod these technologically creative people to take on the challenge and succeed were well worth the bargain (see Chapter 1).

The Rights of Authors and the Public Interest

When it came to copyright, however, the rights of authors were thought to conflict with those of the public to a far greater extent. "Democratic values emphasized equal and widespread access to learning and the importance of information flows for maintaining political freedom, whereas strong copyrights impinged on the fullest attainment of these objectives," notes Bowdoin College historian Zorina Khan, author of *The Democratization of Invention: Patents and Copyright in American Economic Development*, which won the Alice Hanson Jones prize for outstanding work in economic history in 2005.[ii]

As an example, a copyright owner's right to prevent unauthorized use of their work may at times be constrained by the public's First Amendment right of free speech—hence the doctrine of "fair use" (more on this later).

It was believed that a strategy of strong patent rights but weaker copyrights also better reflected the differing incentives that motivated inventors and authors. Inventors, many felt, were driven primarily by economic gain, whereas authors were often interested as much in the prospect of celebrity and reputation as they were in monetary reward.

Supreme Court Justice John McLean emphasized that this distinction between patents and copyrights exists in the structure of U.S. intellectual property law itself. In *Wheaton v. Peters* (1834), the first high court ruling on copyright, he wrote:

> *"It has been argued at the bar that as the promotion of the progress of science and the useful arts is here united in the same clause in the Constitution, the rights of authors and inventors were considered as standing on the same footing. But this, I think, is a non-sequitur … for when Congress came to execute this power by legislation, the subjects are kept distinct and very different provisions are made respecting them."*[iii]

To understand why the Founders gave greater weight to the public domain in copyright law than they did in patent law, it's important to examine the origin and development of early copyright systems and their political and economic impact on society.

Footnotes

- iU.S. Constitution Arr. 1, § 8
- iiB. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790O1920*, Cambridge University Press, 2005.
- iii*Wheaton v. Peters*, 33 U.S. (8 Pet.) 591 (1834)Retrieved from http://supreme.justia.com/cases/fede.../591/case.html *courtesy of B. Zorina Khan*.

13.2.2: Eligible Works

Learning Objectives

After completing this section, you will be able to

- Know what kinds of creative work are eligible for
- Grasp the broad definition of "authors" and "literary works."

Figure 3.4.1: Parthenon Marbles, East Pediment. Photograph taken at the British Museum by Justin Norris via flikr / CC BY 2.0

Can I Copyright That?

Before reading this section, please watch the overview video covering the basics of copyright law—eligible works, the distinction between ideas and their expression, the rights granted to copyright owners, and is copyright term—life plus 70 years.

Title 17 of the United States Code Section 102 explicitly delineates eight categories of original works that are eligible for copyright.

This list, while broad, actually includes a far more extensive range of work than the average citizen might imagine. For example, copyrightable works also include software.

Copyrighting Software

Why is software copyrightable? It’s because an appellate ruling in the 1983 case of *Apple v. Franklin* held that software was a kind of “literary work” and therefore eligible for copyright.

The court noted that the Copyright Act defined the term "literary work" as follows:

> *"Literary works are works, other than audiovisual works, [that are] expressed in words, numbers, or other verbal or numerical symbols or indicia, regardless of the nature of the material objects, such as books, periodicals, manuscripts, phonorecords, film, tapes, disks, or cards, in which they are embodied."*[xii]

Based on this definition, the court determined that a computer software program "is an appropriate subject of copyright."

Note, however, that copyright does not extend to the elements of works of authorship that are potentially patentable processes. And indeed, beginning in the 1990s, software companies began increasingly to patent those elements of their new software that could be described as patentable processes, precisely in order to secure the stronger protections of patent law.

In any event, software is but one example of how the courts have tended to interpret broadly the eight categories of eligible subject matter. Just as technology drove the expansion of eligible subject matter into ever new realms—e.g., first photographs and then motion pictures—the courts have also expanded the definitions of all eight categories of eligible subject matter to include maps, games, puzzles, toys, fabric design, and many other creations.

Ideas to Copyrightable Works

However, not everything is copyrightable—far from it. Just as patent law makes a sharp distinction between ideas and their application—i.e., you cannot patent an idea for a better mousetrap but you most certainly can patent a new, non-obvious, and useful apparatus that catches mice—so, too, does copyright law differentiate between ideas and their expression. You cannot copyright, for example, the idea of an epic space opera in which a mystical cadre of Jedi knights wielding laser swords battle galactic evil, but you can copyright the particular expression of that idea in the screenplay and motion picture *Star Wars*.

Because it is an abstract concept or idea, Einstein's formula $E = MC^2$ is also not copyrightable. It is true that Einstein was the first to derive the famous formula involving mass and energy, which at first blush seems to fit the requirement for creative authorship in a copyrightable work. But the formula was derived from observation of natural physical laws, and must remain in the public domain lest private intellectual property rights create a blockade that prevents scientists and mathematicians from continuing their research and teaching.

Also noncopyrightable are names, addresses, and other known facts that are not creatively compiled. That's why a phone book cannot be copyrighted, whereas the *creative* compilation of facts in a Chinese-American phone directory listing "Bean Curd & Bean Sprout Shops" may be under certain conditions, as a judge ruled in the 1991 case *Key v. Chinatown* .

To be copyrightable, a creative work must not only be *expressed* in a tangible form that allows it to be seen or copied (i.e., put to paper or some other medium), but it must also be *original*. The requirement for originality in copyright has its parallel in the necessity for novelty in patents. But this parallel works only to a point, for a copyrighted work need not be novel in the strictest sense to be original.

As Arthur R. Miller and Michael H. Davis explain in their textbook on intellectual property for law students:

> *"The author's ideas and themes may have appeared in earlier works, Indeed, much of the expression may have been produced before. But copyright will be available to [this] second author if his is a work of independent creation."*[xiii]

To reiterate, a copyrightable work must not only fit under one of the eight broad categories of eligible subject matter, but it must also be:

- Independently created.
- Expressed or fixed on a tangible medium that can be seen or copied.
- Creatively authored or compiled.
- Not a fact or abstract idea.

Footnotes

- xii*Apple Computer, Inc. v. Franklin Computer Corp.*, 714 F.2d 1240 (3d Cir. 1983) Retrieved from http://bulk.resource.org/courts.gov/...0.82-1582.html.

- xiiiArthur R. Miller and Michael H. Davis,*Intellectual Property: Patents, Trademarks, and Copyright in a Nutshell*. (5th ed., p. 25). St. Paul MN: West Publishing Co., 2007.

SECTION OVERVIEW

13.3: Trademark Basics

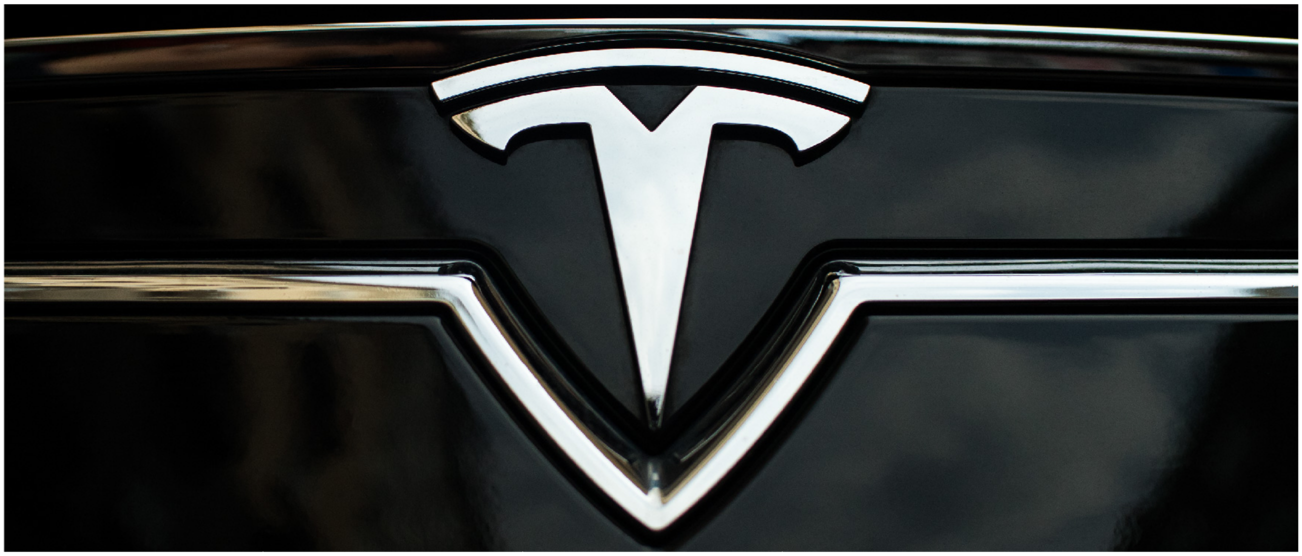


Figure 4.0.1 (credit: modification of work “Close-up of TESLA trademark sign on a car” by Ivan Radic/flikr.com, CC BY 2.0)

13.3.1: Core Concepts

Learning Objectives

After completing this section, you will be able to

- Understand trademarks and their properties.
- Identify differences between trademarks and other intellectual property rights.

A **trademark** is an intellectual property right granted by a government to an individual, business, or legal entity that creates and uses a distinctive word, name, symbol, or device to distinguish its products or services from those from any other entity in the marketplace.

The original purpose of a trademark was to indicate the origin of goods and services. Trademarks thus protected the public by preventing mistakes, confusion, or deception by those who would "palm off" their goods as those of another. But it also served to protect the market and reputation (or goodwill) of the producers of goods. As modern markets evolved, trademarks also developed into guarantees of quality as well as potent marketing and advertising devices.

Trademarks as Branding

Consider, for example, the role that Nike's "Swoosh" logo plays in its $106 billion shoe, equipment, and apparel business. In 1971, Nike founder Phil Knight paid graphic design student Carolyn Davidson a mere $35 to design the "Swoosh" logo for the fledgling new company. According to the Portland *Oregonian*newspaper, when Knight saw her design, he reportedly told her, "I don't love it, but maybe it will grow on me." Nike attorneys nonetheless registered the logo with the U.S. Patent and Trademark Office (USPTO) on June 18, 1971.[i]

Today, this one logo is estimated to be worth as much as $20 billion, and is recognized around the world as a symbol of Nike's quality workmanship and design. Indeed, its vital role in protecting Nike's market share and reputation explains why the company so strenuously protects its trademark rights from being infringed by counterfeiters. As for design student Carolyn Davidson, Phil Knight gave her Nike stock in 1983 that is today worth more than $850,000.

