1. THE DIGITAL DIVIDE

Between the late 1960s and mid-2010s, the Third Industrial Revolution brought microprocessors, personal computing, and the Internet that created an ecosystem that exponentially increased communication capabilities throughout the world. Computers went from expensive and hard to use, room-sized mainframe machines to inexpensive personal computers, beginning with the Commodore 64, and leading to handheld personal devices that contain more processing power than all their predecessors combined. In conjunction with computer advances, the design and use of computer technology—known as human-computer interactions—evolved from Herman Hollerith's "punch" cards to keyboards and mice, and currently operates with touchscreen and voice-activated commands. Advances have allowed for exponential increases in humans' ability to communicate with each other, starting with the telegraph and ending with instantaneous communication via text messaging and video chats. APRANET came online in 1969 with speeds of 56 kilobits per second (Kbps) and was used to connect government agencies and universities focused on defense research; currently, companies offer one gigabyte per second (GBps) fiberoptic speeds, allowing for on-the-spot worldwide knowledge access.[1]

The United States' first great step in this computing evolution was the passage of the High-Performance Computing Act (HPCA) of 1991.[2] HPCA ushered in the necessity of a National Information Infrastructure and provided the funding for the National Research and Education Network (NREN), which focused on providing access to the Internet for all K–12 students. NREN provided a collaboration tool that teachers utilized to share pedagogical tools and methodologies. From 1994 to 1997, the National Science Foundation and the HPCA funded the development of the high-speed research network that would eventually become the Internet.[3] During this same time period (1991–1996), the number of personal computers in the United States increased from three hundred thousand to more than ten million.[4] By the mid-1990s, the development of Internet browsers enabled computers and information to be transmitted via a new realm: cyberspace.[5] The ability to transmit information at high speeds led to the development of a message-delivery system dubbed email, which became increasingly useful due to its speed and widespread accessibility. During this Internet boom, the Bill Clinton administration began to investigate whether access to information technology was being evenly distributed throughout society.[6]

In 1995, the new National Telecommunications and Information Administration (NTIA) produced a report, "Falling Through the Net: A Survey of the 'Have Nots' in Rural and Urban America," which focused on the penetration and usage of information and communication technology (ICT) throughout the United States. The report found that people who did not have access to ICT were disproportionately based in rural areas, and education was correlated with access to the telephone, computer, and household computer modem.[7] The NTIA report is regarded as one of the first instances in which the federal government recognized policies were needed to curb inequalities in access to the Internet, and it was one of the first descriptions of what is now known as the digital divide, or a disparity in the access to, use of, or impact of ICT.

In 1995, whites owned computers at three times the rate of African Americans and Latinos.[8] As Internet connections became more common, demographic groups including African Americans, Latinos, non-English-speaking Asians, tribal and rural populations, the elderly, and adults living with disabilities were slower to adopt the technology. This delay effectively locked them out of the Internet "boom" and its corresponding opportunities for growth and advancement.[9] In 2010, the Pew Research Center found that

1 Randolph A. Miller and Edward H. Shortliffe, "Donald A.B. Lindberg and the U.S. National Library of Medicine Transformed Biomedical and Health Informatics," Information Services & Use 42, 1, May 10, 2022, 3–10, *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9116201/*.

2 Donald A. B. Lindberg and Betsy L. Humphreys, "The High Performance Computing and Communications Program, the National Information Infrastructure, and Health Care," Journal of the American Medical Informatics Association 2, 3 (1995), *https://academic.oup.com/jamia/article-abstract/2/3/156/875750?redirectedFrom=fulltext*.

3 K. M. Hayes and R. J. W. Cline, "Consumer Health Information Seeking on the Internet: the State of the Art," Health Education Research 16, 6 (2001), 671–692, *https://pubmed.ncbi.nlm.nih.gov/11780707/*.

4 Aaron Weiss, "Computing in the Clouds," NetWorker 11, 4 (2007), 16–25, *https://dl.acm.org/doi/fullHtml/10.1145/1327512.1327513*.

5 Ibid.

6 Ibid.

7 Ronald H. Brown, David J. Barram, and Larry Irving, "Falling Through the Net: A Survey of the 'Have Nots' in Rural and Urban America," US Department of Commerce, 1995, *https://www.ntia.doc.gov/ntiahome/fallingthru.html*.

8 Miller, "Donald A.B. Lindberg and the U.S. National Library of Medicine Transformed Biomedical and Health Informatics."

