

Emerging Technologies and Frontiers of Information Systems

Figure 10.1 Robotics and their growing ability to process large volumes of data remain central to discussions on emerging technologies. (credit: modification of work "Artificial Intelligence & AI & Machine Learning – 30212411048" by <https://www.vpnsrus.com/Wikimedia Commons, CC BY 2.0>)

Chapter Outline

- 10.1** Defining Emerging Technologies
- 10.2** The Evolving Frontiers of Information Systems
- 10.3** Societal and Global Importance of Emerging Technologies in Information Systems



Introduction

Innovation can be defined as applying a new process or concept to an existing technology to add value, enhance its capabilities, improve efficiency, or address unmet needs. Innovation is continually applied to technology, resulting in emerging technologies that create opportunities, challenges, and risks. Ultimately, these technologies can significantly impact individuals and organizations.

10.1 Defining Emerging Technologies

Learning Objectives

By the end of this section, you will be able to:

- Define emerging technology and provide examples
- Identify real-world applications of emerging technologies
- Identify the opportunities, challenges, and risks of emerging technologies

When you hear the phrase “emerging technology,” what comes to mind? Have you ever driven an electric car or ridden in a self-driving car? What do you think are the factors that determine if a technology is emerging? Would you consider the latest smartphone an emerging technology? Technically, the first commercial smartphone was released three decades ago. If technology created over thirty years ago was emerging then, is it still emerging technology today? What about Henry Ford’s historical introduction of the moving assembly line? Both of these technologies were built on existing technologies, and both have been revised and advanced over the years to their current forms—both are examples of the important influences of emerging

technologies.

What Makes an Emerging Technology

Any software or hardware that enhances the user experience by obtaining or using information and data in new and compelling ways can be considered an **emerging technology**. The term can be used to describe new technologies or the continuing development of existing technologies. Emerging technology can be found in all areas of our society, including education, information technology, nanotechnology, biotechnology, robotics, and artificial intelligence. If we look back over the last century, there have been many technological advancements: the automated teller machine, the hard disk drive, the magnetic stripe card, mobile telephony, desktop computers, the computer mouse, and more. Each of these was considered an emerging technology at the time and is now a familiar part of our lives.

The progressive nature of emerging technologies allows for companies that embrace them to gain a competitive advantage and the potential for synergies with other technologies that have the same or similar goals. The convergence of technologies has the potential to create efficiencies that may not have previously existed. Consider the convergence of video, voice, and data, for example. All these technologies were new at one time, and as their capabilities became apparent, opportunities became available to combine the technologies for use in one product. Having video, voice, and data on the same network allows multiple forms of communication that are not possible with separate infrastructures. Sending email or text messages to others while having a video chat conversation on the same device used to be hard to imagine, but they are now widely used together.

There are many other forms of technology that are considered to be emerging because of their rapid rate of change. The branch of engineering and computer science called **robotics** involves the conception, design, building, and operation of robots, creating intelligent machines that can assist humans with a variety of tasks. Robotics is considered emerging because it is being used in new and exciting ways every day. For example, many surgeries today are being performed laparoscopically with the assistance of robotic technology. Self-driving and electric vehicles are increasing their presence on roads, making waves in the automotive industry. The Internet of Things (IoT) has introduced biometric scanners and wearable devices that are changing the way we communicate and interact with each other.

Blockchain is considered an emerging technology due to its ability to improve efficiencies and streamline processes across many different industries. A **blockchain** is a shared, immutable ledger that facilitates the process of recording transactions and tracking assets. Blockchains are used for secured, transaction-based actions and information sharing within business networks. Blockchain uses **cryptography**, the process of hiding or coding information so that only the intended recipient can read it. Cryptographic protocols provide secure connections, enabling two parties to communicate with privacy and data integrity and provide additional layers of security. We see examples of blockchain use through the emergence of digital currency, such as cryptocurrency or bitcoin, one type of cryptocurrency. Cryptocurrency uses blockchain technology and allows transactions over the internet with no Federal Reserve System or monetary backing. Blockchain ensures that the cryptocurrency is successfully transferred from the sender to the recipient and arrives at its intended location and that financial transactions occur properly.

In 1977, the U.S. Department of Energy (DOE) was created and charged with promoting broader energy policy, promoting energy conservation, and finding alternative sources of energy. With these goals in mind, the DOE has become one of the largest federal organizations to drive innovation in the areas of power plants, solar panels, and renewable energies, all considered emerging technologies because they influence the way we interact with sustainable resources.

Educational institutions have also provided the means for researchers to foster innovation and develop technology by providing research labs and direct and indirect support, such as funding, research assistants, and faculty with subject matter expertise in research area and statistics. Ivan Sutherland, a professor at

Harvard University, along with his student Bob Sproull, created the first virtual reality (VR) device in 1968 ([Figure 10.2](#)). Sutherland is also credited with the development of augmented reality (AR) that same year.



Figure 10.2 Known as the "Sword of Damocles," Ivan Sutherland and his research team created this first head-mounted virtual reality device in 1968. (credit: modification of work "Virtual Reality Headset Prototype" by "Pargon"/Flickr, CC BY 2.0)

Emerging technologies usually introduce novel approaches, concepts, or applications that may not have been previously considered. They also show rapid advancement, developing and changing quickly, often due to an organization's financial investments and research efforts. Other characteristics of emerging technologies include their prominent impact, volatility, complexity, and uncertainty. Additionally, emerging technologies may be characterized by the type of technology used, the industry in which they are used, or the uniqueness of their attributes.

Emerging technologies are also known for their disruptive or transformative potential. They can introduce significant change and challenge traditional norms. For example, the introduction of self-checkout kiosks in grocery stores has reduced the number of cashiers needed to assist customers with their purchases. Following are some other cutting-edge emerging technologies that merit special attention for their transformative potential:

- Quantum computing harnesses quantum mechanics principles to perform complex calculations exponentially faster than traditional computers. It shows promising breakthroughs in cryptography, drug discovery, and financial modeling.
- Edge computing brings data processing closer to where data are created, reducing latency and enabling real-time applications like autonomous vehicles and smart manufacturing.
- Green computing practices focus on environmentally sustainable computing through energy-efficient hardware, smart power management, and eco-friendly data center design.

The integration of these technologies creates new possibilities. For instance, edge computing can reduce energy consumption by processing data locally, while quantum computing could optimize power grids for better energy distribution. Meanwhile, cross-platform integration allows these technologies to work together. A self-driving car might use edge computing for immediate decisions, quantum algorithms for complex route optimization, and green computing principles to maximize battery life.

If we look back over the last century, there have been many technological advancements: the automated teller machine, the hard disk drive, the magnetic stripe card, mobile telephony, desktop computers, the computer mouse, and more.

Real-World Applications of Emerging Technologies

Real-world applications of emerging technologies are boundless, and you are likely familiar with many usages. An **augmented reality (AR)** overlays digital information onto a user's environment in real time. Augmented reality often involves the use of hardware such as headsets or smartphones to overlay digital information onto physical environments. Slightly different, **virtual reality (VR)** is a computer-generated environment that simulates reality and allows users to interact with three-dimensional environments. AR and VR technologies are advancing (Figure 10.3), particularly in fields like education, health care, and entertainment. New immersive experiences are being created with better hardware, more realistic simulations, and applications in virtual collaboration.



(a)



(b)

Figure 10.3 (a) Augmented reality and (b) virtual reality create immersive experiences that are being used across organizations and fields to help teach and train employees. (credit a: modification of work "Command Center Alpha" by Dale Eckroth, U.S. Air Force/Air Education and Training Command, Public Domain; credit b: modification of work "Razer OSVR Open-Source Virtual Reality for Gaming (16241057474)" by Maurizio Pesce/Wikimedia Commons, CC BY 2.0)

The biggest technological change over the last three decades has been the introduction of cell phones and smartphones, which are almost as powerful as desktop computers. In response to consumer feedback, smartphone manufacturers continue to develop and create more powerful devices with new features, improving screen size, data storage, battery life, camera quality, and processing power.

Another emerging technology, AI, is the branch of computer science focused on creating intelligent machines capable of performing tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation. While AI was originally developed in the 1950s, the power of modern computers provides new uses for AI. Artificial intelligence applications are transforming everyday business operations across industries:

- In retail, AI powers recommendation systems that suggest products based on past purchases and browsing history.
- In health care, AI assists radiologists by flagging potential abnormalities in medical images for review.
- Manufacturing plants use AI for predictive maintenance, analyzing sensor data to identify when machines might fail before they break down.
- Financial institutions employ AI to detect fraudulent transactions by spotting unusual patterns in real time.

These practical applications are examples of how AI moves beyond theory to solve real business problems. AI is not just about complex algorithms; AI is using technology to make processes more efficient, decisions more informed, and services more personalized.