Trademarks vs. Other Intellectual Property Rights

Trademarks share with other intellectual property rights the power to encourage and reward creative enterprise. Trademarks also share with patent rights and copyrights the public policy goal of marshaling the benefits of creative endeavor—in this case, the distinctive branding of one's products and services from those of others—to the public good. They do this by protecting the consumer from deception and encouraging sellers to provide quality products.

But trademarks are different from other intellectual property rights in three key respects. In the first place, the legal foundation for U.S. trademark law comes not from rights expressly enumerated in the Constitution, as is the case with patent rights and copyrights. Rather, it lies in the Commerce Clause of the Constitution, which gives Congress the authority to regulate interstate commerce and enact whatever necessary and proper legislation is required to do that.

Trademarks are also different from other intellectual property rights in that they are not limited in duration. Patents and copyright are granted only for limited periods of time because society benefits by putting an invention or literary work into the public domain once the inventor or artistic creator has recouped the costs of innovation and been rewarded for the pioneering endeavor. Trademarks, however, never hinder the sales of other products or services, so they are granted in perpetuity so long as they are not abandoned by the trademark owner.

Trademarks Mean Business

Finally, trademarks exist only in conjunction with commercial activity. An inventor may receive a patent for a new invention and never employ or "practice" that invention in a business or research endeavor. Similarly, an author can receive a copyright for an original literary or artistic work and yet never publish, display, or sell it. A trademark, however, cannot exist by itself, apart from commercial activity.

Thus a trademark cannot be obtained by mere adoption. It can only be acquired through commercial use or in anticipation thereof —i.e., through the sale of goods and services.

Footnotes

- [i]Allen Brettman, “*Creator of Nike’s Famed Swoosh Remembers Its Conception 40 Years Later*,” the Oregonian, June 15, 2011.

13.3.2: Four Types of Trademarks

Learning Objectives

After completing this section, you will be able to

- Identify the four types of trademarks.
- Compare differences between types of trademarks.

Can I Trademark That?

Before reading this section, please watch the overview video below covering the four types of trademarks and what they are used for, the subject matter of trademarks, and why trademarks are important—not just to their owners, but even more so, to the general public.

The term "trademark" is usually used to describe any of the four types of marks that can be registered with the U.S. Patent and Trademark Office. The two primary types of marks are **trademarks** and **service marks**. The two other marks—**certification marks** and**collective marks**—occur much less frequently and must meet different requirements for registration.[x]

Trademarks

Trademarks identify *products*—i.e., physical goods and commodities—that are either manufactured, produced, grown, or that exist naturally. A trademark is a word, name, symbol, or device—or combination of these—used to identify and distinguish the source of that product. Examples of trademarks include the Nike "Swoosh" symbol, the arched "M" for McDonalds, and the apple symbol with a small curved bite taken out of it for Apple Computer.

Service Marks

Service marks are exactly the same in principle as trademarks except that these words, names, symbols, or devices identify and distinguish the source of a *service*. Examples of service marks include the sleek silver greyhound dog on Greyhound buses, and United Parcel Service's brown shield emblazoned with the bold yellow letters "UPS."

Certification Marks

A certification mark is any word, phrase, symbol, or design—or a combination of any of these—owned by one party that certifies the goods and services of others when they meet certain standards or requirements.[xi] A certification mark identifies either the nature of a product or service—for example, that it meets the quality standards needed to receive the "Good Housekeeping Seal of Approval"—or the**origin** of products or services, as in the certification mark "Washington State" given to apples grown in that state.

Collective Marks

Collective marks come in one of two varieties: collective trademarks and service marks, and collective membership marks. A collective trade or service mark is any word, phrase, symbol, or design that is owned by a cooperative, association, collective group, or organization and is used by its members to indicate the source of goods or services.[xii] An example of a collective trademark is the "Girl Scouts" mark seen on cookies every February, or the designation "CPA" to identify the services provided by a Certified Public Accountant.

A collective membership mark, by contrast, is used to indicate that a person is a member of some organization, such as a trade union or an association like the Rotary Club, but is not used to identify the source of goods and services.

Footnotes

- xUnited States Patent and Trademark Office. (2012, May 24). Trademarks. Retrieved from http://www.uspto.gov/inventors/trademarks.jsp
- xiUnited States Patent and Trademark Office. (2012, March 09). *What Is a Collective Membership Mark*?. Retrieved from http://www.uspto.gov/faq/trademarks.jsp#_Toc275426676
- xiiUnited States Patent and Trademark Office. (2012, March 09). Frequently Asked Questions About Trademarks. Retrieved from http://www.uspto.gov/faq/trademarks.jsp

SECTION OVERVIEW

13.4: Trade Secret Basics

Figure 5.0.1 (credit: modification of work “hush!” by Pixel Addict/flikr.com, CC BY 2.0)

13.4.1: Trade Secret Protections

Learning Objectives

After completing this section, you will be able to

- Define trade secrets.
- Identify the advantages and disadvantages of protecting intellectual property through trade secrets.

What Is a Trade Secret?

Trade secret law is a source of protection for intellectual property that serves as an alternative to patent or trademark law. Whereas patent and trademark law require that the intellectual property to be protected be publicly "disclosed" (for example, through a patent application), trade secret law requires precisely the opposite—that is, that the intellectual property to be protected *not* be publicly disclosed. The subject matter of a trade secret may be virtually any information that is of value as a result of not being generally known.

There is enormous **economic value** in trade secrets—for companies and countries. A study released in March of 2014 estimated that trade secret misappropriation costs the world's top 40 economies between 1 percent and 3 percent of their gross domestic product each year.[i]

Unlike copyright and patent law, there is no formal requirement of "novelty" or "tangibility" under trade secret law. Rather, trade secret protection is extended to information that has independent economic value by virtue of not being generally known or readily ascertainable by others, and which has been subject to reasonable efforts to avoid public disclosure.

Advantages and Disadvantages of Trade Secret Law

There are both advantages and disadvantages to protecting intellectual property through the use of trade secret law. The decision of whether to use trade secret law as opposed to other legal means of protecting knowledge or information is governed primarily by the nature of the intellectual property to be protected.

Advantages

One of the main advantages of trade secret law is that it provides indefinite future protection. Unlike the 20-year time limit that underlies the protection granted to a patent holder, there is no definite time limit placed on the protection granted to a trade secret owner. This indefinite future protection granted to trade secrets is appealing, assuming that the intellectual property to be protected is likely to remain generally unknown well into the future. For example, if the intellectual property to be protected is a method of manufacturing a product that can be determined from examining the product, then the best way to protect the new method of manufacture might be through a patent. On the other hand, if the new method of manufacturing the product cannot be determined from examination of the product, then the best way to protect the intellectual property might be to treat it as a trade secret.

Disadvantages

Although there is no definite expiration of the protection granted to trade secrets, the protection prohibits only the disclosure or use of the trade secret by one to whom the secret was disclosed in confidence. Unlike patent law, trade secret law does not offer any affirmative protection against the use of the same intellectual property that is independently derived or reverse engineered by a competitor. Consequently, if the intellectual property to be protected is a new method of manufacturing a product, and if that method of manufacture is ascertainable from an examination of the product, then the best form of protection for the intellectual property is most likely that offered by patent law.

The same analysis applies to intellectual property that is likely to be independently derived by a competitor. For as the U.S. Supreme Court noted in *Bonito Boats v. Thunder Craft Boats* ,[ii] state trade secret law has never given the holder of a trade secret protection against reverse engineering by the public or a competitor. The Supreme Court commented that in order to receive protection from reverse engineering, the holder of the intellectual property must seek the protection of federal patent law.

Pros and Cons of Trade Secret Law

Pros	Cons

Pros	Cons
Trade secret law provides indefinite future protection, so long as the trade secret stays a secret. Trade secret protection has no expiration date.	If someone came up with the same idea on their own, the trade secret is no longer protected by law.
Trade secret protection prevents the disclosure or use of the trade secret by one to whom the secret was disclosed in confidence.	Trade secret law does not give the holder of a trade secret protection from reverse engineering by the public or a competitor.

Table 5.1

Whereas patent and trademark law involve an affirmative assertion of an intellectual property right, trade secret law only actively operates after a misappropriation or threatened misappropriation of the trade secret has occurred. Due to this difference in the way trade secret law protects intellectual property, the protections given to trade secrets are largely dependent on classifications of information made by courts. Thus, the foundation and development of trade secret law in the United States is inherently tied to the statutes protecting trade secrets, and the court decisions defining and interpreting the statutory protections created for trade secrets.

Footnotes

- i“*Economic Impact of Trade Secret Theft*,” PricewaterhouseCoopers, retrieved from: http://pwc.to/1sVx3AP
- ii489 U.S. 141 (1989).

13.4.2: Elements of a Trade Secret

Learning Objectives

After completing this section, you will be able to

- Identify the key criteria used to qualify as a trade secret.
- Explain how ideas can be protected as trade secrets.

To qualify as a trade secret, the information in question must meet two essential criteria. First, the information must attain its value from the fact that it is not generally known.