9 Robert Branson, Danielle Davis, and Marcella Gadson, "Bridging the Digital Divide," Multicultural Media, Telcom and Internet Council, 2022, *https://www.benton.org/headlines/wireless-communities-color-bridging-digital-divide*.

the top reasons households could not, or chose not to, get access to the Internet were

- They did not have service available in their area;
- They could not afford it;
- They did not understand how to use it;
- They did not trust it; and
- They did not see its usefulness.[10]

Together, these factors created, and later deepened, the digital divide for many of these marginalized communities, and continued to increase the wealth gap and socioeconomic status disparities.

Fortunately, technology is much more widespread today than it was in 1995. Accessibility has increased, as innovation brought reductions in the costs of central processing unit (CPU) memory, storage, and processing power. Modern ICT, particularly mobile devices with wireless connectivity, has been championed as a bridge across the digital divide. Today, more than 91 percent of adults are connected via wired or wireless broadband, and 85 percent have a smartphone, with more than 20 percent using smartphones solely for broadband Internet access.[11] The high rate of adoption of smartphones and their connection to wireless broadband have granted Internet access to more than three hundred and fifteen million people across the country, and helped to narrow the digital divide. Increased adoption of wireless connectivity by minority groups, dubbed by the Cellular Telecommunications and Internet Association as "The Minority Wireless Miracle," is due to wireless' innate mobility-based flexibility, varied pricing tiers, and widespread coverage.[12] People of color have over-indexed wireless Internet usage since tracking began by Pew in 2011; African Americans and English-speaking Latinos are among the most active users of the mobile Internet. In addition, compared to white populations, members of these groups are more likely to own a cellphone but no personal computer (PC).[13] In many cases, cellular access is the only lifeline to the Internet for disenfranchised groups, allowing them to be part of the digital ecosystem.

2. THE GENESIS OF THE DATA DIVIDE

In 1965, Gordon Moore predicted that the number of components in an integrated circuit would double each year for the next ten years—and reach an astonishing sixty-five thousand parts by 1975.[14] Moore's prediction was validated in 1975 and became the "golden rule" in chip manufacturing, becoming known as Moore's Law. Moore's Law states that the number of transistors on a microchip will double every two years, and that exponential growth in microprocessors will thereby increase computing power. Since then, his prediction has defined the trajectory of technology, ushered in the Third Industrial Revolution (characterized by electronics and information technologies), and introduced the Fourth Industrial Revolution.[15]

The Fourth Industrial Revolution, which began in 2016, is an integration of the cyber-physical world. It is an amalgamation of technologies that focus on physical, digital, and biological spheres. Access to low-cost, low-power sensors, standards for accessing the Internet, cloud-computing platforms, machine learning (ML), and artificial intelligence (AI) have enabled the creation of ICT that touches every segment of daily life. The Internet of Things (IoT), billions of low-cost sensors and people connected by mobile devices (or Internet), is currently producing 2.5 quintillion bytes of "big data" daily. Big data differ from the data in the Third Industrial Revolution in their volume, speed of creation, and dissemination, and their variety creates endless opportunities for process inputs to emerging technologies. Big data—along with unrivaled computer processing power, limitless storage capacity, and instant access to knowledge—form the foundations for advanced prediction algorithms. Emerging technologies such as ML, AI, advanced manufacturing, IoT, nanotechnology, biotechnology, energy storage, and quantum computing have the capability to advance global prosperity and development. These breakthroughs have transformed entire systems of production, healthcare, and governance.[16]

This Fourth Industrial Revolution offers an unprecedented opportunity not only to improve the quality of life, but to close societal gaps. People with access to the digital world

10 Aaron Smith, "Home Broadband Adoption 2010," Pew Research Center, August 11, 2010, *https://www.cetfund.org/report/2010-home-broadband-adoption/*.

11 Andrew Perrin, "Mobile Technology and Home Broadband 2021," Pew Research Center, June 3, 2021, *https://www.pewresearch.org/internet/2021/06/03/mobile-technology-and-home-broadband-2021/*.

12 Branson, et al., "Bridging the Digital Divide."

13 Smith, "Home Broadband Adoption 2010."

14 Gordon E. Moore, "Cramming More Components onto Intergrated Circuits," Electronics, 38, 8 (1965), *https://www.cs.utexas.edu/~fussell/courses/cs352h/papers/moore.pdf*.

15 David Rotman, "We're Not Prepared for the End of Moore's Law," MIT Technology Review, February 24, 2020, *https://www.technologyreview.com/2020/02/24/905789/were-not-prepared-for-the-end-of-moores-law/*.

16 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/*.