Chapter 1

Digital Disruption and the Fourth Industrial Revolution

The Evolution of Digital Technologies

We are living in an era defined by remarkable technological advances. Since the mass adoption of the personal computer in the 1980s, we have seen and lived through many changes in our work and leisure activities. Significant shifts have taken place in the economy, finance, businesses, education, government, health care, manufacturing, charity, and even art as the result of developments in digital technologies. Particularly notable is how quickly those digital technologies have evolved. To name a few examples, while floppy disks sound archaic, they were widely used throughout the 1990s, only three decades ago. Their storage capacity of the 3.5-inch floppy disk was 1.44 MB. Today's much smaller USB drive holds 128 GB or more. It was less than thirty years ago, in August 1991, that the very first web page on the World Wide Web by Tim-Berners Lee went live.[1] Now, we can no longer imagine the world without the World Wide Web. It has become a platform for almost every human activity. It was in 2007 that Apple's iPhone, the first smartphone that enabled people to fully access and navigate the World Wide Web, was released. Less than a decade later, the smartphone became ubiquitous.

With the exponential increase in computing power, digital technologies are continuing to advance at a rapid pace. Recent breakthroughs in machine learning techniques of artificial intelligence (AI) have enabled machines to take on tasks that had been regarded as things only humans could perform. Such tasks include image classification, translation, speech recognition, and medical diagnosis. Virtual reality systems, such as HTC Vive and Oculus Rift, have become affordable for the consumer electronics market. A drone, which used to be an obscure military technology, is now widely used for recreational and commercial purposes. Synthetic biologists are building genetic circuits and biological parts to assemble organisms, hoping to make biology and electronics fungible.[2]

Digital Disruption

These technological advances have brought significant changes in many fields. The term *digital disruption* tries to capture this all-encompassing impact of today's fast-advancing digital technologies on our society. It refers to "an effect that changes the fundamental expectations and behaviors in a culture, market, industry, or process that is caused by, or expressed through, digital capabilities, channels, or assets."[3] The emphasis is placed on the nature of the change. Digital technologies are disruptive in that they drive changes in the expectations and behaviors of both consumers and businesses, which are fundamentally different from those in the past. There is no shortage of examples of digital disruption around us.

Amazon Go, Amazon's brick-and-mortar store, is a good example. The first Amazon Go store opened in 2018. In appearance, an Amazon Go store is not much different from many other physical stores where food items are stocked on shelves for shoppers to browse and purchase. But it has neither a cashier nor a checkout line. Shoppers at an Amazon Go store simply grab the items that they want to buy, and Amazon automatically charges their credit cards when they leave the store. How is that possible?

Leading-edge digital technologies, such as sensor fusion, computer vision, and deep learning algorithms, are brought together to make this "Just Walk Out Technology" a reality.[4] An Amazon Go store is fitted with many cameras and sensors that track an item's location, weight, temperature, and so on, and with computing devices that process the data from those sensors and cameras.[5] These electronics detect changes when a shopper takes a product from the shelf or returns it and keep track of the picked-up item in a virtual cart. When shoppers enter or exit the store, they scan a QR code with the Amazon Go app on their smartphones. This allows the store to identify shoppers and mark the beginning and end of each shopping trip. When a shopper leaves the store, Amazon automatically charges their credit card for the items

taken and sends a receipt. At the time of this writing, there are seventeen Amazon Go stores, and six more are planned in Chicago, New York City, San Francisco, and Seattle. Amazon intends to open as many as three thousand stores by 2021.[6]

The Amazon Go store offers advantages to both shoppers and Amazon. Time-constrained shoppers will no doubt welcome the fast shopping experience without having to wait in a long line to check out. Shoppers also no longer need to carry a means of payment, such as cash or a credit card. The Amazon Go app on a smartphone is all that is needed. This will be quite convenient for those who have not planned to shop but have a few things to buy. If they happen to pass an Amazon Go store, they may drop in for a short visit. To Amazon, an Amazon Go store also presents a clear value proposition. With everything automated and handled by sensors and computing devices including the checkout process, Amazon does not have to hire cashiers nor many store clerks, thereby saving on wages. Since the store needs much less labor to operate, it can stay open for longer hours at a much lower cost, which is likely to increase the revenue. In addition, the store requires much less space since it does not need checkout stands and space for lines, yet it can handle a large number of shoppers because their shopping trips will be completed much more quickly without the separate checkout process.