Second, the owner of that information must take reasonable efforts to maintain its secrecy. Absent these two elements, information does not qualify as a trade secret and is not entitled to trade secret protections that prevent or remedy misappropriation under the UTSA.[v]

Trade secrets are not limited to particular subject matters, although the knowledge or information to be protected need not take any particular form. A trade secret can be information or knowledge in the form of a formula, pattern, compilation, program, device, method, technique, or process. Although the UTSA defines what may be a trade secret, various courts interpreting the UTSA have come to different conclusions on what type of material should be considered a trade secret. For example, whereas courts have found that an insurer's database is a trade secret under Wisconsin law, a similar database was found not to be a trade secret in Rhode Island.[vi]

The Value of Secrets

For information or knowledge in any of the above forms to be considered a trade secret, it must derive independent economic value because it is not generally known to, nor readily ascertainable by, other persons who can profit from its disclosure or use. Some examples of information courts have found to be trade secrets include computer software, sales information, customer information, and manufacturing formulas. However, merely because information is not known to the public does not necessarily make the information a trade secret. For example, information that is not generally known by the public but is known by different manufacturers in the same industry likely does not qualify as a trade secret.[vii]

Material that is ascertainable through public sources generally does not derive independent economic value justifying trade secret protection. If the information in question cannot be quickly or easily ascertained from examining or testing the publicly available product, then it is more likely to be a trade secret.[viii] Conversely, if the information may be discovered through public observation of the product or the company's displays, it is unlikely to be a trade secret.[ix] For example, customer lists are not considered trade secrets when the identity of the customers could potentially be discovered through public sources. However, identical information if not available through public sources could constitute a trade secret.[x]Additionally, processes or systems that are simply a compilation of known information generally do not rise to the level of trade secrets. The courts, however, are still quite divided on this issue.

Protecting Ideas as Trade Secrets

In addition to information, certain ideas may constitute trade secrets. Although ideas were not protected as trade secrets under common law, the UTSA provides protection for certain novel and concrete ideas. For example, remedies for misappropriation of an idea may be permitted based on the existence of a confidential relationship. The elements that must be proven under this common theory are: (1) a novel or original idea; (2) reduced to concrete form; (3) disclosed to the defendant in a confidential relationship, i.e., one in which it would be implied that use would not be made without compensation; and, (4) used by the defendant.

Protection of an idea may also be permitted on the basis of a contractual relationship with the defendant. Parties may enter into a contract to protect an idea being submitted or disclosed to another person or company. The major benefit of a contract to the submitter of an idea is evidence of a protected disclosure that is deserving of trade secret protections. The major benefit of a contract to the recipient of an idea is the establishment of the ground rules under which compensation, if any, will be payable to the submitter.

Corporations that receive unsolicited ideas many times grapple with how to best protect use of those unsolicited ideas. To protect themselves from the uncertainties of trade secrets law, the idea must be converted from an unsolicited idea to a solicited idea. This may be accomplished by contacting the submitter and alerting them that the idea will be considered only with the understanding that the use of the idea, and decisions regarding compensation for that idea, rest solely with the corporation.

Whether the trade secret takes the form of information or an idea, the owner of that trade secret must show not only that the trade secret was not generally known or readily ascertainable, but also that the lack of general knowledge of the trade secret conferred some value to the owner. When the owner derives a profit from licensing the use of the protected information, the value to the owner is quite apparent. However, in cases where the owner is seeking to show he was injured in the marketplace or through the loss of profits after costly research and development, the value may only become apparent by inference. But even if information is not generally known and gives the owner some value, the information is not a trade secret unless the owner takes steps to protect the secrecy of the information.

Footnotes

- vThe UTSA defines a trade secret as "information, including a formula, pattern, compilation, program, device, method, technique, or process, that (i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain value from its disclosure or use, and (ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy."
- viCompare *American Fam. Mut. Ins. Co. v. Roth* 485 F.3d 930, 933 (7th Cir. 2007); *APG Inc. v. MCI Telecommunications Corp.* 436 F.3d 294, 307 (1st Cir 2006).
- viiSee e.g. *Ruckelshaus v. Monsanto Co.*, 467 U.S. 986, 1002 (1984); *Speedry Chemical Products, Inc. v. Carter's Ink Co.*, 306 F.2d 328, 331 (2d Cir 1962).
- viiiSee *Morlife, Inc. v. Perry*, 56 Cal. App. 4th 1514 (1st Dist. 1997).
- ixSee *MicroStrategy Inc. v. Business Objects*, S.A., 331 F. Supp. 2d 396,417 (E.D. Va. 2004).
- xCompare *Inflight Newspapers, Inc. v. Magazines In-Flight, LLC,* 990 F. Supp. 119, 129-30 (E.D.N.Y. 1997) (holding that the plaintiff's customer lists were not trade secrets because the customer identity could be easily found through publicly available means, such as the Internet, trade shows, and trade directories) with *North Atl. Instruments, Inc. v. Haber*, 188 F.3d 38, 44 (2d Cir. N.Y. 1999) (finding that a customer list kept in confidence may be treated as a trade secret).

CHAPTER OVERVIEW

14: Future Trends in Information Systems

Learning Objectives

Upon successful completion of this chapter, you will be able to:

- Describe future trends in information systems.

This final chapter will present an overview or advances of some of the new or recently introduced technologies. From wearable technology, virtual reality, Internet of Things, quantum computing to artificial intelligence, this chapter will provide a look forward to what the next few years will bring to potentially transform how we learn, communicate, do business, work, and play.

14.1: Introduction

Information systems have evolved at a rapid pace ever since their introduction in the 1950s. Today, devices that we can hold in one hand are more powerful than the computers used to land a man on the moon. The Internet has made the entire world accessible to people, allowing us to communicate and collaborate like never before. In this chapter, we will examine current trends and look ahead to what is coming next.

14.1.1: Global

The first trend to note is the continuing expansion of globalization due to the commercialization of the internet. The use of the Internet is growing worldwide, and with it, the use of digital devices. All regions are forecasted for significant growth, with some regions higher than others, such as Asia and Latin America.

The United Nations June 2020 "Report of the Secretary-General Roadmap for Digital Cooperation" reports that 86.6% of people in the developed countries are online, while only 19% people are online in the least developed countries, with Europe being the region with the highest usage rates and Africa with the lowest usage rate.

Chapter 11 discussed that by Q3 of 2020, approximately 4.9 billion people, or more than half of the world's population, use the internet and forecast growth of 1,266% for the world total, with Asia being the highest 2136%, Latin America at 2489%. The smallest growth is still forecasted over 200% growth. For more details, please view the data at https://internetworldstats.com/stats.htm.

14.1.2: Social Media

Social media is one of the most popular internet activities worldwide. DataReportal (2023) reports that there are now **4.76 billion** social media users around the world, equating to just under **60 percent** of the total global population.

As of October 2023, Statista.com also reports that Facebook remains the most popular social network globally with about 3.03B monthly active users, YouTube with 2.5B, WhatsApps and Instagram with 2B, WeChat at 1.3B, Instagram at 1.1B, TikTok at 1.2B, and X/Twitter at 666M etc. For more details, please view this report at Statista.com.

14.1.3: Personalization

With the continued increased usage of the internet and e-commerce, users have moved beyond the simple, unique ringtones on mobile phones. They now expect increased personalized experience in the products or services, entertainment, and learning, such as highly targeted, just-in-time recommendations that are finely tuned with their preferences from vendors' data. For example, Netflix recommends what shows they might want to watch. Wearable devices from various vendors such as Apple, Google, Amazon make personalized recommendations for exercises, meditation, diet, among others, based on your current health conditions.

14.1.4: Mobile

Perhaps the most impactful trend in digital technologies in the last decade has been the advent of mobile technologies. Beginning with the simple cell phone in the 1990s and evolving into the smartphones and tablets of today, mobile growth has been overwhelming.

Smartphones were introduced in the 1990s. This new industry has exploded into a trillion-dollar industry with $484B spent on smartphones, $176B in mobile advertising, $118B in Apps, $77B in accessories, $25B in wearables (Statista, 2020.) For more details, please view The Trillion-Dollar Smartphone Economy.

14.1.5: Wearables

The wearable market, which is now a $25B economy, includes specific-purpose products such as fitness bands, smart socks, eyewear, hearing aids. We are now seeing a convergence in general-purpose devices such as computers and televisions and portable devices such as smartwatches and smartphones. It is also anticipated that wearable products will touch different aspects of consumers' life. For example, smart clothing such as Neviano smart swimsuits, Live's Jacquard jacket (Lifewire, 2020),

Advances in artificial intelligence, sensors, and robotics will expand to wearables for front-line workers such as Exoskeletons such as Ekso's EVO to assist workers who have to carry heavy weight items such as firefighters, warehouse workers, or to health industries to provide mobility for people who are limited in mobility.

14.1.6: References

Kempt, Simon. *Digital 2023: Global Overview Report*. Retrieved August 1, 2023 from Datareportal.com.

EVO is designed to provide power without pain. Retrieved December 10, 2020, from https://eksobionics.com/ekso-evo/.

Statista. Most popular social networks worldwide as of October 2023, ranked by number of monthly active users. Retrieved November 1, 2023 from Statista.com.

Statista. *The Trillion-Dollar Smartphone Economy (2019).* Retrieved December 11, 2020, from Statista.com.

Lifewire. *The 7 Best Smart Clothes of 2020.* Retrieved December 11, 2020, from https://www.lifewire.com/best-smart-clothes-4176104.

Report of the Secretary-General Roadmap for Digital Cooperation (June 2020.) Retrieved December 11, 2020, from un.org.

World Internet Usage and Population Statistics 2020 Year-Q3 Estimates (2020). Retrieved December 11, 2020, from internetworldstat.com.

14.2: Collaborative

14.2.1 Collaborators as free content-providers

Internet usage has continued to give rise to the collaborative effort among consumers and businesses worldwide. Consumers have gained influence by sharing reviews of products and services. It is common for people to look up other people's reviews before buying a product, visiting restaurants via sites such as Yelp, instead of believing the information from vendors directly. Businesses have leveraged consumers' collaboration to contribute to the content of a product. For example, the smartphone app Waze is a community-based tool that keeps track of the route you are traveling and how fast you are making your way to your destination. In return for providing your data, you can benefit from the data being sent from all other app users. Waze will route you around traffic and accidents based upon real-time reports from other users. These businesses rely on users spending their free time to write free reviews to be shared with other people in these examples. In essence, they monetize people's time and content.

14.2.2 Shared economy collaborators

New types of companies such as Airbnb and Uber incorporate consumers into their business model and share a fraction of the revenues. These companies monetize everyday person's owned assets. For example, Airbnb uses its technology platform to rent out rooms, houses to people by people who actually own these assets. Uber popularized the gig economy by having people use their own cars as drivers. This trend is expected to continue and expand in other industries such as advertising.

14.2.3 Telecommunication

14.2.3.1 Personal communication

Video communication technologies such as Voice-over-IP (VoIP) have given consumers a means to communicate with each other for free instead of paying for expensive traditional phone lines through free services such as Microsoft Skype and[1]WhatApp The combined use of smartphones, VoIP, more powerful servers, among others, have made landlines outdated and expensive. By 2019, the number of landlines had decreased to less than 40% from 90% in 2004 (Statista.com, 2019.)

14.2.3.2 Entertainment

The above trend continues to affect other industries, such as the consumers' exodus of cable services or pay-TV to streaming services, a phenomenon called 'cutting the cord' due to the rise of companies such as Netflix and Hulu. By 2022, it is estimated that the number of households not paying for TV services in North America will grow to around 55.1 million (Statista.com, 2019). The convergence of TV, computers, and entertainment will continue as technologies become easier to use and the infrastructure such as 5G networks, to deliver data becomes faster.

14.2.4 Virtual environment

14.2.4.1 Tele-work

Telecommuting has been a trend that ebbs and flows as companies experiment with technologies to allow their workers to work from home. However, with the Covid-19 pandemic, telecommuting became essential as people worldwide worked from home to comply with national or regional stay-at-home orders. The debate over the merit of telework has been set aside, and its adoption spread to many industries that have eschewed this use of technology. For example, therapy counseling, medical visits with primary care providers can now be done remotely. The Post-pandemic work environment may not necessarily be the same as it was. Now, organizations have gained valuable insights about having most, if not all, of their entire workforce work from home. In one year, Zoom, the name of a relatively unknown company providing video communications, became a household word, gaining 37% in usage rate, with Microsoft Teams trailing at 19%, Skype at 17%, Google Hangouts at 9%, and slack at 7% (Statista, 2020)

14.2.4.2 Immersion - virtual reality

Tele-work allows us to see other people while we remain in our physical world. Virtual reality (VR) gives us a perception of being physically in another world. Research in building VR has been going on since the 1990s or even earlier. One example is CAVE2, also known as the Next-Generation CAVE (NG-CAVE), a research project funded by the National Science Foundation in 1992 to allow researchers to 'walk around in a human brain or fly on Mars, etc.". Please watch this video on YouTube or search for the phrase with the keyword 'CAVE2' for more details.

Technologies are not yet mature enough to give us a 100% immersive experience. They may be good enough for some products recently on a smaller scale in gaming or training. For example, if we use a VR goggle to play a game, we become a character. The same technology can be used in training for police officers.

Figure 14.2.1: A woman using the Manus VR glove development kit in 2016. (CC BY-SA 4.0; Manus VR via Wikipedia)

14.2.5 3D Printing

3D printing completely changes our current thinking of what a printer is or the notion of printing. We typically use printers to print reports, letters, or pictures on physical papers. A 3-D printer allows you to print virtually any 3-D object based on a model of that object designed on a computer. 3-D printers work by creating layer upon layer of the model using malleable materials, such as different types of glass, metals, wax, or even food ingredients

3-D printing is quite useful for prototyping the designs of products to determine their feasibility and marketability. 3-D printing has also been used to create working prosthetic legs or handguns. Icon can print a 500sqt home in 48 hours for $10,000. NASA wants to print pizzas for astronauts, and we can now print cakes too. In 2020, The US Air Force produces the first 3D-printed metal part for aircraft engines.

This technology can potentially affect the global value chain to develop products, and entrepreneurs can build prototypes in their garage or provide solutions to some social challenges. For example, producing a prototype of a 3D object for research and engineering can now be done in-house using a 3D printer which speeds up the development time. Tiny homes can be provided at a fraction of a cost of a traditional home.

With the rising need from consumers for more personalization (as discussed earlier), this technology may help businesses deliver on this need through shoes, clothing, and even 3D printed cars.

14.2.6 References

CAVE2 immerses scientists and engineers in their research -- literally! - Science Nation (2013). Retrieved December 10, 2020, from https://www.youtube.com/watch?v=kjAviW2alpA.

I Printed a 3D Gun (2013). Retrieved December 10, 2020, from https://mashable.com/2013/06/02/3d-printed-gun/.

NASA astronauts may soon be able to 3D-print pizzas in space (2017). Retrieved December 11, 2020, fromhttps://www.zdnet.com/article/nasa-astronauts-may-soon-be-able-to-3d-print-pizzas-in-space/.

Printed homes (2018). Retrieved December 11, 2020, from https://www.iconbuild.com/hom.

US Air Force produces the first 3D-printed metal part for aircraft engines (2020.) Retrieved December 11, 2020, from https://www.flightglobal.com/fixed-wing/us-air-force-produces-first-3d-printed-metal-part-for-aircraft-engines/139643.article.

Statista. Cord Cutting (2019). Retrieved December 11, 2020, from https://www.statista.com/topics/4527/cord-cutting/.

Statista. Most used collaboration tools used for remote work in the United States in 2020. Retrieved December 10, 2020, from https://www.statista.com/statistics/1123023/top-collaboration-tools-for-remote-workers-in-the-us/.

14.3: Internet of Things (IoT)

Rouse (2019) explains that IoT is implemented as a set of web-enabled physical objects or things embedded with software, hardware, sensors, processors to collect and send data as they acquire from their environments. A 'thing' could be just about anything, a machine, an object, an animal, or even people as long as each thing has an embedded unique ID and is web-enabled.

In a report by McKinsey & Company on the Internet of Things (Chui et al., 2010), six broad applications are identified:

- **Tracking behavior**. When products are embedded with sensors, companies can track these products' movements and even monitor interactions with them. Business models can be fine-tuned to take advantage of this behavioral data. Some insurance companies, for example, are offering to install location sensors in customers' cars. That allows these companies to base the price of policies on how a car is driven and where it travels.
- **Enhanced situational awareness**. Data from large numbers of sensors, for example, in infrastructure (such as roads and buildings), or to report on environmental conditions (including soil moisture, ocean currents, or weather), can give decision-makers a heightened awareness of real-time events, particularly when the sensors are used with advanced display or visualization technologies. Security personnel, for instance, can use sensor networks that combine video, audio, and vibration detectors to spot unauthorized individuals who enter restricted areas.
- **Sensor-driven decision analysis**. The Internet of Things also can support longer-range, more complex human planning and decision making. The technology requirements – tremendous storage and computing resources linked with advanced software systems that generate various graphical displays for analyzing data – rise accordingly.
- **Process optimization**. Some industries, such as chemical production, are installing legions of sensors to bring much greater granularity to monitoring. These sensors feed data to computers, which in turn analyze the data and then send signals to actuators that adjust processes – for example, by modifying ingredient mixtures, temperatures, or pressures.
- **Optimized resource consumption**. Networked sensors and automated feedback mechanisms can change usage patterns for scarce resources, such as energy and water. This can be accomplished by dynamically changing the price of these goods to increase or reduce demand.
- **Complex autonomous systems.** The most demanding use of the Internet of Things involves the rapid, real-time sensing of unpredictable conditions and instantaneous responses guided by automated systems. This kind of machine decision-making mimics human reactions, though at vastly enhanced performance levels. The automobile industry, for instance, is stepping up the development of systems that can detect imminent collisions and take evasive action.

IoT has evolved since the 1970s, and by 2023 it is now most associated with smart homes. Products such as smart thermostats, smart doors, lights, home security systems, home appliances, etc. For example, Amazon Echo, Google Home, Apple's HomePod are smart home hubs to manage all the smart IoT in the home. IoT applications have expanded to include smart watches, fitness trackers, smart appliances, virtual assistants, self-driving cars, and even smart cities with connected infrastructure and services.

14.3.1: Autonomous

A trend that is emerging is autonomous robots and vehicles. By combining software, sensors, and location technologies, devices that can operate themselves to perform specific functions are being developed. These take the form of creations such as medical nanotechnology robots (nanobots), self-driving cars, self-driving trucks, drones, or crewless aerial vehicles (UAVs).

A nanobot is a robot whose components are on a nanometer scale, which is one-billionth of a meter. While still an emerging field, it is showing promise for applications in the medical field. For example, a set of nanobots could be introduced into the human body to combat cancer or a specific disease. In March of 2012, Google introduced the world to their driverless car by releasing a video on YouTube showing a blind man driving the car around the San Francisco area (or search for "Self-Driving Car Test: Steve Mahan). The car combines several technologies, including a laser radar system, worth about $150,000.

By 2020, 38 states have enacted some legislation allowing various activities from conducting studies, limited pilot testing, full deployment of commercial motor vehicles without a human operator; The details can be found at ghsa.org.

The Society of Automotive Engineers (SAE, 2018) has designed a zero to five rating system detailing the varying levels of automation — the higher the level, the more automated the vehicle is.

- Level Zero: No Automation – The driver does all the driving without any help from the vehicle
- Level One: Driver Assistance – The vehicle helps steer or speed up/slow down, but the driver still does the driving.
- Level Two: Partial Automation – The vehicle helps with one or more systems, but the driver still does the driving.

- Level Three: Conditional Automation – The vehicle helps with steering and brake/acceleration, but the driver still needs to monitor, can intervene as necessary still sitting in the driver seat.
- Level Four: High Automation – The vehicle completes all driving duties even if the driver does not intervene in limited conditions (i.e., local taxis)
- Level Five: Full Automation – The vehicle completes all duties without a driver on all roads in all conditions.

Consumers have begun seeing the features in levels 1 and 3 being integrated with today's non-autonomous cars, and this trend is expected to continue.

A UAV often referred to as a "drone," is a small airplane or helicopter that can fly without a pilot. Instead of a pilot, they are either run autonomously by computers in the vehicle or operated by a person using a remote control. While most drones today are used for military or civil applications, there is a growing market for personal drones. For a few hundred dollars, a consumer can purchase a drone for personal use.

Commercial use of UAV is beginning to emerge. Companies such as Amazon plan to deliver their packages to customers using drones, Walmart plans to use drones to carry things in their stores. This sector is forecasted to become a $12.6B worldwide market by 2025 (Statista.com, 2019).

- This video takes you for a drive in Tesla's autopilot mode.: How Tesla'sAuto-pilot Mode Work (2023) [video file: 13:46 minutes] Closed Captioned

14.3.2: References:

Autonomous Vehicles. Retrieved December 10, 2020, from https://www.ghsa.org/state-laws/issues/autonomous%20vehicles.

