# Chapter 1

# Managing Technological Systems

## Outline

- Chapter learning objectives
- Overview
- Technological systems defined
- Information systems management
  - Information technology service management
- Technology management
  - Change management
  - Strategic management
  - Innovation management
- Project management
- Systems thinking
- Process improvement
- Technology transfer
- Internet of things
- Information and technology security
- Globalization
- Career connections
- Sample modular activities
- Terms
- References
- Further reading

## Chapter Learning Objectives

- ❖ Describe the process of managing technological systems.
- ❖ Examine some management areas common in the development and use of technological systems.
- ❖ Consider the roles of security, globalization, and expansion of technologies in the management of technological systems.

## Overview

This chapter broadly defines technological systems and some of the key management skills necessary for successful use of these systems. The field of technology management combines management, leadership, and team-building skills with technical and engineering skills. These are in turn complemented by process, functional, and analytical skills. One of many subsets of technology management has to do with the management of information technology services, which is the application of computer-based systems to store, review, retrieve, transmit, and manipulate data, often in the context of a business. As the use of technologies is increasingly becoming more focal than the technologies themselves, not only is service management important, but also change management, strategic management, and management of innovation. Within technological systems, an understanding of the systems and processes involved is key, as is an understanding of how technologies might transfer from one use or area to another. This will only continue in importance and complexity as the Internet of Things and globalization continue their rapid growth paths.

## Technological Systems

A *technological system* is any set of interconnected components, working together, that either transform, store, transport or control either materials, energy or information for a purpose. The term may be applied both as a whole, as in automotive technologies; or specifically, as in electronic automatic transmissions. Essentially, the system takes some type of input or inputs, changes it in some manner via system components, and freely produces an outcome that differs from the input, such as in the electrical system depicted in Figure 1.1.

If you consider a simple desk lamp, it is a technological system that converts electrical energy to a light source. If you consider the outlet where it plugs in, that is part of a system as well. Any technological system may embody various subsystems.

## Information Systems Management

An *information system* (IS) is an organized system used for collection, organization, storage, and communication of information. It includes hardware, software, people, and processes

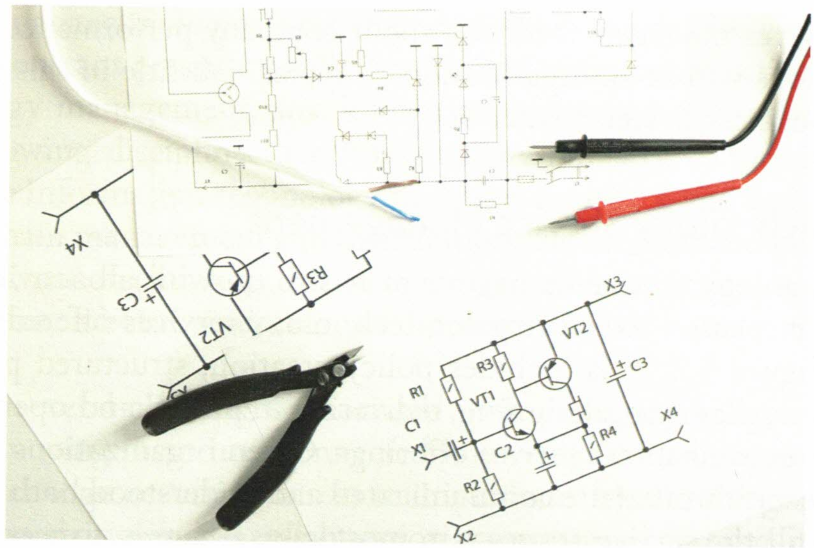


**Figure 1.1:** Drawing of electrical system



used to collect, filter, process, create, and distribute data. Often, there are several individuals involved in the operations of these systems including technology support services, systems developers, security managers, data and information managers, network and infrastructure services, and administrative computing.