It would not have been possible to realize these benefits without the necessary digital technologies. In that sense, technology has been pivotal in creating this type of new business opportunity and customer experience. Thus, digital technologies can make businesses operate differently than they had in the past. An Amazon Go store's everyday operation depends on the performance of the software and hardware components of the store. Without them, it cannot function as a store at all. By contrast, store clerks and managers are much less important because sensors and data analytics can generate needed information to optimize the store operation without requiring much input or help from those store clerks and managers. Naturally, Amazon will invest heavily in the IT side of the Amazon Go store and prioritize it over the HR side.

New types of businesses, such as Amazon Go, may also lead to different expectations from customers. People will no longer care much about the cheerful attitude and the helpfulness of store clerks. While those have been traditionally important factors for customer satisfaction, a store that does not require a separate checkout process makes them simply irrelevant. Instead, the smooth functioning of the Amazon Go app and the accurate and fast tracking of picked-up items become crucial to a good shopping experience. Shoppers at an Amazon Go store will also spend much less time than at other physical stores. For this reason, they are likely to be less interested in how spacious or nice the store is.

Right now, not many people shop at an Amazon Go store, so their experience is not the typical shopping experience. But imagine a future in which all stores would work like the Amazon Go store. We can immediately see how this would change the way we live our lives and organize our daily activities. A smartphone would be a must-carry item since it would function as a de facto wallet. There would be no more anonymous purchases because all shopping activities and purchased items would be associated with the person who picked up and paid for them. Since the store would track every item's location on the shelf in real time, shoppers would be instantly able to check if an item was in stock, and if so, exactly where in the store it was placed. Even at peak times, stores would be much less crowded since people would not have to wait to check out. Stores would become very computing-heavy as they would be fitted with a large number of sensors, cameras, and other electronics to detect purchases. They would also no longer be designed as spaces where people roam around and explore. Stores would be used more and more like large vending machines, where few store staff would be around and shoppers would be quick to arrive and leave with the items that they needed.

The Fourth Industrial Revolution

What the Amazon Go store accomplishes may appear to be simply reducing shopping time. But we need to observe a more important trend here. For the first time in human history, machines are starting to perform not only physical and mechanical but also cognitive tasks. Digital technologies have been increasing automation in many areas. But now, with the recent breakthroughs in AI, automation is spreading to areas that used to be seen as the exclusive domain of humans.

Two MIT economists, Erik Brynjolfsson and Andrew McAfee, named this phenomenon "the second machine age" in the book of that title published in 2014.[7] In the book, they stated that the industrial revolution was the first machine age, in which machines complemented humans by performing physical labor; now we have entered the second machine age, in which the automation of cognitive tasks substitutes for rather than complements humans. In their more recent 2017 book, *Machine, Platform, and Crowd*, McAfee and Brynjolfsson argued that many decisions, judgments, and forecasts currently made by humans should be turned over to algorithms, with humans sometimes in the loop and other times completely out of the loop.[8] They acknowledged that incomplete or biased data can produce faulty algorithms whose use generates erroneous or unfair results. But they also

see intelligent machines complementing the weaknesses of inaccurate and irrational human decisions and judgments often resulting from the so-called "System 1," the fast and intuitive part of the human brain that operates automatically but cannot be logically scrutinized or turned off at will.[9]