LINK TO LEARNING

While AI offers many opportunities for technological advancements, it also creates challenges. For example,

this documentary explores how [bias is an issue in AI facial recognition](https://openstax.org/r/109FacRecogBias) (<https://openstax.org/r/109FacRecogBias>) and how some aspects of AI may violate civil liberties.

A type of AI called **generative AI** creates new content or ideas in the form of text, images, videos, music, audio, and other forms of data, and its supporting tools are being used to create mounds of content for different professions. Educators, students, lawyers, project managers, and even publishers are using generative AI to shorten the time on tasks. The information gathering that can be done from internet sources and web applications can be pulled together quickly through generative AI.

ETHICS IN IS

Trust Issues in Artificial Intelligence Cause Ethical Concerns

Generative AI, such as ChatGPT, will change the way we approach learning and all forms of technology. Generative AI has the ability to facilitate our learning, help with industry research, and diagnose many different problems. But, there is one major flaw—it cannot be trusted all of the time. When gathering information—such as images, audio, and text—from the internet, generative AI tools often use copyrighted material, often without obtaining permission from the intellectual property owners. While generative AI software can do a phenomenal job creating text and images, it lacks this ethical component.

Additionally, if AI is unable to find the information you request in your prompt, it may create that information itself, which can result in fake articles, photographs, events, and people. For example, following hurricanes on the East Coast during fall 2024, several fake AI-generated images were used to highlight how the hurricane affected the area.¹ In 2023, *The Guardian* determined that ChatGPT listed fake, unpublished journal articles as responses to prompts asked for through the ChatGPT interface.² ChatGPT may fabricate content that mimics real articles if prompted, highlighting generative AI's inability to verify factual accuracy. This is a real problem in a virtual world. If generative AI software fabricates information, how can individuals identify real information from fake information? The material generated by AI looks and reads just like real articles. This only diminishes the trust of what is found on the internet. Without any type of regulation, fake information can be referenced and even cited on the internet, leading to more misinformation and potentially disinformation.

¹ "Fake Images Generated by AI Are Spreading on Social Media, Compounding Misinformation Surrounding Hurricane Recovery Efforts," ABC News, October 15, 2024, <https://abcnews.go.com/US/video/fake-images-generated-ai-spreading-social-media-compounding-114824660>

² Chris Moran, "ChatGPT Is Making Up Fake Guardian Articles: Here's How We're Responding," *The Guardian*, April 6, 2023, <https://www.theguardian.com/commentisfree/2023/apr/06/ai-chatgpt-guardian-technology-risks-fake-article>

Quantum computing represents another real-world application of emerging technologies. Rensselaer Polytechnic Institute in Troy, New York, became the first university to house an IBM quantum computer, costing the school more than \$150 million in investment capital.³ This acquisition allows students at the college to propose research projects, and if the project has merit, time will be allotted for the project to run on the quantum computer, providing students with an opportunity to gain hands-on experience in quantum computing. In **quantum computing** computers use quantum mechanics principles to perform complex calculations exponentially faster than traditional computers. With this ability, the computer models problems and simulations that are extremely hard for researchers to conceptualize, such as complex weather forecasting, large-scale financial modeling, and advanced pharmaceutical formulas for new drugs. These and other complex problems tend to involve multiple variables that have elaborate interactions, requiring sophisticated technology to analyze and understand the problems and potential solutions. Quantum computing can provide the sophistication needed. However, the most significant challenge in quantum computing is considered to be quantum error correction; effectively managing the noise and errors that occur within quantum systems, which is crucial for achieving reliable and large-scale quantum computations.

Opportunities, Challenges, and Risks of Emerging Technologies

Emerging technologies offer a multitude of opportunities to enhance our lives in every way. For example, businesses can use AI to generate valuable data about customer experiences and satisfaction, and these data can be the impetus to make changes needed to improve customer service. Artificial intelligence can help students learn by providing educational materials like customized flash cards and quizzes. At the same time, the use of emerging technologies can pose challenges and risks that must be managed in balance with the benefits that these technologies offer.

Opportunities

Emerging technologies provide boundless opportunities for businesses to evolve and increase their competitive advantage. For example, **enterprise modeling and integration (EMI)**, a process that uses computer-based tools to model the business structure and facilitate the connection of its technology, work, and information flow across an organization, has increasingly been considered a value-add for businesses as it allows a quicker response to business challenges, and improves efficiencies. EMI connects functionality and communication between information systems to include applications, data, clouds, application programming interfaces, processes, and devices. It combines multiple integration approaches into one combined effort, with one governance model. Incorporating AI into this process would be a value-add for businesses as its capabilities can be integrated directly into products and systems to enhance performance in all system areas.

Augmented reality and VR also provide opportunities for business growth and improved performance. AR and VR technologies allow users to access animated three-dimensional experiences, videos, and targeted detection directly from their personal devices, leveraging components within the device such as the camera, magnetometer, orientation, and other functions. An example of this functionality is the use of AR-enabled applications to enhance user shopping experiences ([Figure 10.4](#)).

³ "Rensselaer Polytechnic Institute Plans to Deploy First IBM Quantum System One on a University Campus," IBM, June 28, 2023, <https://newsroom.ibm.com/2023-06-28-Rensselaer-Polytechnic-Institute-Plans-to-Deploy-First-IBM-Quantum-System-One-on-a-University-Campus>



Figure 10.4 Augmented reality is used with many online retailers to help shoppers visualize how that item would fit in their environment. We are now able to see how a couch fits in our living room or how a dress looks on our body prior to purchase. (credit: modification of work "Augmented reality fashion" by "sndrv"/Flickr, CC BY 2.0)

Additionally, emerging technologies continue to influence areas such as information technology, integrated manufacturing, medical informatics, digital libraries, and electronic commerce, supporting efficiencies in manufacturing, health care, e-commerce, and other facets of business. Another area impacted by emerging technologies is **information economics**, which is a branch of microeconomics that analyzes how economic decisions and consumer behaviors are influenced by knowledge and power. It focuses on how information is produced, distributed, and used in economic systems. It is an important field of study to provide businesses and other organizations with the data and knowledge they need to be competitive in the marketplace.

Another example is Bitcoin, which provides specific opportunities with its functionality, including the following:

- Data sharing between businesses is enabled in a decentralized structure where no single entity is exclusively in charge.
- Security and privacy are improved wherein transactions have end-to-end encryption protections from unauthorized activity.
- Costs are reduced as a result of efficiencies in transaction and business processes.
- Speed is increased as compared to manual processes and other technologies with similar functions.

Blockchain technology continues to evolve, finding new applications in areas like decentralized finance, supply chain management, and secure data sharing. Blockchain technologies have touted benefits and opportunities in several industries including financial institutions, health-care organizations, and nonprofit and government agencies. Customers of these industries have experienced faster and less costly clearing and settlement of financial transactions, increased security of patient privacy, and transparent supply chains to maximize social impact. Specific to health-care organizations, patient- and organizational-related benefits can be attributed to the use of blockchain technologies ([Figure 10.5](#)).

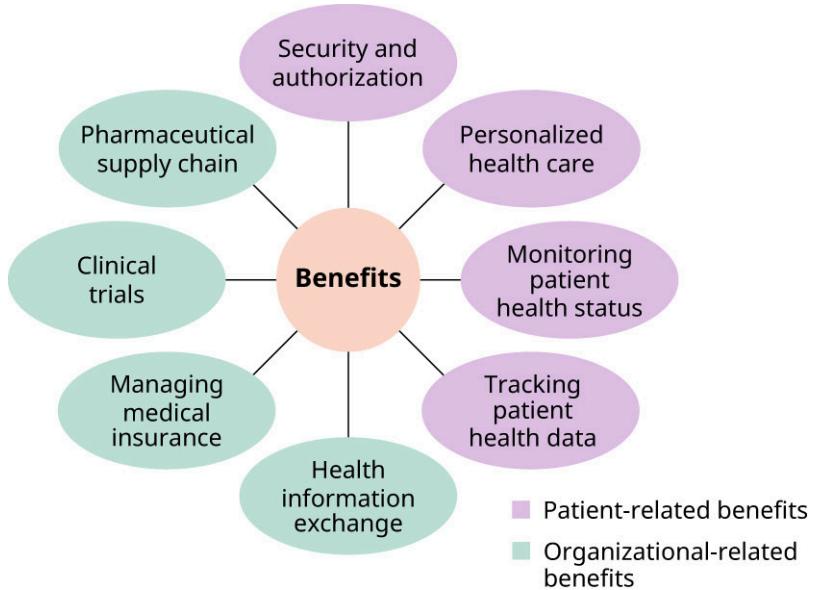


Figure 10.5 Health care's use of blockchain technology has benefits for both the health-care organization and patients. (credit: modification of work "Fig. 3. Benefits of blockchain technology" by Israa Abu-elezz, Asma Hassan, Anjanarani Nazeemudeen, Mowafa Househ, Alaa Abd-alrazaq/*International Journal of Medical Informatics*, Volume 142, October 2020, 104246. <https://doi.org/10.1016/j.ijmedinf.2020.104246>, CC BY 4.0)

Challenges and Risks

The opportunities derived from emerging technologies are indeed exciting; however, with their expected growth and expansion come challenges and associated risks. Security and data privacy will continue to be ongoing concerns as cybercriminals are increasingly sophisticated at usurping the security protocols of networked and cloud-based systems. Broader access to AI tools has equipped adversaries with the means to exploit these technologies, generating misleading or incorrect information. For example, in fall 2023, fake videos generated by AI featured Taylor Swift promoting Le Creuset cookware and Tom Hanks promoting a dental plan. Both celebrities decried the videos as fake content produced without their input or permission.⁴

Artificial intelligence can be used to analyze patterns and detect vulnerabilities faster than security teams can respond as the impact may be increasingly widespread as more of our services become reliant on AI. Users can be tricked into responding to impostor prompts asking for identifying information. These challenges continue to risk the security and data privacy protections needed to protect the personal information of users and customers.

There are also security and data privacy concerns with the use of AR and VR. Unauthenticated data content is sometimes used by AR browsers that facilitate the augmentation process; therefore, people can be misled by false information provided on these sites. Aside from the cybersecurity challenges, the biggest VR danger is its ability to interfere with one's visual and auditory connection to the outside world. When users are immersed in VR, they may experience a sensory conflict between what their bodies are experiencing in the real world and the visuals of the virtual world. This can lead to cybersickness, which may include disorientation, dizziness, and even nausea as users lose spatial awareness. It is crucial to maintain awareness of one's surroundings when immersed in these environments.⁵

Early implementations of blockchain technology have exposed some of the technology's challenges and risks, including ongoing threats to security and data privacy of its users. Additional challenges include the scalability and performance, interoperability, regulatory and legal concerns, and adoption and integration of blockchain technology. Energy consumption is also a significant challenge as blockchain technology requires high-powered computing equipment to create new blocks and verify transactions. The energy needs to power this

⁴ Megan Cerullo, "AI-Generated Ads Using Taylor Swift's Likeness Dupe Fans with Fake Le Creuset Giveaway," ed. Anne Marie Lee, CBS News, updated January 16, 2024, <https://www.cbsnews.com/news/taylor-swift-le-creuset-ai-generated-ads/>

⁵ Ann Pietrangelo, "All About Cybersickness," *Healthline*, February 4, 2021, <https://www.healthline.com/health/cybersickness>

equipment are so great that blockchain technology's energy consumption is causing substantial greenhouse gas emissions and contributing to climate change.

10.2 The Evolving Frontiers of Information Systems

Learning Objectives

By the end of this section, you will be able to:

- Discuss the frontiers of information systems
- Explain the convergence of information systems frontiers and emerging technologies
- Explain the opportunities and challenges related to information systems frontiers

Information systems are constantly evolving as communities of researchers, developers, think tanks, and others have expanded their thinking beyond what many of us can imagine in terms of where information systems may take us next. We have seen the evolution of systems from concept through iterations of change as the technology supporting these systems has evolved. Just look back on the evolution of the Apple iPhone, first introduced in 2007. From its initial functionalities that included mobile phone calling, personal computing, music, and a camera to its more contemporary features such as extended battery life, assistive touch, AI features, and camera resolution, iPhone functionality continues to be developed and enhanced with each new release. What do you think the next step is for the iPhone? How will the future versions of these types of technologies continue to impact our lives?

The Frontiers of Information Systems

The concept of **information systems frontiers** refers to the latest developments in the field of information systems. Frontiers explore new research areas, innovative applications, and emerging technologies that have the potential to significantly impact the field. These frontiers encompass a wide range of topics including data analytics, AI, cybersecurity, cloud computing, mobile computing, and social media.

Data Analytics

Data analytics has been identified as the future of information systems and innovation. In response to the increasing number of systems available and the breadth of data collected, organizations are increasingly looking to utilize this information. Walmart, for example, collects substantial amounts of data from their website (such as purchase histories, and products sold and returned) and in store (like customer demographics, store details, and products sold and returned). These data inform many of their business practices.

Data analytics, as you learned in [Chapter 8 Data Analytics and Modeling](#), is the process of examining datasets to draw conclusions and insights, typically using statistical and computational methods to inform decision-making or solve problems ([Figure 10.6](#)). The insights generated from data analytics help businesses with the foundational information needed to increase performance and operational efficiencies. Along with better decision-making and operational efficiencies, data analytics can lead to the simplification of data, increasing the organization's ability to make sense of the raw data collected and share that data as needed. Refer to [8.3 Analytics to Improve Decision-Making](#) for data analytics tools and techniques that are used to process and examine data, allowing insight into business challenges and future trends, and leading to more informed business decisions.



Figure 10.6 Data analytics uses data visualization to gain a better understanding of the habits of customers, leading to more informed decisions in business offerings and strategies. For example, Walmart might study purchase data to adjust its marketing strategy. (credit: modification of work "Examining Fisheries Data" by NOAA's National Ocean Service/Flickr, Public Domain)

CAREERS IN IS

Tech Market Researcher

Tech market research is becoming increasingly popular as organizations attempt to gauge how well technology-related products are being received. Tech market researchers study market trends, consumer behaviors, emerging technologies, competitor information, and other factors to determine the viability of a new technological product or service. It is a systematic process of gathering, analyzing, and interpreting data related to the technology sector. Specific roles in this area may include analyst, specialist, recruiter, and general researcher, with general focus in wide-ranging areas of technologies to include data cloud computing, big data management, and emerging technologies.

Artificial Intelligence

Artificial intelligence is an important innovation in information systems. Artificial intelligence is increasingly being used in many industries, including health care, logistics, manufacturing, automotive, and publishing, as well as in daily lifestyle applications. Artificial intelligence-enabled computer systems are able to process large amounts of data, identify patterns and trends, and make decisions, tasks that generally require human intelligence and a great deal of time and resources. Artificial intelligence uses reasoning, learning, problem-solving, and perception as it processes the data.

It is important to recognize that to function optimally, AI must be grounded in data that are valid and reliable. Without robust data, AI may produce inaccurate data analyses and biased algorithms. In addition, since AI doesn't have the reasoning capabilities of humans, the technology is poorly suited for situations that require adaptation to change, such as using AI to operate machinery safely.

Artificial intelligence has several subfields that focus on its different aspects

- The field of **machine learning** involves the creation of algorithms and models that enable machines to learn from or make decisions about the data without specific programming.
- A neural network is a method of AI that uses algorithms to teach computers to process data much like the human brain, using image and speech recognition.
- Deep learning uses multiple layers of neural networks to address deeper, more complex decision-making and is often considered a subset of machine learning.
- Cognitive computing simulates human thought processes via reasoning and learning.
- Computer vision teaches machines how to see and interpret information from images or videos using facial recognition, object identification, and segmentation.
- The field of **natural language processing** teaches machines to understand and generate human language and involves tasks such as speech recognition, text analysis, and language translation.

Cybersecurity

Cybersecurity is the practice of protecting internet-connected systems from internal and external threats of unauthorized access, attack, or damage to its technologies and networks. It combines the people, processes, policies, systems, and technology needed to thwart cyber risks, safeguard assets, and protect assets.

Cybersecurity has become increasingly vital to business as the breadth of today's information is managed electronically. The exposure caused by a breach can compromise personal information, leading to a loss of trust and potential financial liabilities. Additionally, cybersecurity allows organizations to remain compliant with regulations, safeguard against identity theft, and protect intellectual property, finances, and people's personal information.

Currently, cybersecurity is a critical aspect of information systems, and this will continue to be true as new technologies emerge. The work of the National Institute of Standards and Technology (NIST) will continue to be important for emerging technologies. The NIST-developed Cybersecurity Framework (CSF) leads as an essential approach for organizations to create and manage their cybersecurity strategy. Refer to [Chapter 5 Information Systems Security Risk Management](#) and [Chapter 6 Enterprise Security, Data Privacy, and Risk Management](#) for more on information on cybersecurity.

As new technologies emerge, there remain several pivotal layers of cybersecurity necessary to guard against ever-evolving cyber threats:

- Application security is a principal component of cybersecurity, adding security inside an application to shield it from attacks on vulnerabilities within its code. Various tools (such as firewalls, antivirus software, encryption techniques, and web application firewalls) combined with various types of application security (authentication, authorization, encryption, logging, and application security testing) assist in keeping applications secure.
- Companies must protect customer, client, employee, and user information from unapproved access, use, modification, loss or deletion. This component is dedicated to protecting the integrity of the data residing within a system.
- Network security protects the network from unapproved access and potential dangers. Firewalls and antivirus software are examples of strategies used to support network security efforts.
- Disaster recovery planning helps businesses identify the necessary and mission-critical applications vital to maintain the operations of the organization and how the implementation of these plans will occur in the event of a cyberattack.
- Operational security encourages management to step inside the role of a hacker to identify areas of vulnerability within the organization.
- End-user security targets the safeguards of individual devices connected to a network, such as computers, tablets, printers, and smartphones. Coupled with end-user education and training, these controls help to alleviate security threats that may be caused by human error.

Biometrics are increasingly used to authenticate a person's identity, such as fingerprints to access smartphones, or the use of facial recognition technology at airport smart-gates. Some examples of biometrics that could be used in 5G network security include fingerprint scanning, iris recognition, and voice recognition.

Cloud Computing

Cloud computing is an emerging technology defined as the use of hosted services like data storage, servers, databases, networking, and software that run over the internet (or an intranet) rather than on private servers and hard drives. Cloud computing services are available via public, private, or hybrid means and are generally owned by a third party, allowing the customer to pay for the choice of how they want their infrastructure to be managed and supported. Review [Chapter 7 Cloud Computing and Managing the Cloud Infrastructure](#) for more information on cloud computing.

CAREERS IN IS

Cloud Engineering

Cloud engineers are increasingly needed to support the design, development, maintenance, security, and management of cloud infrastructures. Cloud engineers ensure the security of the network. Additionally, they assist with the planning and design of cloud computing applications and services for the business, deployment of cloud-based infrastructure, and programming code in various languages such as Java, Python, and C++. They also work with organizations on disaster planning, preparedness, and recovery. Experience working with coding languages, as a systems administrator or network engineer and excellent written and communication skills are necessary to succeed in this position.

Mobile Computing

The emerging technology of **mobile computing** involves the strategies, technologies, products and services that enable users to access information without restricting the user to a single geographic location. Combined, mobile computing technologies support the use of mobile devices that are portable, and wireless devices that are enabled to transmit data, voice, and video communications. The convenience of mobile computing allows people to access network services anywhere and anytime. Most could not have imagined a few decades ago a future where you could call or text a relative in another country from an underground subway train or connect with a long-lost classmate through a social media application.

Mobile computing combines infrastructure (technical pieces that enable communication such as a wireless network), hardware (physical devices such as laptops), and software (applications and operating systems) technologies. Characteristics of mobile computing technologies include portability, connectivity, social interactivity, context sensitivity, and individualization. These are all applicable to the types of mobile devices consumers enjoy using, such as tablets, mobile phones, and laptop computers.

In addition to being able to privately connect, interact, and collaborate with people through different applications, there are several other advantages to mobile computing. For example, studies have shown that mobile computing increases productivity. With the move toward working remotely, organizations have realized that the cost of an office location may not make sense when employees can work from any location and be just as productive.⁶ Mobile computing has also enabled a plethora of entertainment options with applications that provide movies (like Netflix and YouTube), games (such as Wordle), lifestyle content (for example, HGTV and Amazon), and more. Additionally, mobile computing now supports and connects to the cloud and cloud computing services, allowing data such as photos, videos, and documents to be secured for future retrieval.

Mobile computing does have limitations. For example, the range and bandwidth (the capacity at which a network can transmit data) of some devices is limited, leading to transmission interference or unwanted disruptions while communicating. This can severely interrupt the quality of the sound or picture being displayed on the device. Security standards that govern mobile computing technologies also remain an issue as the industry regulations can lag behind the rate of innovation. Additionally, mobile computing technologies present power consumption and battery charging challenges. For example, batteries can be negatively impacted by temperature changes, making it difficult to recharge and maintain battery performance.

The Convergence of Information Systems Frontiers and Emerging Technologies

In the context of computing and technology, **convergence** is the joining of two or more different entities in a single device or system. The convergence of emerging technologies and IS frontiers can create new

⁶ Jane Thier, "Bosses, You're Wrong: Remote Workers Are More Productive than Your In-Office Employees," *Fortune*, October 20, 2022, <https://fortune.com/2022/10/20/remote-hybrid-workers-are-more-productive-slack-future-forum/>

opportunities for innovation and growth as the research and development processes in new frontiers helps foster and promote emerging technologies to develop and evolve. For example, the convergence of AI and data analytics can help organizations make better decisions by analyzing vast amounts of data in real time. It can enable organizations to gain a competitive edge, optimize operations, and drive business value by providing insights into data that a data analyst may not be able to uncover. Data analysts will still be needed to interpret the data in a business sense as these technologies do not yet have the capacity to accomplish such tasks.

The IoT can connect devices and sensors to create smart systems that can optimize operations and enhance user experiences. These technologies can be leveraged to create smart homes, where internet-enabled appliances and devices can be managed remotely via a connected network. For example, IoT smart devices can support the needs of people who are hard of hearing or deaf by providing real-time alerts, such as a smoke detector that activates non-sound-based alarms. Overall, the intersection of emerging technologies and IS frontiers is an exciting area that has the potential to transform various industries and improve people's lives.

Opportunities, Challenges, and Risks of Information Systems Frontiers

The rapidly evolving field of information systems presents both significant opportunities and complex challenges for organizations navigating the digital landscape. Frontiers of information systems, such as data analytics, AI, cloud computing, mobile computing, and social media, provide opportunities, challenges, and even risks to people and organizations as they continue to evolve.

Opportunities

Businesses can expect IS frontiers to expand and grow, becoming more advanced and mature in their functions. For example, natural language processing enhancements will further the abilities of machines to understand and generate human language, making it easier for users to interact with information systems. This expected growth may provide increased employment opportunities to develop and manage such systems, as well as a growth in educational and training opportunities in these areas.

Another opportunity afforded by these systems will be an overall improvement in networking infrastructure, allowing increased compatibility between networked systems. Problems with voice, data, and image transmission will be reduced, improving overall communication quality and delivery. This will also lead to a reduction in hardware and software costs, reducing the overall costs of processing data. Over time, the cost savings should make information systems more affordable, allowing businesses to become more competitive.

We have already seen exponential growth in mobile computing in the variations of devices, their functionality, and their processing power. Mobile computing will continue to exhibit improved functioning, making it easier to use and maintain, and possibly become more affordable in the future.

Challenges and Risks

Data analytics will experience challenges with big data (large amounts of complex data) in that it is unable to be stored, processed, or analyzed in traditional data storage formats—a significant challenge. However, analyzing this data in a timely manner can help decrease risks to society, nature, or the ecosystem. For example, hospitals, pharmaceutical companies, and other medical and health organizations store large amounts of medical data. When completed in a timely manner, data analytics can provide trend analysis and identify potential health-related threats to different communities, improving and even saving lives. Another risk occurs when, even if data are analyzed in a timely manner, the analysis uses bad data, such as those caused by outdated records, inaccurate data integration processes, and data entry errors.

Data breaches are an increasing concern as hackers are becoming more sophisticated in breaking through networks. In health care, which shows much promise in the convergence of IS frontiers and emerging technologies, 45.9 million U.S. health-care records were breached in 2021, 51.9 million breaches occurred in 2022, and this increased to 133 million records exposed, stolen, or otherwise impermissibly disclosed in 2023.⁷ Care needs to be taken to protect data as it is processed in new ways.

Businesses are also challenged to maintain regulatory compliance as the increased use of these technologies continues to push the boundaries of regulatory bodies. It is becoming more difficult and expensive to ensure adherence to these regulations, and violations may result in substantial penalties, data breaches, and reputational risk to the business.

Challenges and risks for cloud computing include misconfiguration of security settings, a common vulnerability that occurs when security settings such as default configurations, improper access controls, insufficient firewall protections, and other misconfigurations result in security issues. The data itself may pose quality issues where duplicate data, corrupt data due to human error, or mixed data types may exist, all creating challenges when gathering data for analysis.

LINK TO LEARNING

The publication [*Information Systems Frontiers: A Journal of Research and Innovation*](https://openstax.org/r/109ISFrontiers) (<https://openstax.org/r/109ISFrontiers>) explores topics in areas of emerging technologies, including research developments in EMI, medical informatics, mobile computing, and e-commerce.

10.3

Societal and Global Importance of Emerging Technologies in Information Systems

Learning Objectives

By the end of this section, you will be able to:

- Identify the societal and global impact of emerging technologies
- Describe the global reach of research and innovation
- Examine how research and innovation lead to emerging technologies
- Discuss questions in emerging technologies

Emerging technologies are changing how information systems-related work and projects are managed.

Virtual assistants and chatbots, machine learning, predictive analyses, resource optimization, natural language processing, data management, and other functionalities of emerging technologies help to automate repetitive and routine tasks, enhance collaboration with team members and stakeholders, and efficiently plan and track project tasks.⁸ Societal innovation can also have a major impact on social groups, resulting in a change in behavior or practice that has far-reaching consequences worldwide. In an era defined by rapid technological advancement, the emergence of innovative technologies has revolutionized societal interactions.

⁷ Steve Alder, "Healthcare Data Breach Statistics," *The HIPAA Journal*, January 15, 2025, <https://www.hipaajournal.com/healthcare-data-breach-statistics/>

⁸ Ana María Choquehuanca-Sánchez, Keiko Donna Kuzimoto-Saldaña, Jhonatan Rubén Muñoz-Huancá, et al., "Emerging Technologies in Information Systems Project Management," *EAI Endorsed Transactions on Scalable Information Systems* 11, no. 4 (2024), <https://doi.org/10.4108/eetsis.4632>

Societal and Global Impact of Emerging Technologies

The societal and global impact of emerging technologies refers to their worldwide effect of change—to economy, culture, public policy, public services, health, the environment, and quality of life. For example, emerging technologies are rapidly changing many aspects of the finance industry. When customers contact their financial institutions with general banking questions, such as location, hours, account balance, and bill payments, they can interact with AI-enabled systems to get the information they need and accomplish banking tasks. Other uses include fraud detection, anti-money-laundering, risk management, credit scoring, and trade and investment services (Figure 10.7). By automating routine tasks, organizational resources (human and financial) can be allocated elsewhere, improving efficiency. As noted during a 2023 panel discussion at the JP Morgan NBFI Leaders Forum in Sydney, Australia, generative AI could add \$2.4 to \$4.4 trillion annually to the global economy.⁹ It is expected to impact 75 percent of areas, such as customer operations, marketing, software engineering, and research and development, while reducing fraud and account rejection rates by 15 to 20 percent.¹⁰ We can also look at these services, enabled by AI and other emerging technologies, as contributors to the closure of over 3,000 branches of large financial institutions in 2023 due to the rise of digital banking.¹¹



Figure 10.7 The financial sector utilizes artificial intelligence to support many areas of its business. (attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license)

Another emerging technology with a societal impact is **self checkout (SCO)**, in which machines are enabled with artificial intelligence technology, product images, barcodes, and other mechanisms for customers to complete purchases. First introduced in the 1980s, SCO technology began appearing in stores in greater numbers in the 1990s. The SCO systems market generated \$3.5 billion in revenue in 2021 and is expected to grow 13 percent between 2022 and 2028 (Figure 10.8).¹²

⁹ Michael Chui, Roger Roberts, Lareina Yee, et al., *The Economic Potential of Generative AI: The Next Productivity Frontier*, (McKinsey & Company, June 14, 2023), <https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-ai-the-next-productivity-frontier#introduction>

¹⁰ "How AI Will Make Payments More Efficient and Reduce Fraud," J.P.Morgan, November 20, 2023. <https://www.jpmorgan.com/insights/payments-optimization/ai-payments-efficiency-fraud-reduction>

¹¹ Courtney Rau and Konner McIntire, "Fact Check Team: Major Banks Close Their Doors amid Rise in Digital Banking," The National News Desk, November 28, 2023, <https://thenationaldesk.com/news/fact-check-team/fact-check-team-major-banks-close-their-doors-amid-rise-in-digital-banking-pnc-jpmorgan-chase-bank-of-america-citizens-federal-deposit-apps-websites-branches-locations>

¹² "Global Self-Checkout Systems Market Size, Share, Trends, Industry Growth by Component (Systems, Services), by Type (Cash, Cashless), by Application (Retail, Financial Services, Entertainment, Travel, Healthcare, Others), by Region, and Forecast to 2028," Research Corridor, updated March 6, 2024, <https://www.researchcorridor.com/self-checkout-systems-market/>



Figure 10.8 Self-checkout systems, which rely on artificial intelligence technology, enable customers to independently complete purchases. (credit: "Self Checkout" by "pin add"/Flickr, CC BY 2.0)

LINK TO LEARNING

The processes of [self-checkout technology](https://openstax.org/r/109SelfCheckout) (<https://openstax.org/r/109SelfCheckout>) have encountered unexpected challenges, including scanning difficulties, inaccuracy of produce scales, problems with weights in bagging areas, missed scans, and theft, to name a few. This technology can be costly to a business with a four-kiosk system, costing six figures, on average. Some organizations are reversing the course on this technology by putting limits on its use, installing cameras, and even removing systems.

The societal and global impact of emerging technology may not be apparent right away. For example, social media began in the 1990s with small platforms like Classmates.com, GeoCities.com, and SixDegrees.com, all with messaging and chat functions. Today, billions of people worldwide use social media daily for purposes including finding entertainment, interacting with others, and conducting business. Social media has expanded beyond its original designs to include e-commerce functions that allow users to buy, sell, or trade items, earn income, and find other financial incentives for use. Businesses often utilize e-commerce functions to run targeted ads, build brand awareness, generate online sales, and attract a global online following. The interaction of businesses in real time can foster a sense of community and loyalty.

Another example is the availability and adoption of solar power by consumers. First introduced in the 1980s, solar power has experienced significant growth as a result of improved solar energy technology. The conversion of energy from the sun into power for electricity and heat, or solar power, is generated through the use of solar panels. These can be found for general use on private rooftops or solar farms/fields, and large areas of land with interconnected solar panels generate large amounts of energy at the same time.

The advancements in solar power technology along with federal incentives and tax credits in the United States have increased sales of solar cells. Over five million solar systems have been installed with enough solar energy-generating systems installed to power 32.5 million homes (Figure 10.9).¹³ In other parts of the world, solar technology is being adopted in places where laws have been passed to enable access of solar energy to their citizens. The adoption and widespread use of this emerging technology have helped consumers lower electricity bills, increase property values, and reduce dependence on fossil fuels, all positive impacts on public health and the environment.



Figure 10.9 Solar farms, such as the one shown here, use solar panels to convert energy from the sun into power used to support electricity and provide heat. (credit: "Hawaii solar; a photovoltaic power station" by Reegan Moen, U.S. Department of Energy/Wikimedia Commons, Public Domain)

While there are positive societal and global impacts of emerging technology, such as job creation, improved access to education and health care, and environmental conservation efforts, there can also be negative consequences. Unintended consequences of emerging technology include increased inequality, job loss, and a harmful impact on the environment. For example, using AI may be challenging for individuals with different abilities, reducing the opportunity for them to interact with AI-enabled systems. Similarly, solar power technologies are limited to those who have the financial means to invest.

LINK TO LEARNING

Read this article from *Forbes* to learn [how AI can exploit consumer vulnerabilities](https://openstax.org/r/109EthicsAI) (<https://openstax.org/r/109EthicsAI>) if not built and trained ethically, especially in the marketing industry.

The global impact of emerging technologies is also evident across frontiers in information systems. Data analytics tools and techniques are being used and applied in all aspects of society from transportation to health care, marketing to education, finance to political campaigns. Public health organizations collect nonidentifying information on disease prevalence to spur and fund research efforts, provide targeted medicines, improve efficiencies in health care-related supply chains and logistics, resource health care, and initiate targeted marketing campaigns aimed at increasing awareness and disease prevention. The year-by-year identification of different strains of flu and its prevalence is an example of how data analytics can drive

¹³ "5 Millions Solar Installations: Powering American Communities," Solar Energy Industries Association, updated May 2024, <https://seia.org/5m/>

societal and global change.

We also see the societal and global impacts of data analytics in the frontier of education. A student's personal learning experience is enhanced, educational resources are optimized, and the student's strengths and weaknesses are identified in order to tailor instruction and set them up for success. The same transformative effects can be seen in environmental conservation efforts where deforestation, pollution, and climate change data are collected and used to enact positive change. This is evident, for example, in the World Resources Institute's work on global forestry, where analytics is helping to identify deforestation in countries across the world, improving impacts to climate, biodiversity, and human well-being.¹⁴

The Global Community of Research and Innovation

Without research and development, we would not have smartphones, computers, the internet, or any of the technologies many of us use on a daily basis. Research and development are crucial in ensuring that technology continues to evolve and improve, and that new and innovative solutions are developed to address emerging challenges.

The global community of scientists supporting research and innovation continues to make strides toward furthering new findings, technologies, and processes. And those latest developments in the field of information systems continue to push to further the potential reach of new technologies worldwide. For example, global growth in data analytics and the predictive analytics market is expected to grow from \$16.41 billion in 2023 to \$83.98 billion by 2032.¹⁵

Regionally, North America is leading global efforts in data analytics and the predictive analytics market, and the largest increases in growth are in Europe, Asia-Pacific, Middle East and Africa, and South America.¹⁶ Together, countries in these regions are increasingly seeing solution and service gains in banking, financial services, insurance, health care, telecommunications, and information technology. For example, the banking industry is using these technologies to customize insurance plans and premium amounts based on user data and documentation. Large global organizations will dominate these markets as they have increased their capacity to store, process, and analyze large amounts of data to leverage the outcomes and create marketing strategies that target customers and improve user experiences.

We can also find global communities working to adopt and expand on these technologies in uses like the continued adoption and development of 5G. This fifth-generation wireless technology is an example of how mobile computing is evolving regionally and throughout the world, increasing the speed of use, enhancing connectivity, and enabling other mobile options while connected. The next generation, 6G technology is currently being developed in regions throughout the world and is expected to be available in the United States in 2030.¹⁷

How Research and Innovation Lead to Emerging Technologies

Research and innovation have played a significant role in the growth of emerging technologies. Research, or the systematic process to generate understanding or knowledge, is a precursor to innovation, the process of using the knowledge generated from research to meet real needs. When we think of research, we might imagine a scientist behind a microscope. But research can be thought of more broadly, beginning with a broad idea, leading to preliminary investigation, designing and planning, collecting and interpreting data, and then disseminating findings.

¹⁴ Mikaela Weisse, Elizabeth Goldman, and Sarah Carter, "Forest Pulse: The Latest on the World's Forests," *World Resources Institute*, updated April 4, 2024, <https://research.wri.org/gfr/latest-analysis-deforestation-trends>

¹⁵ *Global Market Overview and Competitive Analysis* (Introspective Market Research, May 2024), <https://introspectivemarketresearch.com/reports/data-science-and-predictive-analytics-market/>

¹⁶ *Global Market Overview and Competitive Analysis* (Introspective Market Research, May 2024) <https://introspectivemarketresearch.com/reports/data-science-and-predictive-analytics-market/>

¹⁷ "ITU's IMT-2030 Vision: Navigating Towards 6G in the Americas," 5G Americas, September 2024, <https://www.5gamericas.org/itus-imt-2030-vision-navigating-towards-6g-in-the-americas/>

Innovation is a catalyst for change as stagnation or inactivity can impede the growth of a competitive and fiscally sound organization. The innovation process is generally composed of three systematic steps: conception, implementation, and marketing (Figure 10.10). It begins with a conceptual idea—its evaluation, the generation of requirements, and the planning needed for potential implementation. The implementation stage is where the idea is further developed or constructed, and a prototype or pilot is produced and tested. Generally, within the marketing step, the prototype or pilot application is moved to production or to launch for use. The organization may also choose specific markets to release the product.

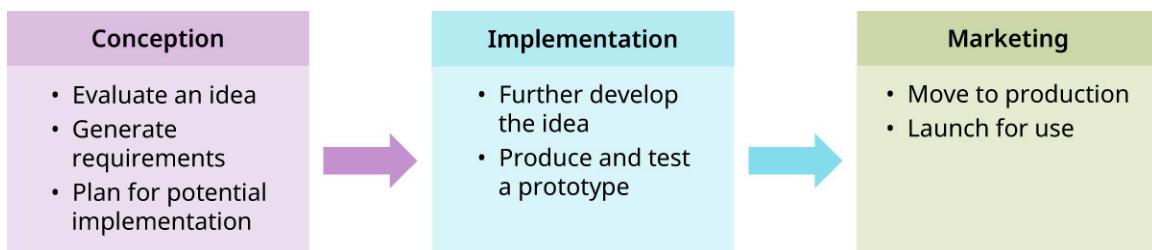


Figure 10.10 Innovation can occur in three steps: conception, implementation, and marketing. (attribution: Copyright Rice University, OpenStax, under CC BY 4.0 license)

FUTURE TECHNOLOGY

Agricultural Technologies

The agricultural industry continues to make research and innovation gains in addressing food insecurity, animal welfare, the environmental impacts of meat production, and the overall protection of human health. Research and innovation advances in tissue engineering techniques and regenerative medicine technologies have led to the production of cultured or cultivated meat, produced from culturing animal cells *in vitro*. These advances represent new and innovative approaches that significantly enhance the efficiency, productivity, and sustainability of farming practices as they integrate digital tools, sustainable practices such as drone monitoring, precision agriculture using GPS, and automation and robotics. *New Harvest*, a leading U.S.-based nonprofit research organization, is pioneering these emerging technologies ¹⁸ with the goal of reducing dependence on animal agriculture by using cells instead of animals.

Through its continuous research and innovation processes, India has become a global leader in information technology and **business process outsourcing (BPO)**, a service industry that supports outsourcing of business service operations to third-party vendors. It is estimated that these services have garnered \$157 billion in the fiscal year 2021–22, comprising \$106 billion of information technology services and \$51 billion of BPO services, respectively. ¹⁹ This growth has also contributed to the emergence of an Indian workforce trained to solve complex problems and manage the technical functions of global corporations including consulting, design, product development, business process management, and infrastructure support.

Governments, think tanks, and private enterprises have also made major contributions to the research of new discoveries and uses for emerging technologies. The U.S. government has contributed to research and innovation through its support of federally funded agencies, such as the Department of Defense, the National Science Foundation, National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency Office of Research and Development. According to the National Science Board, the proposed fiscal year 2025 budget for federal research and development is approximately \$201.9 billion, with the Department of Defense (DOD) accounting for 46 percent and the Department of Health and Human Services accounting for 25 percent. ²⁰

¹⁸ "New Harvest Is a Field-Building Organization Advancing Cellular Agriculture Globally," New Harvest, accessed December 19, 2024, <https://new-harvest.org/>

¹⁹ "How India Is Emerging as the World's Technology and Services Hub," EY India, January 27, 2023, https://www.ey.com/en_in/india-at-100/how-india-is-emerging-as-the-world-s-technology-and-services-hub

The RAND Corporation, considered one of the top think tanks in the world, is an example of an organization or institution that maintains a scholarly and interdisciplinary approach to research on particular issues, policies, or ideas. The RAND Corporation receives public and private funds to support research efforts, educational opportunities, analyses, consulting, training, and other services, with \$390 million in revenue in 2023.²¹ Areas of expertise include public policy, education, environment, national security, law, and corporate governance, and also science, technology, infrastructure, defense, and economic development.

Questions in Emerging Technologies

While there is an emphasis on a multidisciplinary approach for emerging technologies in information systems that draws from such fields as computer science, telecommunications, operations research, economics, and cognitive sciences, the field is constantly evolving, and there are many questions to explore. Here are some of the central issues.

How can we ensure the ethical and responsible use of emerging technologies such as AI, blockchain, and the IoT? Ensuring the ethical and responsible use of emerging technologies should occur at individual and organizational levels as there is a great deal at stake. As complex technologies are developed, it is necessary to consider bias, fairness, transparency, privacy, and data protection as well as the human control of these technologies. Additional proactive ethical strategies to consider include the following:

- Promote open and transparent dialogue among technical teams, users, leadership, and other stakeholders about the ethical implications needed to navigate the complex landscape that technologies may bring.
- Foster collaboration and engage diverse stakeholder perspectives to create, adopt, and promote ethical standards.
- Embed ethics within the design through all stages from conception to implementation. Be sure to address questions in the integration to cover processes in place, levels of access, responsible parties or departments to respond, and ongoing monitoring processes.
- Invest in research and education of emerging technologies to aid in the development of ethical guidelines.

How can we design information systems that are resilient to cyberattacks and other security threats? As new technologies and attack vectors emerge, how can we keep systems and data safe? Organizations have recognized the need to design information systems that are resilient to cyberattacks and other security threats. Creating cyber-resilient strategies is key to safeguarding systems and data, such as the following best practices:

- Identify emerging trends in cybersecurity. Explore the specific technology and the threats that may be inherent in them. Discuss the challenges posed for each, the potential controls, validating techniques and other means to manage their vulnerabilities with leadership and other stakeholders.
- Build a resilient infrastructure. Be sure to build a comprehensive cybersecurity infrastructure that includes all the hardware, software, firewalls, encryption protocols, and regular security surveillance needed to mitigate potential risks.
- Collaborate with external partners. Explore collaborative communities to include vendors, industry peers, and governing organizations. The value of partnerships with external partners may far outweigh the cost of an attack.
- Explore the cybersecurity landscape. Research the evolving nature of threats, methods to address them, and potential impacts to the organization, such as regulatory penalties, financial losses, reputational damage, and the loss of customer trust.
- Implement training and security protocols within the organization to include user controls, privileges, and data access. Multifactor authentication and regular access reviews can also aid in strengthening security.

20 Laurie Harris, Lisa S. Benson, Marcy E. Gallo, et al., *Federal Research and Development (R&D) Funding: FY2025* (Congressional Research Service, December 9, 2024), <https://crsreports.congress.gov/product/pdf/R/R48307/2>

21 2023 RAND Annual Report (RAND Corporation, April 10, 2024) 39, https://www.rand.org/pubs/corporate_pubs/CPA1065-4.html

- Develop an incident response plan. Creating a culture of prompt incident reporting to test the effectiveness of systems is needed to identify areas of improvement.

How can we leverage emerging technologies to improve health-care delivery and patient outcomes? For example, can AI be used to diagnose diseases more accurately or predict patient outcomes more effectively? Emerging technologies are increasingly used throughout the health-care sector to improve health-care delivery and patient outcomes. According to the Health Information and Management Systems Society, a leading organization driving reformation of health-care delivery through information and technology, health-care stakeholders are optimistic about emerging health-care-related tools and technologies and their ability to improve accuracy and efficiency in care.²² Another study found that 80 percent of 80 percent of health organizations intend to expand their use of digital systems between 2022 and 2027.²³ [Figure 10.11](#) shows some of these emerging technologies and some examples of how they are being used to support health-care delivery:

- Artificial intelligence has been leveraged in areas such as clinical decision support where presenting conditions can be narrowed down to further identify a diagnosis or causation of a presenting health challenge. It can also improve the accuracy of the diagnosis using predictive analyses and other functionality. Additionally, AI has been used to support standard operating procedures, ensuring that patient care protocols are consistently adhered to.
- Cloud computing has enabled health-care organizations to expand their capacity for data storage and scalability. Cloud computing–enabled interoperability in devices supports collaboration and data-sharing capabilities between patients and their care team.
- The management and secure transfer of patient medical records through hospitals, pharmacies, diagnostic laboratories, and other health-care entities have been attributed to the use of blockchain technologies. Its system also enables increased protection and safeguards of health-care data.
- The IoT enhances patient monitoring capabilities, medication adherence, and overall well-being. IoT–enabled devices support videoconferencing, allowing patients to confer with their medical team remotely. These devices also support the distribution of medical information where patients can use their mobile devices to track health measures or check the results of medical tests.

²² "Future of Healthcare Report: Exploring Healthcare Stakeholders' Expectations for the Next Chapter," HIMSS, August 11, 2021, <https://www.himss.org/resources/future-healthcare-report-exploring-healthcare-stakeholders-expectations-next-chapter>

²³ Bill Siwicki, "Where to Invest Increasing Digital Health Dollars," Healthcare IT News, August 24, 2022, <https://www.healthcareitnews.com/news/where-invest-increasing-digital-health-dollars>

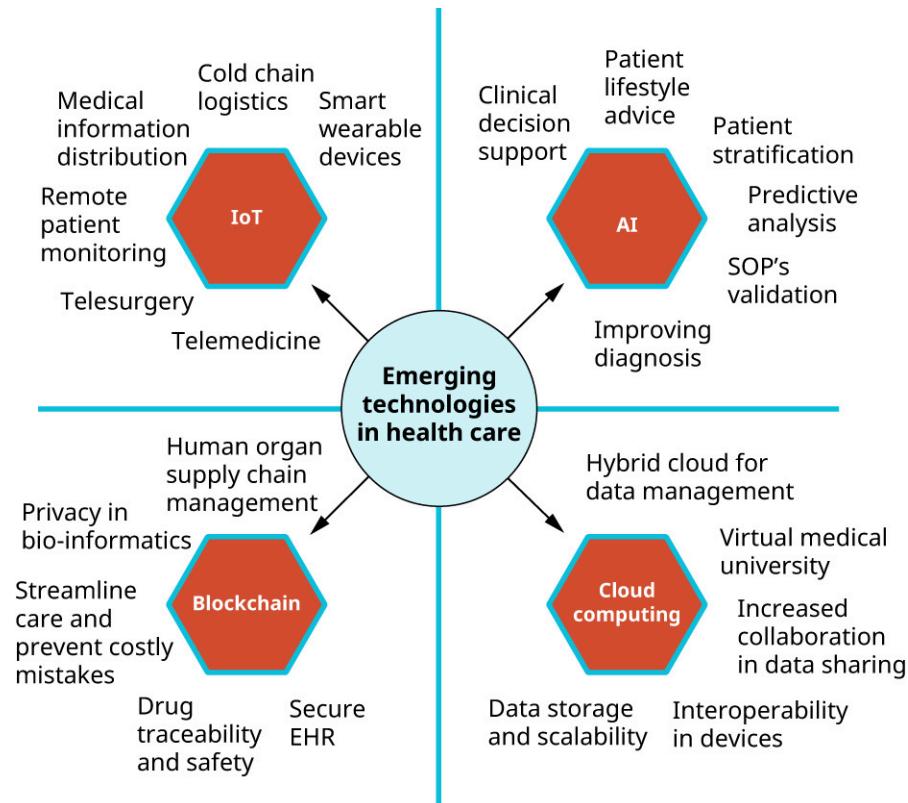


Figure 10.11 Emerging technologies support several segments of health-care delivery to include clinical integration and operational optimization. (credit: modification of work “Figure 2” by Abdulatif Alabdulatif, Ibrahim Khalil, and Mohammad Saidur Rahman, “Security of Blockchain and AI-Empowered Smart Healthcare: Application-Based Analysis,” *Applied Sciences* 12, no. 21 (October 31, 2022): 11039, <https://doi.org/10.3390/app12211039>, CC BY 4.0)

What are the implications of emerging technologies for the future of work? How will automation and AI impact the job market, and how can we prepare workers for this new reality? There are some who believe that emerging technologies will take away jobs. A more optimistic viewpoint explores the potential these technologies will have to not only enhance and transform the skills and competencies of the current workforce but also add new types of roles to augment existing roles. For example, traditional sales jobs (cold-calling, door-to-door) may have decreased due to the introduction and use of new technologies; however, new opportunities have been created and leveraged for companies to hit their sales targets. For example, automating sales activities can increase efficiencies such as lead qualification and generation, the use of virtual assistants to manage human tasks more efficiently, and algorithms to identify promising prospects. Data analytics can also create algorithms to identify opportunities and customer-focused prospects. Additionally, social media provides marketing options, reducing the need for cold-calling, improving the reach of services, and increasing the potential to attain sales goals. According to the *Harvard Business Review*, there are several capabilities companies need to have or build to realize the value of AI to exceed its costs.²⁴ They recommend that companies change behaviors to maximize learning, control experimentation to determine the value of a potential full organizational rollout, measure the value of the technology for the business, manage the data as current data stores may need to be augmented to support the potential volume of data captured, and develop personnel to engage with the technology to improve productivity and operations.

²⁴ Tom Davenport and John J. Sviokla, “The 6 Disciplines Companies Need to Get the Most Out of Gen AI,” *Harvard Business Review*, July 8, 2024, <https://hbr.org/2024/07/the-6-disciplines-companies-need-to-get-the-most-out-of-gen-ai>

How can we ensure that emerging technologies are accessible to all, regardless of income, location, or ability? How can we bridge the digital divide and ensure that everyone has equal access to the benefits of new technologies? The adoption of responsible and inclusive approaches is necessary to ensure inclusivity and accessibility of emerging technologies. According to the World Health Organization, an estimated 1.3 billion people, or 16 percent of the global population, experience significant physical and/or mental disabilities.²⁵ Best practices for inclusive and accessible design include conducting user research, engaging diverse perspectives, prioritizing features, and creating flexible designs that are tested and iterated. We must bridge the gap between the technological world and users to increase accessibility. Some technologies have been developed with accessibility challenges in mind, such as GPT-4 offering advanced capabilities such as visual assistance to those who are visually impaired. Apple has introduced a wide range of tools to improve voice-controlled and assistive technology functions within its devices. Additionally, Google has improved its navigation features within Google Maps so users can access wheelchair accessibility, walking routes, and live experiences for those with visual impairments.

As emerging technologies continue to evolve, research and development will continue to address new issues and ensure that technology advances and meets society's needs. An important part of this will be addressing the power demands of AI and other emerging technologies. To ensure that organizations have sufficient resources to support these power needs, research and development need to focus on sustainable energy practices. This may include efforts such as the development of processors that are more energy efficient and collaboration on open sources to share power. Efforts to manage the power consumption of emerging technologies can reduce these technologies' environmental footprints as well as improve efficiencies and cost-effectiveness.

ETHICS IN IS

Ethics in the United Kingdom

There are growing calls for ethics in research and innovation, particularly as emerging technologies are increasing their global reach and impact. The UK Research and Innovation organization is one such entity that has acknowledged the need for collective responsibility where funders, researchers, stakeholders, and the public all have a role to play. The organization says that the responsibility goes beyond the consideration of risk and regulation and should also be aligned with creating value for society in an ethical and responsible way. The Framework for Responsible Research and Innovation was created as a guiding process to promote creativity and opportunity for science and innovation.²⁶

²⁵ "Disability," World Health Organization, March 7, 2023, <https://www.who.int/news-room/fact-sheets/detail/disability-and-health>

²⁶ "Framework for Responsible Research and Innovation," UK Research and Innovation, updated March 16, 2023, <https://www.ukri.org/who-we-are/epsrc/our-policies-and-standards/framework-for-responsible-innovation/>



Key Terms

- augmented reality (AR)** technology that overlays digital information onto a user's environment in real time
- blockchain** shared, immutable ledger that facilitates the process of recording transactions and tracking assets
- business process outsourcing (BPO)** service industry that supports outsourcing business service operations to third-party vendors
- convergence** joining of two or more different entities; in the context of computing and technology, into a single device or system
- cryptography** process of hiding or coding information so that only the intended recipient can read it
- emerging technology** software or hardware that enhances the user experience by obtaining or using information and data in new and exciting ways; can be used to describe new technologies or the continuing development of existing technologies
- enterprise modeling and integration (EMI)** process that uses computer-based tools to model the business structure and facilitate the connection of its technology, work, and information flow across an organization
- generative AI** type of artificial intelligence that creates new content or ideas in the form of text, images, videos, music, audio, and other forms of data
- information economics** branch of microeconomics that analyzes how economic decisions and consumer behaviors are influenced by knowledge and power
- information systems frontiers** latest developments in the field of information systems, exploring new research areas, innovative applications, and emerging technologies that have the potential to significantly impact the field
- machine learning** use of algorithms and models that enable machines to learn from or make decisions about data without specific programming
- mobile computing** strategies, technologies, products, and services that enable users to access information without restricting the user to a single geographic location
- natural language processing** teaching machines to understand and generate human language; involves tasks such as speech recognition, text analysis, and language translation to build this understanding
- quantum computing** use of quantum mechanics principles to perform complex calculations exponentially faster than traditional computers
- robotics** branch of engineering and computer science that involves the conception, design, building, and operation of robots, creating intelligent machines that can assist humans with a variety of tasks
- self checkout (SCO)** machines enabled with artificial intelligence technology, product images, barcodes, and other mechanisms for customers to complete purchases
- virtual reality (VR)** computer-generated environments that simulate reality and allow users to interact with three-dimensional environments



Summary

10.1 Defining Emerging Technologies

- Emerging technology is defined as software or hardware that enhances the user experience by obtaining or using information and data in new and compelling ways. It includes novel technologies and the continuing development of existing technologies.
- Emerging technology can be found in many areas including education, information technology, and AI, and continues to have great potential to provide synergies with other technologies of similar or different functionalities.
- Characteristics of an emerging technology include its novelty or newness, rapid advancement, and disruptive potential.
- Emerging technologies may be developed from a combination of private and/or public entities, such as government agencies and educational institutions.

- Blockchain, AI, AR, and VR are all real-world applications of emerging technologies.
- Opportunities, challenges, and risks are apparent with these technologies and should be considered for each technology.

10.2 The Evolving Frontiers of Information Systems

- Frontiers of information systems are the latest developments in the field of information systems.
- IS frontiers explore new research areas, innovative applications, and emerging technologies that have the potential to significantly impact the field.
- The convergence of IS frontiers and emerging technologies provides opportunities for two or more of these technologies, like AI and data analytics, to converge, which can help organizations analyze vast amounts of data in real time and inform decision-making.
- The opportunities, challenges, and risks associated with these information systems continue to evolve as they are further integrated for business and personal use.

10.3 Societal and Global Importance of Emerging Technologies in Information Systems

- Emerging technologies can have far-reaching societal and global consequences.
- The emergence of innovative technologies, such as AI-enabled customer service systems in banking, SCO machines, e-commerce-enabled websites, and solar power, has revolutionized societal interactions and affected worldwide change in economy, culture, public policy, public services, health, and the environment.
- Data analytics tools and techniques are being applied in all aspects of society, helping organizations to leverage their functionality to support business processes.
- Emerging technologies and innovations are expected to continue to grow globally to include data analytics, IoT, and others, with solution and service gains in the banking, financial services, and insurance sector, health care, telecommunications, and information technology.
- Research is a precursor to innovation, and it begins with a broad idea and ends with the dissemination of findings. The idea, or concept, evolves through specific process steps to where it will be available for market use.
- Emerging technologies will continue to evolve and so will be of great importance in research and development. As the field continues to evolve, new questions will arise, and researchers will need to work together to find answers.



Review Questions

1. Which of the following statements about emerging technologies is false?
 - a. Emerging technologies only include hardware.
 - b. They can be described by their novelty, disruptive potential, and rapid advancement.
 - c. Augmented reality, virtual reality, Internet of Things and artificial intelligence can be considered emerging technologies.
 - d. The progressive nature of these technologies allows for synergies with other technologies.
2. What term refers to digital money used for online transactions?
 - a. artificial intelligence
 - b. blockchain
 - c. bitcoin
 - d. augmented reality
3. Which statement best describes the convergence of frontiers of information systems and emerging technologies?
 - a. Connecting Internet of Things and devices creates a disruptive environment and negatively impacts user experiences.

- b. It enables organizations to create new opportunities for innovation and growth.
 - c. Blockchain combined with augmented reality and virtual reality can lead to profit losses for organizations.
 - d. The role of data analysts will no longer be needed as the convergence of emerging technologies and innovation systems has the potential to accomplish analysis-related tasks.
4. Frontiers of information systems present several opportunities, challenges, and risks for use. Which of the following is an opportunity?
- a. It can increase compatibility between networked systems.
 - b. It will lead to a reduction in hardware and software costs, increasing the overall costs of processing data.
 - c. Data breaches become of increasing concern.
 - d. Adherence challenges to regulatory compliance requirements may be at risk.
5. Which of the following is true about societal and global impacts of emerging technologies?
- a. They only affect small groups.
 - b. Emerging technologies have only had a small effect on communities.
 - c. Academia is the only area of societal change.
 - d. Artificial intelligence-enabled systems are examples of the societal and global impacts of emerging technologies.
6. Why is solar power considered an emerging technology?
- a. It has seen widespread adoption, helping consumers to lower their electricity bills.
 - b. Laws have been passed to prevent companies from marketing these products to consumers.
 - c. Economies have been negatively impacted by its widespread use.
 - d. It has decreased dependency on fossil fuels.
7. How do data analytics support health-care efforts?
- a. It helps to identify different strands of the flu and its prevalence in communities.
 - b. The data collected reduce efficiencies in health care-related supply chains and logistics.
 - c. It provides information on health-care resourcing to help organizations identify staffing and financial needs.
 - d. It helps to initiate targeted marketing campaigns aimed at increasing awareness and disease prevention.
8. Which is not a correct statement about research and innovation in technology?
- a. It has contributed to significant growth in the data analytics and predictive analytics markets.
 - b. Global growth in technologies has been experienced in several countries in varying sectors of business.
 - c. Research and innovation activities further new findings, technologies, and processes.
 - d. It has been funded primarily by governments in all countries.
9. What is the purpose of research as it relates to technology?
- a. It is the precursor to innovation.
 - b. It is a secondary component within the design process.
 - c. Research provides the full picture of how the technology is supposed to function.
 - d. Research prevents innovation from being adopted by consumers.
10. Which of the following is a true statement about the process of innovation?
- a. It follows the systematic steps: conception, implementation, marketing, and communication.
 - b. Analyzing and recording information is the first step in identifying and selecting resources.
 - c. The scientific research process and associated skills are at the core of the research process.
 - d. Information must be recorded and communicated immediately.
11. Which of the following is a false statement as it relates to the Internet of Things in health care?

- a. It enhances patient monitoring capabilities, medication adherence, and overall well-being.
- b. It supports the distribution of medical information.
- c. Patients can use their mobile devices to check the results of medical tests.
- d. It creates challenges in videoconferencing with the medical care team.

Check Your Understanding Questions

1. What are the major differences between virtual reality and augmented reality?
2. What is the U.S. Department of Energy's relationship to emerging technologies?
3. Describe how blockchain technology supports the safe use of cryptocurrency.
4. How do augmented reality and virtual reality enhance user shopping experiences?
5. What is the difference between emerging technologies and frontiers of information systems?
6. What are the main goals in using different tools and techniques in data analytics?
7. What are some opportunities provided by mobile computing technologies?
8. What is a drawback to not analyzing big data in a timely manner?
9. What is the relationship of emerging technologies and society from a global perspective?
10. How are businesses able to leverage e-commerce functions using social media?
11. How does data analytics support education?
12. What is the importance of research in innovation?
13. How do research and innovation lead to emerging technologies?
14. What is the purpose of fostering collaboration of stakeholders in creating ethical and responsible use of emerging technologies?
15. How does the identification of emerging trends in cybersecurity help to create a cyber-resilient information system?

Application Questions

1. Discuss the benefits of blockchain technology in health-care organizations.
2. Watch this [Wall Street Journal video \(https://openstax.org/r/109BatteryPlant\)](https://openstax.org/r/109BatteryPlant) that highlights an engine factory in Germany that is being transformed into a battery plant. Why is so much software development involved in the making of electric vehicles? Why might electric vehicle start-ups have a certain advantage in writing software? Why might software development be a difficult task for traditional automakers like VW to manage?
3. Discuss how banks have optimized many of their customer service functions with the use of artificial intelligence.
4. Describe how frontiers of information systems technology is used to enact positive social change.
5. Business process outsourcing has evolved as a major technology-supporting industry. Discuss the importance of business process outsourcing and its impact on the industry.
6. How has the evolution of technology changed telemedicine?