The study of information systems management is a formal discipline that bridges the gap between computer science, finance, marketing, and management. Its core function is to determine business requirements for information systems and implement these systems. This encompasses planning, installation, maintenance, oversight, and updates. Information systems managers also work to improve efficiency and effectiveness of strategic decision making based on system-based information. IS managers may focus on a specific issue such as network security, as will be discussed later in this chapter, or they may coordinate all technology operations.

The system that an individual works with in this field is often known as the companies' Management Information System (MIS). In this context, an MIS is generally a computerized information processing system of financial and related information that is organized and used to support the activities of a company or organization management. It gives managers feedback about company performance and supports managerial decisions within an organization. A typical job title in this area might be something like Business Systems Analyst.

## Information Technology Service Management

Information technology service management has to do with all activities and planning that occur in relation to information technology services offered to customers, as depicted in Figure 1.2. This includes policy creation, structured processes, supporting procedures, planning, designing, delivering, training, and operating that are necessary for the organization's service offerings. Often organizations have a service strategy and expectations that are communicated and understood both internally and externally. To fulfill the service strategy, in most cases, there is a means to offer services, such as via a service desk, and a means to address any service incidents, positive or negative. To fulfill service expectations, organizations may create process maps, operational procedure documentation, service models, governance mechanisms, or similar. In virtually every case, communications are necessary and assessment highly recommended.

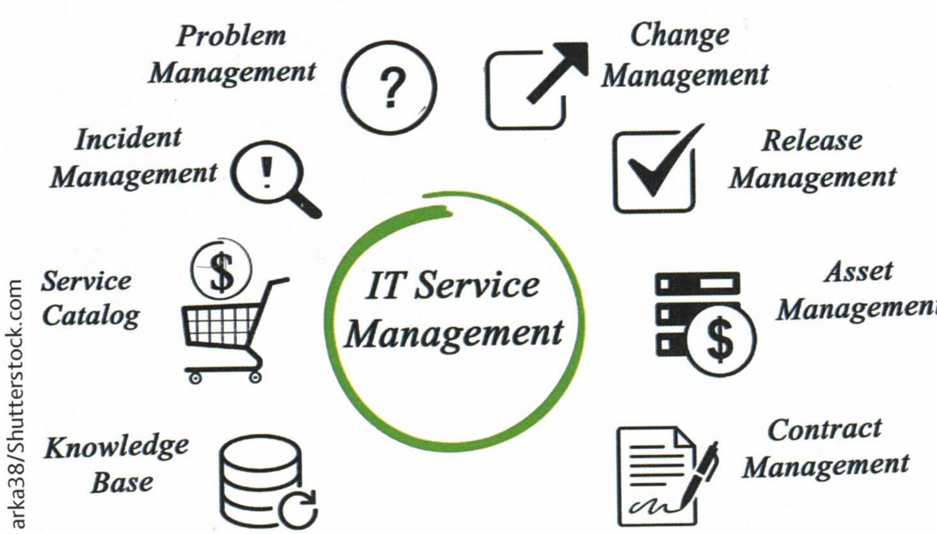


Figure 1.2

# Technology Management

All the technologies and technological systems discussed in this chapter and within the textbook need someone to manage them. There is rapid technological change occurring in society, coupled with increasing complexities that are involved in the convergence of different industries. Businesses must create value, be effective, and do things quickly as technologies, and thus customer's needs, are constantly changing. There is also constant pressure to allocate limited resources effectively.

Technology management, also known as *management of technology* (MoT), is a broad and growing discipline that crosses many industry sectors including but not limited to: the information technology industry, aerospace and transportation industries, supply chain management and distribution, the medical and health care industry, biotechnology, nanotechnology, manufacturing and production, analytics and business intelligence, robotics and artificial intelligence, and energy and environmental industries.

There are several challenges associated with managing today's high-tech industries. We are moving to an interconnected knowledge-based economy. There is rapid technological change occurring across multiple industries in the global economy. The increased connectivity requires collaboration among varied partners, including academics, industry, and governments to optimize the benefits. Innovation in product lines, services, and processes requires keeping employees up to date and proficient in the use of the new technologies and this poses challenges to managers in today's businesses. Industry needs creative, highly skilled employees to provide the knowledge-intensive products and services that people desire. A high level of information is required, and communication capabilities are necessary to provide access to all the information that is being generated today.

Technology managers plan, organize, and coordinate many areas; they cultivate operational capabilities and provide guidance and leadership in the development of business strategy. There are several core competencies associated with the MoT: management of technological change, management of organizational change, project management, assessment and evaluation of technology, quality MoT, information and knowledge management, innovation and product development, and strategic MoT (Becker, 2008).

The management of technological change, such as the increasing use and incorporation of smart sensors, often brings about a corresponding change in organization structure. For example, data that once had to be gathered and input by someone are now automatically generated from a smart sensor. Thus, the person who had previously collected the data is no longer needed for data collection, but now the vast amount of data generated needs to be analyzed by someone in order to turn the data into useful information. Thus, there is a shift in worker requirements, tending toward more specialized skills.

There is also an increasing need to manage technologically based projects. New systems are constantly coming online at organizations. The deployment of the new technology is a project with start and end dates. A variety of tasks are necessary to keep the project moving forward. In addition, there are a variety of constraints including budget, time, suppliers, and workforce that must be managed. All of these efforts come under the umbrella of project management.

The assessment and evaluation of technology is an important part of technology management. Managers need to be able to assess risks associated with bringing new technologies onboard and they need to be able to evaluate existing technologies. Managing quality is a critical component of technology management. All the systems mentioned in this chapter and within the textbook must meet certain quality standards in which to function. Business processes are put in place which attempt to ensure that certain quality standards are met. Continuous improvement processes are cyclical and employed. ISO 9000 standards are used internationally to measure quality practices within organizations.

Managing information and knowledge is becoming increasingly important in today's highly interconnected world. People can obtain information about products easily on the Internet, and social media plays a central role in many consumers' decisions on whether to make a purchase. Access to knowledge is critical, how this information drives change is important, and having informed knowledgeable employees has become essential.

Innovation, product development, and design are integral to technology management. There is constant innovation in products and processes today. The way innovation and product development are approached and supported is a key strategic area that business leaders must address. If organizations do not adopt innovative practices they may be out of business. Methods such as design thinking, as described in a separate chapter, have become core to many businesses.

Technology managers require strategic planning today. They must have the ability to constantly scan the environment in which their organization lies and be able to make decisions that will move the organization forward. They need to decide the important directions in which to steer to the organization. They must determine the types of resources needed for moving in the desired direction.

## Change Management

Almost all technology projects are in some state of fluidity. Continual change and improvement is commonplace. Organizations need to adapt continually due to shifting market conditions, customer demands, new technologies, input costs, shareholder expectations, and competition. Due to this, change management plays an important role. Change management sets forth clear processes for changes to occur, whether large or small, and


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works to ensure minimal disruption for services, goods, and individuals both inside and outside the company.

The change management process most often entails a formal mechanism for a request for a change. Impact analysis (identifying and assessing the potential consequences of a change) follows. The change request is then approved or denied and implemented as applicable. Finally, after the change has been completed, review and reporting occur. Change management involves not just establishing these mechanisms, but also communications, training, support, monitoring, and leadership.

### Strategic Management

Strategic management of technology entails having a long-range perspective on the wide-ranging effects that technologies will have on all levels and functions of an organization. It involves establishing business strategy. Often strategic management involves innovation, risk, technologies, market analysis, and financials. It commonly has a focus on value of the enterprise or company as related to current profits and cash flow and, perhaps more importantly, how it is sustained in the future. It also emphasizes systematic management through its expected life cycle from birth to decline. After a new technology is created and implemented into a product, assuming it is accepted and utilized, it will at some point hit maturity and ultimately decline and be replaced.

### Innovation Management

Innovation has to do with developing new methods, ideas, devices, or products. In most cases, innovation meets previously unmet or new requirements or needs and can refer to products, processes, or even organizations. Innovation management, therefore, is the management of innovation as well as change management. Often, innovation management has to with developing a common understanding of processes and goals. It encourages pursuit of opportunities and creativity.

## Project Management

A project is a temporary endeavor undertaken to create a unique product, service, or result. According to Kathy Schwalbe, author of *An Introduction to Project Management*, "Many people and organizations today have a new or renewed interest in project management." Today's project management involves much more, and people in every industry and every country manage projects. New technologies have become a significant factor in many organizations, and the use of interdisciplinary and global work teams has radically changed the work environment.

There are various methods of incorporating project management in businesses. However, two distinct methods have become commonplace. One is known as the

Project Management Institute methodology; the second is known as Six Sigma. Each incorporates components from within both this chapter and this book.

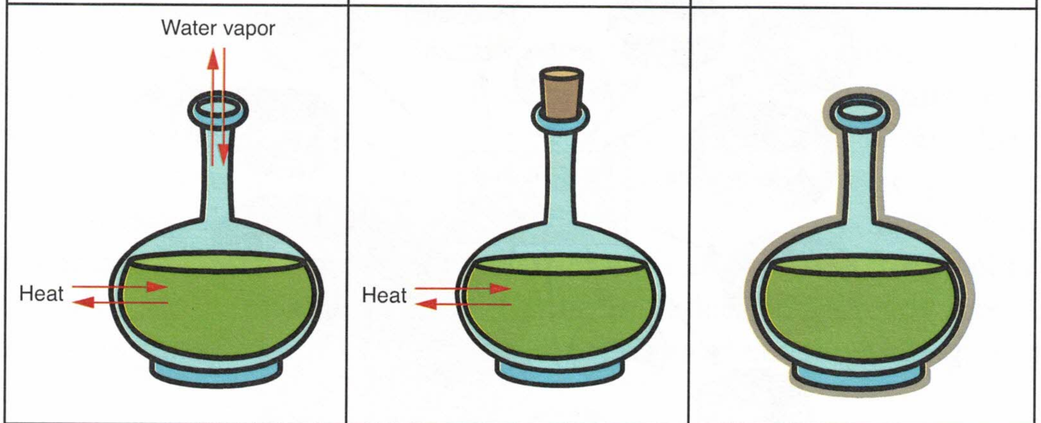
Project Management Institute's methodology incorporates the following process areas or performance domains: initiating, planning, executing, monitoring and controlling, and closing. They also identify key knowledge areas including integration management, scope management, time/schedule management, cost management, quality management, resource management, communications management, risk management, procurement management, and stakeholder management.

Six Sigma project management emphasizes the identification of root causes to problems and prevention of their recurrence. Its management techniques focus on error reduction and process improvement and often makes use of a data-driven improvement cycle that includes the following processes: define, measure, analyze, improve, and control (DMAIC). DMAIC will be discussed further in the process management segment below. Incorporated into Six Sigma are concepts of lean manufacturing and production, which is a systematic method for minimizing waste without loss in productivity. Common practices include just-in-time manufacturing and *kaizen*, based on continuous improvement; *jidoka*, based on acting on abnormalities; *poka yoke*, based on mistake proofing; and *heijunka*, based on production levelling. Six Sigma is discussed further in the advanced manufacturing and production chapter.

## Systems Thinking

A system is a set of connected items that form a complex whole. In the world of technology, it is often a set of devices, capabilities, methods or routines that operate together for an activity, function, or duty. Systems thinking in a management discipline that examines links and interactions between organized components. This includes not just the tactile (touchable, tangible) items, but the procedures, rules, and use of these systems. Systems may have clear boundaries, which are known closed systems, or have links with their environment, which are known as open systems. Systems, also, may be made up other systems; when this occurs, they are often called whole systems. One example if this is a network system, which may include multiple local area networks and wide area networks within it. Then again, though, a network system might just be a single local area network. Management of all types and sizes of systems entails understanding how the system is intended to work, how it actually works, its limitations, and its capabilities to best use the system and avoid any failures.

Systems are sometimes referred to as open, closed, or isolated, particularly in fields such as chemistry. Open systems allow exchange of energy or matter (physical substances) with its surroundings. Closed systems can transfer and exchange energy but not matter. Isolated systems transfer or exchange neither energy nor matter. See Figure 1.3 for visual depictions of each.




| Open system | Closed system | Isolated system |
|---|---|---|
| *An **open system** can exchange mass and energy, usually in the form of heat with its surroundings* | ***closed system,** which allow the transfer of energy (heat) but not mass.* | ***isolated system,** which does not allow the transfer of either mass or energy.* |



**Figure 1.3:** Three types of systems

## Process Improvement

*Process improvement* involves the improvement of a system after it has been established which goes beyond general operation and maintenance of that system. Via monitoring and reviewing of the system, along with other inputs from interested parties, requirements or expectations can be modified and implemented, causing the managed system to produce different outputs. This might entail efficiencies, the ratio of useful work performed by a machine or process as compared to the total energy expended, or effectiveness, the degree to which the machine or process is able to produce desired results. Figure 1.4 shows some common areas of process improvement.

Process improvement entails analysis and definition of a process, measurement and analysis of that process, improvements made to the process, and control to sustain the improvements over the long run. One process improvement plan which is used in Six Sigma project management practices is known as DMAIC, which stands for: Define the problem and the ideal; Measure the process and the problem; Analyze the process to understand the cause and effect and identify root causes; Improve the process inputs and outputs; and Control via standards and technology to sustain the improvements over the long run. DMAIC will be covered in greater depth in the advanced manufacturing and production chapter.


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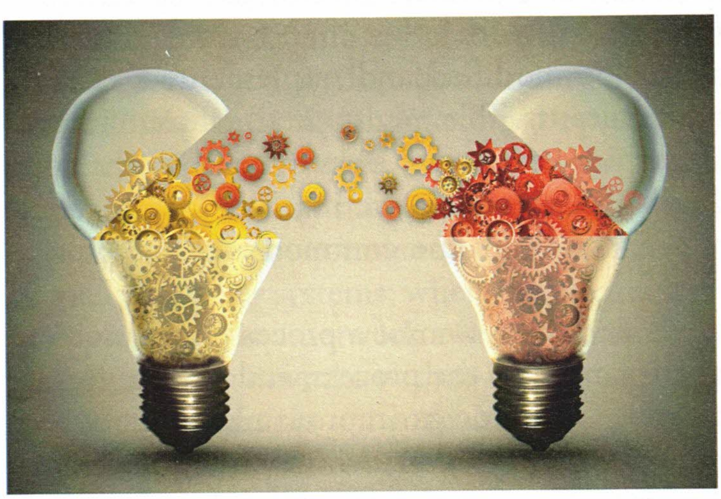
**Figure 1.4:** Process improvement mind map

## Technology Transfer

Technology transfer, also known as the *transfer of technology*, is a process of transferring a technology from one function or place to another or from an originator to a secondary user. It often has nuanced definitions based on the context of its use. In the legal world of technology licensing or franchising it likely consists of technological intellectual property. In federally funded sectors it may have to do with bringing technologies to the marketplace via the process of commercialization. In a global political context, it is more likely to entail the movement of technologies from one area of the world to another. In almost all cases, however, there is an originating idea which is used in an original context after research and development has occurred. That originating idea, then, is brought to market and is put to use in areas other than just the original market based on additional development, refinement, dissemination, or implementation.



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## Internet of Things

The Internet of Things (IoT) will eventually change the way we live, work, and communicate with each other. It is all about connectivity and convergence of systems. "The Internet of Things is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction" (Techtarget.com, n.d.). Objects will increasingly be interconnected with each other through the Internet. Figure 1.5 shows some of the ways this can happen. These objects can be anything from the refrigerator in your home, to the drug delivery device in a hospital, to your car, your wearable health and fitness tracker, or your electricity meter. Basically, anything that can be connected to the Internet with an Internet Protocol (IP) address and that can send and receive data will be included. We already have electronics embedded in many of our devices and connecting them together in useful ways is the next step.

The IoT has the potential to change business models and improve processes in business as well as reducing costs and creating value. Decision making, including resource allocation and use, will be improved because of the improved ability to obtain data and process and store it with fewer input errors. Businesses need to think about how the IoT will impact their processes and customer base. They will need to have leadership that will assist them in development and implementation of a business strategy that optimizes the IoT. Their production processes and retail operations will change, as will the ways that they structure and use data, all as a result of the technological integration of the various systems in the IoT (Rudman & Sexton, 2016).

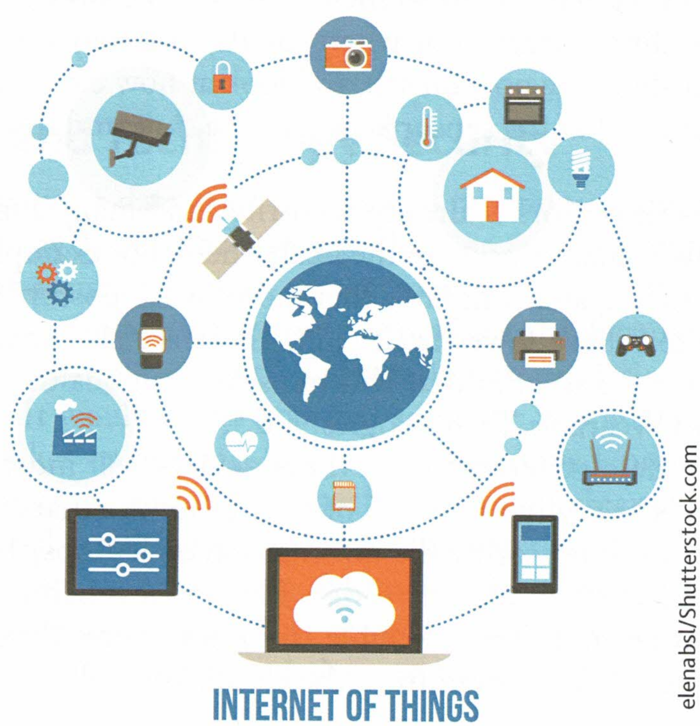


**Figure 1.5:** Internet of things connectivity map

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**Figure 1.5:** Internet of things connectivity map

There are three important elements required for the IoT to function: (1) the communication and sensing technologies, (2) the ability to store data and analyze it, and (3) the applications developed to optimize or make decisions based on the data that have been received. These three elements work in conjunction with each other to enhance lives and improve business performance. This network of interconnected objects will provide real-time information needed for analysis and responses tailored to the situation.

As an example, the communication and sensing devices can be a radio frequency identification (RFID) tag or smart sensor and a wireless network can be the communication device. Smart sensors are critical, as they collect the input from the environment and perform functions that have been predefined. Minimally smart sensors have a microprocessor and some type of communication technology along with the sensor itself. The ability for the smart sensor to compute is critical to the physical design of the mechanism; the sensor incorporates software that does the predefined functions such converting data, communicating with other external devices, and digital processing. The smart sensor is an essential and primary element in the IoT.

For example, your fitness tracker notes that you have walked 10,000 steps for five days in a row, this information could automatically be sent to your local sports store. The "Sports R Us" store works with the fitness tracker manufacturer and they then send you a congratulatory note on your achievement and a discount coupon on your smartphone for new walking shoes (As your shoes must be wearing out if you are walking 10,000 steps a day). If you are in the area where the store is located (remember your GPS and the ability to track your whereabouts) you may even get a notification that states, "Walking shoes are now on sale and look at how close you are to the store." It could even be possible that the sensor is part of the shoe and it will notify you when you need new ones.

The use of wearable sensors is already occurring, and many applications are being developed for wearable smart sensors in the health field. For example, there are devices one can wear when sitting at a computer that monitor for posture and will encourage you do to exercises to relieve lower back pain. There are also wearable monitors for people who have asthma and ones that will transmit vital health information to your health care provider (Wearable Technologies: n.d.).

Vast amounts of data generated from these devices will most likely be stored in the cloud. The cloud is basically a network of remote servers that are used to store and retrieve data from. Instead of storing the information on laptops, desktop computer or servers located in a business organization, data files are now being stored in the cloud. This makes information and files accessible from anywhere. Programs and applications can also be stored and retrieved from the cloud. You will no longer have to carry a laptop with you to get to the file you need. Companies can and do have individuals from across the globe working on the same files from their various locations in real time. However, there are added security risks inherent in placing one's files on remote systems. This might include unauthorized access, security defects, and inability to set or enforce security policies in a cloud service-provider environment.

Several challenges are associated with the design and implementation of the IoT. First, standards have not yet been decided. As with many emerging technologies, it may take some time for standards to be developed. This drawback will make implementation into existing business systems somewhat difficult and expensive initially. The development of standards is especially important for data integrity and security. For example, companies will likely want sensors that can be used on different platforms including Windows, Android, iOS, and Linux-based devices as well as working with different industry applications. This would be difficult if not impossible without established and consistent standards.

Companies need to have technical expertise and skills to develop the physical infrastructure and to perform the data analysis. They will have networks of sensors, computers, and actuators that move or control something. Investments will be required to build the necessary infrastructure both at the network and software levels. Companies will also need to have control of access, because if the objects have sensors connected to the Internet it poses a security risk. In addition, companies need to ensure that the object has a unique identifier that can be verified to ensure that the information being received is in fact from the object intended versus being from another object—otherwise the correct information will not be sent.

## Information and Technology Security

Security and integrity of data is critical to the functioning of virtually all technology systems. You may have heard about Chrysler recalling more than 1.4 million vehicles because of security risks in the onboard computer system in the vehicles. Hackers were able to remotely take over control of the Uconnect dashboard computer on a Jeep, with computer-controlled steering, transmission, and brake functions (Greenberg, 2015). It would be terrifying if someone was able to hack into your car and disable your brakes or steering. Chrysler Automobile Company, in collaboration with Sprint Corporation, was able to fix the software vulnerability in their vehicles by sending a universal serial bus (USB) drive to owners and having them update the onboard computer system. Preventing future attacks on vehicles' computerized systems will be of great importance. Most of today's cars have computers that assist in the control of different functions and that are connected. In many ways we benefit from the connectivity of our vehicles, traffic jams can be seen on the display screen of new vehicles and you can be rerouted to avoid them. There are even integrated apps that will notify you via text message that your automobile needs an oil change or other service.

Health care is another area where security is extremely important. Personal data could be leaked from your fitness and health-tracking devices, for example (Mansfield-Devine, 2016). There are millions of pieces of medical equipment installed in hospitals today, many of which are interconnected to networks. If a hospital's network or a health insurance company's network is breached by hackers, the hospital or insurer could incur fines and their brand name could be damaged. It becomes even potentially life-threatening if a medical device in the hospital or doctor's office is hacked. For example Symbiq, the medication infusion pump (a system that delivers drugs to patients usually through an intravenous line) produced by Hospira, was able to be accessed remotely through a hospital's network. The U.S. Food and Drug Administration issued a warning to hospitals, nursing homes, and other facilities that used this infusion pump about the cybersecurity vulnerability. They strongly encourage that health care facilities transition to alternative infusion systems as soon as possible. Not having a secure device cost Hospira a great deal of money and there was damage to their brand name.

Information and technology security involves protection of equipment via firewalls, tracking, software systems, hardware systems, and physical protection. It also entails the protection of data and information from manipulation or theft whether via spyware, viruses, phishing, or hackers.

Spyware is software that enables others to obtain covert information about a person's computer activities by transmitting data secretly. A virus is a piece of code that can copy itself, often to detrimental effect to the affected system. Phishing is the practice of sending fraudulent emails purporting to be from an entity they are not with the intent of inducing individuals to reveal personal information or make monetary offerings. A hacker is a person who uses computers to gain unauthorized access to data or systems.

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## Globalization

The world we live and work in has become interconnected and information is readily accessible globally with modern-day technologies. Information, individuals, ideas, technology, products, culture, and capital investment all flow easily between nations today (Kushwaha, Chaurasiya, & Chohan, 2015). We can have conference calls inexpensively with people around the world. Data are transmitted in seconds to the other side of the globe. We travel in a matter of hours to other countries. Goods are produced and sent throughout the world. Business is no longer confined to one state, one country, or one continent; the world is now where business is conducted. In managing in a global environment, practices such as open communications, total company involvement, integrated systems, shared goals and objectives, and mutual trust are critical. Often there will be team members and stakeholders who will never directly meet one another in person.

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Many firms are multinational today; they perform different aspects of business in different countries. Science and technology transfer are integral aspects of globalization (Sidhu, Sharma, Shiny, & Shivani, 2015). A firm may have engineering staff in the United States, production facilities in China, buyers throughout Asia and the Americas, and the controlling interest held in Japan. The ability to communicate easily and inexpensively with people from other nations has made doing business in multiple countries feasible for a growing number of firms. The globalization of the economy and industry has also lead to the exchange of culture and ideas. We now have people from different countries working together to solve complex problems. The synergy created by science and technology applications and the collaborative efforts of scientists and technologists is changing and will continue to change the way we live and work in the world.

The globalization of technology can be seen not just in increased use of remote videoconferencing, shared filed editing, or other global interconnectedness, but in our increasing production that occurs at the point of consumption. Energy, food, and products often have lower costs of entry for new competitors and more available options for development and distribution due to technological advancements. Additionally, there is increasingly worldwide access to abundant information, software, and services. These factors are transforming global supply chains.

# Career Connections

## Information Assurance Analysts

Analysts who work in information assurance plan and design software systems that are deployed to prevent unwanted attacks on data and systems. They focus on security issues and risk assessment of software and hardware. They make sure that both internal employees and external customers' data and information are not accessible, nor can it be manipulated by unauthorized users. Most positions require a bachelor's degree (Bureau of Labor Statistics, 2016a).

## Technology Managers

A technology manager works in a variety of industries including manufacturing, information technology, medicine, education, transportation, biotechnology, and aerospace to name a few. They plan, organize, and coordinate many areas, as well as cultivate operational capabilities and provide guidance and leadership in the development of business strategy. Most technology managers have a bachelor's or master's degree. This field is expected to grow.

## Computer and Information Systems Managers

Computer and information systems managers plan, coordinate, and direct computer-related activities in an organization. They often are responsible for implementing computer systems which meet the information technology goals of the company. Entry-level education for this field is commonly a bachelor's degree and the job outlook is higher than average. Note, however, that you can expect to work more than 40 hours a week (Bureau of Labor Statistics, 2016b).

# Sample Modular Activities

- Interactive: Discuss how society drives technological changes and vice versa. What are your thoughts and why?
- Interactive: Discuss, with examples, challenges and risks in managing technological systems. What are your thoughts and why?
- Research: Often management of technological/information systems is associated with databases or server rooms. However, it is more than that. Research an area of technological/information systems management and write up a two-page informative paper. You must use a minimum of two sources that must be properly cited.

- Design and/or Build Projects: Imagine the role you see the Internet of Things (IoT) playing in the next 10 to 20 years. Create a poster, collage, or diagram showing the role you predict it to have in the future. You will be assessed on the quality, thoughtfulness, and professionalism of your work.
- Critical Thinking: After searching job sites and other sources, compare technology management with information systems management and write a two-page summary of your views on how they are similar and different.

## Terms

***Convergence***—Convergence, generally, is to move toward one point and join together. In this context, it crosses traditional disciplinary boundaries and integrates tools and knowledge from different disciplines including physical science, life sciences, engineering, physics, and mathematics

***Internet of Things***—a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

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## Further Reading

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