Chui, M. and Roberts R (2010, March 1). *The Internet of Things*. Retrieved December 10, 2020, from https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-internet-of-things.

Rouse, Margaret (2019). *Internet of things (IoT).* IoT Agenda. Retrieved December 11, 2020, from https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT.

SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles (2018). Retrieved December 10, 2020, from https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles.

Statista. *Commercial Drones are Taking Off (2019).* Retrieved December 11, 2020, from https://www.statista.com/chart/17201/commecial-drones-projected-growth/.

14.4: Future of Information Systems

14.4.1: Quantum computer

Some of these concepts require me to go into a little more technical details to explain the concept.

Let's go over essential key terms you should know related to quantum computer.

> **Definition: Terms**
>
> **Qubit** - The basic unit of information in a quantum computer. Unlike binary bits, qubits can represent a 0, 1, or a superposition of both states at the same time due to the quantum mechanical phenomenon of superposition.
>
> **Superposition** - The ability of a quantum system like a qubit to exist in multiple states simultaneously. This allows qubits to represent both 0 and 1 at the same time.
>
> **Entanglement** - When two qubits become correlated such that the state of one qubit affects the state of the other, even when separated by large distances. This enables quantum parallelism.
>
> **Quantum Parallelism** - The ability of a quantum computer to evaluate multiple computational paths in parallel, calculating on all possibilities simultaneously.
>
> **Interference** - The cancellation of probabilities that occurs when qubits are measured, collapsing superposition states to a single state. Both constructive and destructive interference occur.
>
> **Quantum Algorithm** - An algorithm designed to run on a quantum computer harnessing properties like superposition and entanglement to solve problems faster than classical algorithms.
>
> **Quantum Supremacy** - The point at which a quantum computer can solve a problem that is practically impossible for a classical computer in a reasonable amount of time.

Today's computers use bits as data units. A bit value can only be either 0 or 1, as we discussed in Chapter 2. Quantum computers use qubit, which can represent a combination of both 0 and 1 simultaneously, leveraging the principles of quantum physics. Superposition is a fundamental property of quantum mechanics where a quantum system can exist in multiple states simultaneously. This means a quantum bit or qubit can represent a 0 and 1 at the same time, unlike a classical binary bit which can only be in a single 0 or 1 state. Superposition is what gives quantum computers their ability to perform calculations on multiple possibilities in parallel, enabling powerful computational capabilities not possible with regular bits alone. The concept of superposition contrasts with our everyday experience where objects exist in only one state at a time. But at the quantum scale, particles behave according to the strange rules of quantum mechanics, allowing counterintuitive phenomena like superposition.

This is a game-changer for computing and will disrupt all aspects of information technology. The benefits include a significant speed increase in calculations that will enable solutions for unsolvable problems today. However, there are many technical problems to be solved yet since all the IS elements will need to be re-imagined. Google announced the first real proof of a working quantum computer in 2019 (Menard, et al., 2020). Menard et al. also indicated that the industries that would benefit from this new computer type would be industries with complex problems to solve, such as pharmaceutical, autonomous vehicles, cybersecurity, or intense mathematical modeling such as Finance, Energy. For a full report, please visit McKinsey.com.

Example: A problem that cannot be solved with today's problem but can by Quantum computer

Factoring very large numbers

> Factoring is the process of breaking down a composite number into its smaller constituent prime numbers.
>
> The number 60 is a composite number that can be factored into its prime constituents:
>
> 60 = 2 x 2 x 3 x 5
>
> So the prime factors of 60 are: 2, 2, 3, and 5.
>
> Factoring breaks down a larger composite number into the smaller prime numbers that multiply together to make that composite number. This process reveals the smallest constituent parts of a number.

Classical computers can factor smaller numbers efficiently but have trouble factoring large prime numbers. For example, factoring a number with over 200 digits would take longer than the universe's age on even the most powerful supercomputers today.

However, a quantum computer with enough stable qubits could theoretically factor such a large number efficiently in minutes or hours. This is because quantum computing harnesses the ability of qubits to represent 0 and 1 simultaneously to perform calculations on all possible factors in parallel.

Whereas normal bits can only represent 0 or 1, qubits can represent a superposition of both states at once. This allows quantum computers to solve problems with a vast number of variables much faster than checking each possibility sequentially like classical computers.

Large number factoring is relevant for cryptography, where the security of widely used schemes depends on the difficulty of factoring large prime numbers. Quantum computers could upend modern cryptography.

Quantum computing's exponential parallelism enabled by qubits in superposition provides capabilities far beyond binary bits, allowing problems to be solved that are impossible or impractical with classical computing. Factoring large primes is one example highlighting the quantum advantage.

While Quantum has begun to apply to practical solutions, it still has a long way to go before it can deploy to the mass, according to Intel, one of the leading chip manufacturer.

14.4.2: Blockchain

Definition: Essential Blockchain-related Terms

Blockchain - A distributed ledger technology that records transactions in immutable, linked blocks that are secured using cryptography.

Distributed Ledger - A database that is shared, replicated, and synchronized among multiple participants across a decentralized peer-to-peer network.

Block - containers that carry transactions, timestamps, and reference the previous block via a cryptographic hash. Chained together to create the blockchain.

Node - Any computer connected to the blockchain network that stores and verifies blocks and transactions.

Mining - The process where nodes compete to validate transactions and create new blocks, for which they earn cryptocurrency rewards.

Cryptography - Encryption techniques used in blockchain to secure data through cryptographic hash functions and digital signatures.

Consensus - Method for nodes in a blockchain network to agree on the legitimate state of the ledger. Common algorithms include proof-of-work and proof-of-stake.

Smart Contracts - Self-executing lines of code that run on a blockchain when predetermined conditions are met.

A blockchain is a set of blocks or a list of records linked using cryptography to record a transaction and track assets in a network. Anything of value can be considered an asset and be tracked. Examples include a house, cash, patents, a brand. Once a transaction is recorded, it cannot be changed retroactively. Hence, it is considered highly secured.

Blockchain has many applications, but bitcoin is mostly associated with it because it was the first application using blockchain technology. Sometimes bitcoin and blockchain are mistakenly meant to be the same thing, but they are not.

Bitcoin is digital money or a cryptocurrency. The crypto market grew to over $3 trillion in late 2021, led by Bitcoin and Ethereum. Emerging uses of blockchain include NFTs (non-fungible tokens) for digital art and collectibles, as well as Metaverse and Web3 applications. It is an open-source application built using blockchain technology. It is meant to eliminate the need for a central bank since people can directly send bitcoins. Simply put, bitcoin keeps track of a list of who sends how many bitcoins to another person. One difference with today's money is that a bitcoin's value fluctuates since it works like a stock. Anyone can buy different bitcoin cryptocurrencies or other cryptocurrencies on bitcoin exchanges such as Coinbase. Bitcoin and other cryptocurrencies are accepted by a few organizations such as Wikimedia, Microsoft, Wholefoods. However, bitcoin's adoption is still uncertain. If the adoption by major companies is accelerated, then banking locally and globally will change significantly.

Some early businesses have begun to use blockchain as part of their operations. Kroger uses IBM blockchain to trace food from the farms to its shelves to respond to food recalls quickly (IBM.com.) Amazon Managed Blockchainis a fully managed service that makes it easy to create and manage scalable blockchain networks.

Example: Kroger uses IBM Blockain

Kroger uses the IBM Food Trust blockchain solution to trace food products across its complex supply chain. This provides enhanced traceability from farm to store shelf.

For example, Kroger can track fresh produce like lettuce from the grower, through processing facilities, distribution centers, and finally to the grocery shelf. At each stage, data like timestamps, locations, temperatures etc. are recorded on the immutable blockchain ledger.

If there is ever a foodborne illness outbreak, Kroger can use the Food Trust data to quickly identify the source. They can trace back the contaminated lettuce to the exact farm, batch, and date. This enables targeted recalls to remove only affected product vs. clearing entire shelves.

In the past, tracing items back through the supply chain was slow, difficult, and imprecise. The transparency and speed enabled by the blockchain allows Kroger to pinpoint issues and reduce waste. This improves food safety while also reducing costs and maintaining customer trust.

So why can't today's computer achieve the same thing for Kroger?

Here are a few reasons why it is challenging for today's system to provide the end-to-end traceability that a blockchain solution can.

- Centralized systems - Typical supply chain databases are fragmented across different companies and centralized within each entity. There is no complete visibility across the full chain.
- Lack of transparency - Participants like suppliers and distributors don't have access to the same data, which inhibits transparency.
- Manual processes - Tracking often involves manual paperwork, spreadsheets, scanned documents etc. that can be error-prone.
- Lack of trust - Suppliers may be hesitant to share sensitive data with competitors under traditional systems.
- Difficult to trace - With no unified ledger, tracing back a contaminated item across multiple nodes is extremely challenging and time consuming.
- Data silos - Information lives in organizational silos, making it hard to connect data across the entire supply network.
- Vulnerable to fraud - Centralized databases can be more easily manipulated without the immutable, cryptographically-secured records of a blockchain.

The decentralized, transparent, and cryptographically-verified nature of blockchains overcomes many of the shortcomings of traditional supply chain tracking systems. This enables the end-to-end traceability needed for food safety and recall situations.

14.4.3: Artificial Intelligence (AI)

Artificial intelligence (AI) comprises many technologies to duplicate the functions of the human brain. It has been in research since the 1950s and has seen an ebb and flow of interest. AI has advanced rapidly in recent years, though the goal of duplicating all facets of human cognition remains elusive.

To understand and duplicate a human brain, AI is a complex interdisciplinary effort that involves multiple fields such as computer science, linguistics, mathematics, neuroscience, biology, philosophy, and psychology. One approach is to organize the technologies as below, and commercial solutions have been introduced:

- **Robotics**: Advances in sensorimotor skills allow robots to perform manual tasks with greater precision, safety, and adaptability. However, costs remain prohibitive for many applications.this trend is more recent even though it has been in research for decades. Robots can come in different shapes, such as a familiar object, an animal, or a human. It can be tiny or as big as it can be designed:

    A nanobot is a robot whose components are on the scale of about a nanometer.

    A robot with artificial skins to look like a human is called a humanoid. They are being deployed in limited situations such as assistants to police, senior citizens who need help, etc. Two popular robots are Atlas from Boston Dynamic and humanoid Sophia from Hanson Robotics.

    Consumer products such as the smart vacuum iRobot Roomba are now widely available. The adoption of certain types of robots has accelerated in some industries due to the pandemic: Spot, the dog-like robot from Boston dynamics, is used to patrol for social distancing.

Figure 14.4.1: Sophia, First Robot Citizen at the AI for Good Global Summit 2018. Image by ITU Pictures is licensed under CC BY 2.0

- **Natural language processing**: Systems like ChatGPT demonstrate impressive conversational abilities and knowledge, though remain limited in reasoning and common sense compared to humans.
- **Computer vision**: AI can identify and categorize images, detect anomalies, read documents, and more at high accuracy. Applications include manufacturing, medicine, and self-driving cars.
- **AI generated content**: Models like DALL-E 2 and Stable Diffusion create synthetic imagery and art from text prompts with increasing sophistication. Legal and ethical questions persist around originality and ownership.

- **Algorithmic trading**: AI performs high-speed analytics of news and market data to automate stock trading, often faster than human traders. Concerns include overreliance and flash crashes.
- **Neural networks:** Neural networks are a class of machine learning algorithms modeled loosely after the human brain's network of neurons. They have seen significant advances in recent years. Neural networks enable AI systems to infer knowledge from data, learn from experience, and perform human-like cognitive functions. They remain an active research field as we pursue more advanced AI capabilities. Key innovations include:
    - Deep learning neural nets with many layers that can extract complex patterns from large datasets. Applications include image and speech recognition.
    - Spiking neural networks that mimic biological neuron spikes more closely. They are computational efficient for tasks like pattern recognition.
    - Generative adversarial networks (GANs) comprising two neural nets competing against each other to generate new content. Used for image and video generation.
    - Recursive neural networks that apply the same set of weights recursively over a structured input like a graph. Used in natural language processing.
    - Neuromorphic hardware like GPUs tailored to massively parallel neural net computations. This specialized hardware trains networks faster.
    - An example: This is a collection of hardware and software technologies. The hardware includes wearable devices that allow humans to control machines using thoughts such as Honda Motor’s Brain-Machine Interface. This is still in the research phase, but its results can impact many industries such as healthcare.

The goal of 100% duplicating a human brain has not been achieved yet since no AI systems have passed the Alan Turing test known as Turing Test to answer the question 'Can a machine think?" Alan is widely considered a founder of the AI field and devises a test to a machine's ability to show the equivalent intelligent behavior to that humans. The test does not look for correct answers but rather answers closely resemble those a human would give.

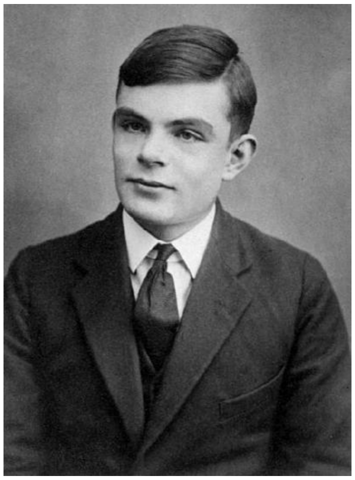


Figure 14.4.2 Alan Turing Aged 16. Image is licensed Public Domain

Even though AI has not been able to duplicate a human brain yet, its advances have introduced many AI-based technologies such as AI bot, robotics in many industries. AI progress has contributed to producing many practical business information systems that we discussed throughout this book such as, voice recognition, cameras, robots, autonomous cars, etc. It has also raised concerns over how ethical is the development of some AI technologies as we discussed in previous chapters.

Advances in artificial intelligence depend on the continuous effort to collect vast amounts of data, information, and knowledge, advances in hardware, sophisticated methods to analyze both unconnected and connected large datasets to make inferences to create new knowledge, supported by secured, fast networks.

AI has advanced rapidly, with innovations like DeepMind's AlphaFold for protein folding, AI generated art and content, and natural language models like ChatGPT demonstrating new capabilities.

Now, in 2023, we have the first AI robot as the world's words 1st Experiental CEO. Meet Mika the CEO in this video.

14.4.4: References

Boston Dynamics' dog-like robot Spot is being used on coronavirus social distancing patrol (2020). Retrieved December 13, 2020, from https://www.cnbc.com/2020/05/15/boston-dynamics-dog-like-robot-spot-used-on-social-distancing-patrol.html.

Changing your idea of what robots can do. Retrieved December 13, 2020, from https://www.bostondynamics.com/.

Honda's Brain-Machine Interface: controlling robots by thoughts alone (2009). Retrieved December 11, 2020, from https://newatlas.com/honda-asimo-brain-machine-interface-mind-control/11379/#:~:text=Honda%20Research%20Institute%2C%20Japan%2C%20has,using%20nothing%20more%20than%20thought.&text=Then%2C%20the%20doors%20will%20be,and%20act%20directly%20upon%20them.

Kroger uses IBM Blockchain technology for farm to fork food traceability. Retrieved December 11, 2020, from https://mediacenter.ibm.com/media/Kroger+uses+IBM+Blockchain+technology+for+farm+to+fork+food+traceability/0_527q9xfy.

Menard A., Ostojic I., and Patel M. (2020, February 6). *A game plan for quantum computing*. Retrieved December 10, 2020, from https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/a-game-plan-for-quantum-computing.

The Journey to Building a True Quantum Computer (November 2022). Retrieved August 1, 2023, from intel.com.

The smarter AI assistant for business. Retrieved December 11, 2020, from https://www.ibm.com/cloud/watson-assistant-2/

14.5: Summary

Information systems continue advancing at an exponential pace, bringing emerging technologies with new capabilities and disruptions. Several accelerating trends are colliding, including ubiquitous connectivity, vast data generation, improved infrastructure, and new analytics techniques.

Key innovations highlight the technological horizons ahead. Quantum computing promises new computational power by leveraging quantum bits and phenomena like superposition. Blockchain facilitates decentralized, transparent digital transactions and asset tracking. Artificial intelligence is automating cognitive tasks in diverse domains through innovations in machine learning. The Internet of Things embeds connectivity and intelligence into devices and infrastructure.

Adoption of these advances is spreading rapidly. However, prudent governance is required to ensure ethical alignment and responsible innovation. By thoughtfully integrating breakthroughs, organizations can enhance products, services and decisions. But wisdom must accompany technological ingenuity to craft an equitable digital future benefitting all. This chapter illuminated information systems' emerging landscape so we can proactively shape tomorrow.

14.6: Study Questions

❓ Study Question 14.6.1

What are some key global Internet usage trends?

Answer

Internet usage continues growing worldwide, with Asia forecast to see the highest growth at over 2000%. Social media usage is also rising globally, with over 60% of the world using social platforms.

❓ Study Question 14.6.2

How has mobile technology impacted society?

Answer

Mobile technologies like smartphones and tablets have deeply transformed how we communicate, access information, work, and live. The mobile industry has exploded into a trillion-dollar space.

❓ Exercise 14.6.3

What are some examples of wearable technologies?

Answer

Wearables include devices like fitness trackers, smartwatches, smart clothing, hearing aids, and exoskeletons to assist workers. These are converging with mobile tech and becoming more versatile.

❓ Study Question 14.6.4

What are some differences between virtual reality and telework?

Answer

Telework allows remote interaction but users remain in the physical world. Virtual reality aims to give an immersive simulated experience and perception of being in another environment.

❓ Study Question 14.6.5

What are some examples of virtual reality technologies?

Answer

Virtual reality aims to create an immersive simulated experience and perception of being in another environment. Examples include multi-screen CAVE simulations and VR goggles/headsets.

Study Question 14.6.6

What are some examples of collaborative technologies?

Answer

Examples include crowdsourced review sites, ridesharing platforms like Uber that tap into the shared economy, and video conferencing tools used for remote work.

Exercise 14.6.7

How does a blockchain record transactions?

Answer

Transactions are recorded in permanent, transparent blocks that link cryptographically to create an immutable ledger replicated across many nodes.

Study Question 14.6.8

What is quantum superposition?

Answer

Superposition is the quantum effect of a qubit representing both 1 and 0 simultaneously. This exponentially scales a quantum computer's computational power.

Study Question 14.6.9

What are some AI innovations?

Answer

Key innovations include computer vision, conversational agents, algorithmic trading, robots, neural networks leveraging big data, and generated art/content.

Study Question 14.6.10

What ethical concerns exist around AI?

Answer

AI raises issues like bias, accountability, privacy, job loss, manipulation, and more. Responsible governance is needed to address risks.

Exercise 14.6.11

What factors are driving rapid technological change?

Answer

Ubiquitous connectivity, vast new data, improved infrastructure, new analytics algorithms, and cross-disciplinary research are accelerating progress.

14.6.1: Exercises

1. If you were going to start a new technology business, which of the emerging trends would be the biggest opportunity? Do some original research to estimate the market size.
2. What could privacy concerns be raised by collaborative technologies such as Zoom?
3. Do some research about the first handgun printed using a 3-D printer and report some of the concerns raised.
4. Write up an example of how the Internet of Things might provide a business with a competitive advantage.
5. How do you think wearable technologies could improve overall healthcare?
6. What potential problems do you see with a rise in driverless cars? Do independent research and write a two-page paper describing where driverless cars are legal and what problems may occur.
7. Review the 2022 Kleiner Perkins Internet Trends Report . Write a one-page paper describing the top three trends, in your opinion.
8. Visit ghsa.org to find what level of support California or your state has given to autonomous vehicles. Write a summary of the different levels of support for your state.
9. Compare the privacy policies of three major technology companies. What are their key similarities and differences?
10. Interview two people of different generations on what emerging technology excites or concerns them. How do their views differ?
11. Find a recent news article discussing 5G networks. Summarize what potential changes faster mobile internet could bring.

15: Artificial Intelligence

> **Learning Objectives**
>
> By the end of this section, you will be able to:
>
> - Discuss the application of robotics and the workplace changes it will bring
> - Identify artificial intelligence applications in the workplace
> - Explain the ethical challenges presented by the use of artificial intelligence

As we have seen earlier in this chapter, general advances in computer technology have already enabled significant changes in the workplace. In this module, we will look at how future workforce demographics may be affected by existing and emerging technologies. The combination of automation and robotics has already changed not only the workplace but everyday life as well. It also comes with a host of ethical and legal issues, not least being where humans will fit in the workplace of tomorrow. Managers of the future may ask, “Does my company or society benefit from having a human do a job rather than a robot, or is it all about efficiency and cost?”

Robotics and Automation in the Workplace

Advances in the field of **robotics**—a combination of computer science, mechanical and electronics engineering, and science—have meant that machines or related forms of automation now do the work of humans in a wide variety of settings, such as medicine, where robots perform surgeries previously done by the surgeon’s hand. Robots have made it easier and cheaper for employers to get work done. The downside, however, is that some reasonably well-paying jobs that provided middle-class employment for humans have become the province of machines.

A McKinsey Global Institute study of eight hundred occupations in nearly fifty countries showed that more than 800 million jobs, or 20 percent of the global workforce, could be lost to robotics by the year 2030.[74] The effects could be even more pronounced in wealthy industrialized nations, such as the United States and Germany, where researchers expect that up to one-third of the workforce will be affected. By 2030, the report estimates that 39 million to 73 million jobs may be eliminated in the United States. Given that the level of employment in the United States in mid-2018 is approaching 150 million workers, this potential loss of jobs represents roughly one-quarter to one-half of total current employment (but a smaller share of employment in 2030 because of future population and employment growth).

The big question, then, is what will happen to all these displaced workers. The McKinsey report estimates that about twenty million of them will be able to transfer easily to other industries for employment. But this still leaves between twenty million and more than fifty million displaced workers who will need new employment. Occupational retraining is likely to be a path taken by some, but older workers, as well as geographically immobile workers, are unlikely to opt for such training and may endure job loss for protracted periods.

In developing countries, the report predicts that the number of jobs requiring less education will shrink. Furthermore, robotics will have less impact in poorer countries because these nations’ workers are already paid so little that employers will save less on labor costs by automating. According to the report, for example, by the same date of 2030, India is expected to lose only about 9 percent of its jobs to emerging technology.

Which occupations will be most heavily affected? Not surprisingly, the McKinsey report concludes that machine operators, factory workers, and food workers will be hit hardest, because robots can do their jobs more precisely and efficiently. “It’s cheaper to buy a $35,000 robotic arm than it is to hire an employee who’s inefficiently making $15 an hour bagging French fries,” said a former McDonald’s CEO in another article about the consequences of robots in the labor market.[75] He estimated that automation has already cut the number of people working in a McDonald’s by half since the 1960s and that this trend will continue. Other hard-hit jobs will include mortgage brokers, paralegals, accountants, some office staff, cashiers, toll booth operators, and car and truck drivers. The Bureau of Labor Statistics (BLS) estimates that eighty thousand fast-food jobs will disappear by 2024. As growing numbers of retail stores like Walmart, CVS, and McDonald’s provide automated self-checkout options, it has been estimated that 7.5 million retail jobs are at risk over the course of the next decade. Furthermore, it has been estimated that as self-driving cars and trucks replace automobile and truck drivers, five million jobs will be lost in the early 2020s.

Jobs requiring human interaction are typically at low risk for being replaced by automation. These include nurses and most physicians, lawyers, teachers, and bartenders, as well as social workers (estimated by the BLS to grow by 19 percent by 2024), hairstylists and cosmetologists, youth sports coaches, and songwriters. McKinsey also anticipates that specialized lower-wage jobs like gardening, plumbing, and care work will be less affected by automation.

The challenge to the economy, then, will be how to address the prospect of substantial job loss; about twenty million to fifty million people will not be able to easily find new jobs. The McKinsey report notes that new technology, as in the past, will generate new types of jobs. But this is unlikely to help more than a small fraction of those confronting unemployment. So the United States will likely face some combination of rapidly rising unemployment, an urgent need to retrain twenty million or more workers, and recourse to policies whereby the government serves as an employer of last resort.

ETHICS ACROSS TIME AND CULTURES

Advances in Robotics in Japan

Japan has long maintained its position as the world's top exporter of robots, selling nearly 50 percent of the global market share in terms of both units and dollar value. At first, Japan's robots were found mainly in factories making automobiles and electronic equipment, performing simple jobs such as assembling parts. Now Japan is poised to take the lead by putting robots in diverse areas including aeronautics, medicine, disaster mitigation, and search and rescue, performing jobs that human either cannot or, for safety reasons (such as defusing a bomb), should not do. Leading universities such as the University of Tokyo offer advanced programs to teach students not only how to create robots but also how to understand the way robot technology is transforming Japanese society. Universities, research institutions, corporations, and government entities are collaborating to implement the country's next generation of advanced artificial intelligence robot technology, because Japan truly sees the rise of robotics as the "Fourth Industrial Revolution."

New uses of robots include hazardous cleanup in the wake of the 2011 earthquake and tsunami disaster that destroyed the Fukushima Daiichi nuclear power plant. After those events, Japan accelerated its development and application of disaster-response robots to go into radioactive areas and handle remediation.

In the laboratory at the University of Tokyo School of Engineering, advances are also being made in technology that mimics the capabilities of the human eye. One application allows scientists a clear field of vision in extreme weather conditions that are otherwise difficult or impossible for humans to study.

Japanese researchers are also developing a surgical robotic system with a three-dimensional endoscope to conduct high-risk surgery in remote mountainous regions with no specialized doctors. This system is in use in operating rooms in the United States as well, but Japan is taking it a step further by using it in *teletherapy*, where the patient is hundreds of miles away from the doctor actually performing the surgery. In Japan's manufacturing culture, robots are viewed not as threats but as solutions to many of the nation's most critical problems. Indeed, with Japan's below-replacement fertility since the mid-1970s, Japan's work force has been aging quite rapidly; in fact, beginning in the period from 2010 to 2015, the Japanese population started shrinking. Clearly, robots are potentially quite important as a means to offset prospective adverse consequences of a diminishing labor force.

Critical Thinking

- Does using robots cause a loss of jobs, a shifting of jobs, or both? How should society respond?
- How might the use of robots add to the increasing inequality in the U.S. economy?
- Do companies have an ethical responsibility to their workers to training or other support to workers displaced by automation?

Artificial Intelligence

Although some robots are remotely controlled by a human operator or a computer program written by a human, robots can also learn to work without human intervention, and often faster, more efficiently, and more cheaply than humans can. The branch of science that uses computer algorithms to replicate human intelligent behavior by machines with minimal human intervention is called **artificial intelligence (AI)**. Related professions in which the implementation of AI might have particular impact are banking, financial advising, and the sales of securities and managing of stock portfolios.

According to global consulting giant Accenture, AI is "a collection of advanced technologies that allows machines to sense, comprehend, act and learn." Accenture contends that AI will be the next great advance in the workplace: "It is set to transform business in ways we have not seen since the Industrial Revolution; fundamentally reinventing how businesses run, compete and thrive. When implemented holistically, these technologies help improve productivity and lower costs, unlocking more creative jobs and creating new growth opportunities."[76] Accenture looked at twelve of the world's most developed countries, which account for more than half of world economic output, to assess the impact of AI in sixteen specific industries. According to its report, AI has the potential to significantly increase corporate profitability, double rates of economic growth by 2035, increase labor productivity by as much as 40 percent, and boost gross value added by $14 trillion by 2035, based on an almost 40 percent increase in rates of return.[77] Even news articles have begun to be written by robots.[78]

link to learning

Read this article about AI and its applications and watch this video about how automation and AI are changing the accounting profession to learn more. Also, read this article about how some startups are creating new AI-related technology and products to automate accounting systems to learn more.

A report by KPMG, another global consulting and accounting firm, indicates that almost 50 percent of the activities people perform in the workplace today could be automated, most often by using AI and automation technology that already exist. The ethical question facing the business community, and all of us on a broader level, is about the type of society in which we all want to live and the role automation will play in it. The answer is not simply about efficiency; a company should consider many variables as it moves toward increased automation (Figure 10.9).

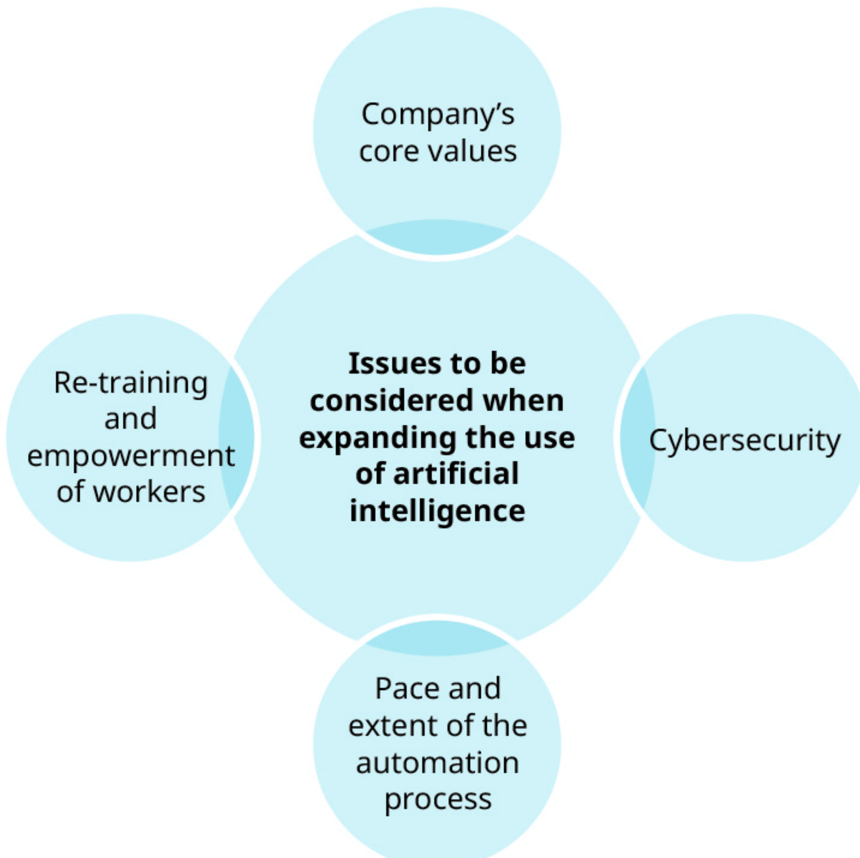


Figure 15.9: Managers should balance multiple variables as the workplace moves toward increased use of artificial intelligence, automation, and robotics. (CC BY 4.0; Rice University & OpenStax)

For example, as AI programs become better able to interact with humans, especially online, should a company be required to inform its customers if and when they are dealing with any form of AI and not a person? If people cannot tell when they are communicating with an AI program and not a human being, has an AI-controlled computer or robot reached a form personhood? Why or why not? Although traditional business ethics can provide us with a starting place to answer such questions, we will also need a philosophical approach, because we also need to decide whether it is necessary to have consciousness to be considered a person. This issue is further muddied when a human employee largely is tapping AI i to serve customers or clients. Should this combination of human and AI assistance be made patently clear?

Another issue in AI and all forms of automation is liability. According to Reuters News, "lawmakers in Europe have agreed on the need for [European Union]-wide legislation that would regulate robots and their use, including an ethical framework for their development and deployment, as well as the establishment of liability for the actions of robots, including self-driving cars."[79] The legal and ethical questions in assigning liability for decisions made by robots and AI are not only fascinating to debate but also an important legal matter society must resolve. The answers will one day directly affect the day-to-day lives of billions of people.

Index

Glossary

Sample Word 1 | Sample Definition 1

Detailed Licensing

Overview

Title: Management Information Systems Remix

Webpages: 142

All licenses found:

- CC BY 4.0: 97.2% (138 pages)
- Undeclared: 2.8% (4 pages)

By Page

- Management Information Systems Remix - *CC BY 4.0*
  - Front Matter - *CC BY 4.0*
    - TitlePage - *CC BY 4.0*
    - InfoPage - *CC BY 4.0*
    - Table of Contents - *Undeclared*
    - Licensing - *CC BY 4.0*
  - 1: What an Information System is - *CC BY 4.0*
    - 1.1: Introduction - *CC BY 4.0*
    - 1.2: Identifying the Components of Information Systems - *CC BY 4.0*
    - 1.3: The Evolution and Role of Information Systems - *CC BY 4.0*
    - 1.4: Can Information Systems Bring Competitive Advantage? - *CC BY 4.0*
    - 1.5: Summary - *CC BY 4.0*
    - 1.6: Study Questions - *CC BY 4.0*
  - 2: Hardware - *CC BY 4.0*
    - 2.1: Introduction - *CC BY 4.0*
    - 2.2: Tour of a Digital Device - *CC BY 4.0*
    - 2.3: Moore's Law - *CC BY 4.0*
    - 2.4: Removable Media - *CC BY 4.0*
    - 2.5: Other Computing Devices - *CC BY 4.0*
    - 2.6: Summary - *CC BY 4.0*
    - 2.7: Study Questions - *CC BY 4.0*
  - 3: Software - *CC BY 4.0*
    - 3.1: Introduction to Software - *CC BY 4.0*
    - 3.2: Types of Software - *CC BY 4.0*
    - 3.3: Cloud Computing - *CC BY 4.0*
    - 3.4: Software Creation - *CC BY 4.0*
    - 3.5: Summary - *CC BY 4.0*
    - 3.6: Study Questions - *CC BY 4.0*
  - 4: Data and Databases - *CC BY 4.0*
    - 4.1: Introduction to Data and Databases - *CC BY 4.0*
    - 4.2: Examples of Data - *CC BY 4.0*
    - 4.3: Structured Query Language - *CC BY 4.0*
    - 4.4: Designing a Database - *CC BY 4.0*
    - 4.5: The Difference between a Database and a Spreadsheet - *CC BY 4.0*
    - 4.6: Big Data - *CC BY 4.0*
    - 4.7: Data Warehouse - *CC BY 4.0*
    - 4.8: Data Mining - *CC BY 4.0*
    - 4.9: Database Management Systems - *CC BY 4.0*
    - 4.10: Enterprise Databases - *CC BY 4.0*
    - 4.11: Knowledge Management - *CC BY 4.0*
    - 4.12: What is data science? - *CC BY 4.0*
    - 4.13: Summary - *CC BY 4.0*
    - 4.14: Study Questions - Data and Databases - *CC BY 4.0*
  - 5: Networking and Communication - *CC BY 4.0*
    - 5.1: Introduction - *CC BY 4.0*
    - 5.2: A Brief History of the Internet - *CC BY 4.0*
    - 5.3: Concepts - Networking and Communication - *CC BY 4.0*
      - 5.3.1: Introduction - *CC BY 4.0*
      - 5.3.2: Providing Resources in a Network - *CC BY 4.0*
      - 5.3.3: LANs, WANs, and the Internet - *CC BY 4.0*
      - 5.3.4: Network Representations - *CC BY 4.0*
      - 5.3.5: The Internet, Intranets, and Extranets - *CC BY 4.0*
      - 5.3.6: Internet Connections - *CC BY 4.0*
      - 5.3.7: The Network as a Platform Converged Networks - *CC BY 4.0*
      - 5.3.8: Reliable Network - *CC BY 4.0*
    - 5.4: Trends, the Changing Environment - *CC BY 4.0*
      - 5.4.1: Home Technology Trends - *CC BY 4.0*
    - 5.5: Network Security - *CC BY 4.0*
    - 5.6: Summary - *CC BY 4.0*
    - 5.7: Study Questions - *CC BY 4.0*
  - 6: Information Systems Security - *CC BY 4.0*
    - 6.1: Introduction - *CC BY 4.0*
    - 6.2: The Information Security Triad- Confidentiality, Integrity, Availability (CIA) - *CC BY 4.0*
    - 6.3: Tools for Information Security - *CC BY 4.0*
    - 6.4: Threat Impact - *CC BY 4.0*
    - 6.5: Security Operations Centers - *CC BY 4.0*

LibreTexts

Detailed Licensing

Overview

Title: Management Information Systems Remix

Webpages: 142

All licenses found:

- CC BY 4.0: 97.2% (138 pages)
- Undeclared: 2.8% (4 pages)

By Page

- Management Information Systems Remix - *CC BY 4.0*
  - Front Matter - *CC BY 4.0*
    - TitlePage - *CC BY 4.0*
    - InfoPage - *CC BY 4.0*
    - Table of Contents - *Undeclared*
    - Licensing - *CC BY 4.0*
  - 1: What an Information System is - *CC BY 4.0*
    - 1.1: Introduction - *CC BY 4.0*
    - 1.2: Identifying the Components of Information Systems - *CC BY 4.0*
    - 1.3: The Evolution and Role of Information Systems - *CC BY 4.0*
    - 1.4: Can Information Systems Bring Competitive Advantage? - *CC BY 4.0*
    - 1.5: Summary - *CC BY 4.0*
    - 1.6: Study Questions - *CC BY 4.0*
  - 2: Hardware - *CC BY 4.0*
    - 2.1: Introduction - *CC BY 4.0*
    - 2.2: Tour of a Digital Device - *CC BY 4.0*
    - 2.3: Moore's Law - *CC BY 4.0*
    - 2.4: Removable Media - *CC BY 4.0*
    - 2.5: Other Computing Devices - *CC BY 4.0*
    - 2.6: Summary - *CC BY 4.0*
    - 2.7: Study Questions - *CC BY 4.0*
  - 3: Software - *CC BY 4.0*
    - 3.1: Introduction to Software - *CC BY 4.0*
    - 3.2: Types of Software - *CC BY 4.0*
    - 3.3: Cloud Computing - *CC BY 4.0*
    - 3.4: Software Creation - *CC BY 4.0*
    - 3.5: Summary - *CC BY 4.0*
    - 3.6: Study Questions - *CC BY 4.0*
  - 4: Data and Databases - *CC BY 4.0*
    - 4.1: Introduction to Data and Databases - *CC BY 4.0*
    - 4.2: Examples of Data - *CC BY 4.0*
    - 4.3: Structured Query Language - *CC BY 4.0*
    - 4.4: Designing a Database - *CC BY 4.0*
    - 4.5: The Difference between a Database and a Spreadsheet - *CC BY 4.0*
    - 4.6: Big Data - *CC BY 4.0*
    - 4.7: Data Warehouse - *CC BY 4.0*
    - 4.8: Data Mining - *CC BY 4.0*
    - 4.9: Database Management Systems - *CC BY 4.0*
    - 4.10: Enterprise Databases - *CC BY 4.0*
    - 4.11: Knowledge Management - *CC BY 4.0*
    - 4.12: What is data science? - *CC BY 4.0*
    - 4.13: Summary - *CC BY 4.0*
    - 4.14: Study Questions - Data and Databases - *CC BY 4.0*
  - 5: Networking and Communication - *CC BY 4.0*
    - 5.1: Introduction - *CC BY 4.0*
    - 5.2: A Brief History of the Internet - *CC BY 4.0*
    - 5.3: Concepts - Networking and Communication - *CC BY 4.0*
      - 5.3.1: Introduction - *CC BY 4.0*
      - 5.3.2: Providing Resources in a Network - *CC BY 4.0*
      - 5.3.3: LANs, WANs, and the Internet - *CC BY 4.0*
      - 5.3.4: Network Representations - *CC BY 4.0*
      - 5.3.5: The Internet, Intranets, and Extranets - *CC BY 4.0*
      - 5.3.6: Internet Connections - *CC BY 4.0*
      - 5.3.7: The Network as a Platform Converged Networks - *CC BY 4.0*
      - 5.3.8: Reliable Network - *CC BY 4.0*
    - 5.4: Trends, the Changing Environment - *CC BY 4.0*
      - 5.4.1: Home Technology Trends - *CC BY 4.0*
    - 5.5: Network Security - *CC BY 4.0*
    - 5.6: Summary - *CC BY 4.0*
    - 5.7: Study Questions - *CC BY 4.0*
  - 6: Information Systems Security - *CC BY 4.0*
    - 6.1: Introduction - *CC BY 4.0*
    - 6.2: The Information Security Triad- Confidentiality, Integrity, Availability (CIA) - *CC BY 4.0*
    - 6.3: Tools for Information Security - *CC BY 4.0*
    - 6.4: Threat Impact - *CC BY 4.0*
    - 6.5: Security Operations Centers - *CC BY 4.0*