The fourth industrial revolution is another concept that attempts to capture this phenomenon of the all-encompassing and fundamental changes brought on by digital technologies. The advocates of the term *fourth industrial revolution* distinguish today's era from the computer or digital revolution, which began with the developments of semiconductors in the 1960s and was further catalyzed by the spread of mainframe computing, personal computers, and the Internet in the 1970s, 1980s, and 1990s respectively. They observe that the first industrial revolution mechanized production, using water and steam power; the second industrial revolution created mass production with electricity and the assembly line; the third industrial revolution automated production with electronics and information technology.[10] The fourth industrial revolution began at the turn of the twenty-first century and is characterized by a much more ubiquitous and mobile internet; smaller, more powerful, and cheaper sensors; and AI, particularly machine learning.[11] Klaus Schwab, author of the 2016 book, *The Fourth Industrial Revolution*, emphasized that what differentiates the fourth industrial revolution from the previous digital revolution is not simply a multitude of novel technologies—such as 3-D printing, gene sequencing, nanotechnology, renewable energy, and quantum computing—but the fusion of these technologies and their interaction across the physical, digital, and biological domains.[12]

The idea that the recent advancement in digital technologies has reached a qualitatively distinct stage of digital revolution is becoming more widely accepted as new digital technologies bring changes that are much more rapid and comprehensive than in the past to the way we live, work, and interact with one another. As Schwab argued, the newest technologies are indeed blurring the lines between the physical, digital, and biological spheres. They are also disrupting almost every industry in every corner of the world, transforming entire systems of production, management, and governance.[13]

In the following chapters, I will highlight some of the areas where such digital disruption is already blurring the lines between the physical, digital, and biological spheres. I will also examine what kind of transformations today's digital technologies are enabling in production, management, and governance. Lastly, I will discuss how those changes, disruptions, and transformations will impact libraries. How can libraries and library professionals prepare for the digital disruption? How can libraries adopt and utilize new technologies to make library services, programs, and operation more successful and innovative and at the same time contribute to social progress? If we are indeed at the dawn of the fourth industrial revolution as some argue, then now is certainly a good time to ask these questions.

Notes

1. "History to Date," WWW Project History, CERN, accessed September 9, 2019, http://info.cern.ch/hypertext/WWW/History.html.
2. When these techniques of biological engineering sufficiently advance, biological matter can be programmed to perform specified functions and placed in different organisms. This is a vision of synthetic biology—that is, using living cells as substrates for general computation. See Joy Ito, "Why Bio Is the New Digital: Joy Ito Keynote," Solid Conference 2015, YouTube video, 11:45, posted by O'Reilly, June 25, 2015, https://www.youtube.com/watch?v=pnHD8gvccpI.
3. "Digital Disruption," Information Technology, Gartner Glossary, accessed September 9, 2019, https://www.gartner.com/it-glossary/digital-disruption.
4. *Sensor fusion* means the process of merging and improving data from multiple sensors to increase accuracy.
5. Amazon patented its "smart shelves" system in 2018. See Alan Boyle, "Fresh Patents Served Up for the Smart Shelf Technologies Seen in Amazon Go Stores," GeekWire, September 4, 2018, https://www.geekwire.com/2018/fresh-patents-served-smart-shelf-technologies-seen-amazon-go-stores.
6. "Amazon Go," Amazon, accessed November 9, 2019, https://www.amazon.com/b?ie=UTF8&node=16008589011.
7. Erik Brynjolfsson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (New York: W. W. Norton & Co., 2014).
8. Andrew McAfee and Erik Brynjolfsson, *Machine, Platform, Crowd: Harnessing Our Digital Future* (New York: W. W. Norton & Co., 2017), 64.
9. Daniel Kahneman, *Thinking, Fast and Slow* (New York: McMillan, 2011), 20–21, quoted in McAfee and Brynjolfsson, *Machine, Platform, Crowd*, 36.
10. Klaus Schwab, *The Fourth Industrial Revolution* (New York: Currency, 2017), 6–7.
11. Schwab, *Fourth Industrial Revolution*, 6–7.
12. Schwab, *Fourth Industrial Revolution*, 8.
13. Klaus Schwab, "The Fourth Industrial Revolution: What It Means, How to Respond," World Economic Forum, January 14, 2016, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond.