



# Computing and Socioeconomic Transformations

**Nir Kshetri**, University of North Carolina at Greensboro

**Jeffrey Voas**, IEEE Fellow

**Ravi Sharma**, Zayed University

*This year marks the 75th anniversary of the IEEE Computer Society. Join us as we commemorate some of the historic milestones in computing technology from that period.*

**T**his article is the first in a series of four articles that *Computer* is publishing to celebrate the 75th anniversary of the IEEE Computer Society (CS). The plan to do so was announced in the editor in chief's message in the January 2021 issue. This article gives an overview of socioeconomic transformations facilitated by computing technology during the past 75 years and looks at some of the key roles played by the CS to enable this change.

The origins of the CS can be traced to the formation of the Subcommittee on Large-Scale Computing Devices (LCD) of the American Institute of Electrical Engineers (AIEE) in May/June 1946.<sup>1</sup> The first large-scale electronic computer, Colossus, had started its operation in 1944, just two years before the subcommittee was formed.<sup>2</sup> The Colossus computers were deployed at Bletchley Park, the U.K.'s World War II code-breaking headquarters to decrypt secret German codes.

Before the 1950s, computing technologies were limited to scientific, mathematical, and

Digital Object Identifier 10.1109/MC.2020.3038410  
Date of current version: 11 February 2021

defense applications.<sup>3</sup> Their uses gradually started expanding into business purposes such as banking and accounting in the 1950s.<sup>3</sup> By this time, predecessor organizations of the CS had

been engaged in extensive research activities, including conferences, workshops, and publications. For instance, the Subcommittee on LCD's first computer conference session took place in

January 1947, just a few months after its establishment, as a part of the AIEE Winter Meeting. The first transactions, *IEEE Transactions on Computers*, was published in 1952.<sup>4</sup>

**TABLE 1.** A history of computing technologies and the CS: Major milestones and key events.

Time	Event/milestone	Remarks
1946	The Subcommittee on LCD of the AIEE is formed.	The CS is traced to this subcommittee.
1951	The Institute of Radio Engineers created the Professional Group on Electronic Computers, the first broad membership organization for computer professionals.	This is viewed as the official start date for CS.
1965	Two computers “talked” to each other for the first time.	The TX-2 computer in Massachusetts was connected to the Q-32 in California.
July 1966	The first issue of <i>Computer Group News</i> was published.	<i>Computer Group News</i> was a bimonthly publication.
1969	The U.S. Department of Defense created the Arpanet. <sup>20</sup>	The Arpanet was the forerunner of today's Internet; many of the protocols developed by the Arpanet are used in today's Internet.
1971	Kenbak Corporation launched the Kenbak-1 computer, described as the first personal computer by the Boston Computer Museum. <sup>5</sup>	The price of the Kenbak-1 was US\$750, with an inflation-adjusted price of US\$4,659 in 2018.
1972	Email was introduced.	Arpanet founder Bolt Beranek and Newman Inc. (now BBN Technologies) sent the first email using “@.” <sup>21</sup>
August 1991	The World Wide Web became publicly available. <sup>22</sup>	The World Wide Web was developed by Tim Berners-Lee.
1993	The number of countries connected to the Internet rose to 60.	By this time, most developed and some developing countries had introduced the Internet.
August 1994	The first e-commerce transaction took place.	New Hampshire-based NetMarket sold a CD online, which was paid for with a credit card in an encryption-protected transaction.
1997	The first social media site <sup>23</sup> was founded. <sup>24</sup>	The site allowed users to create a profile page and lists of connections and send messages.
2000	The number of countries connected to the Internet reached 214. <sup>6</sup>	In 1999, Bhutan became the last country to connect to the Internet. <sup>25</sup>
2008	The Internet overtook newspapers as a source of news in the United States. <sup>26</sup>	Forty percent of people obtained most of their news from the Internet, while 35% got it from newspapers.
2010	The Internet overtook TV as the main source of news for 18–29-year-old adults in the United States. <sup>27</sup>	Sixty-five percent of respondents cited the Internet as their main source of news (34% in 2007). In 2007–2010, the percentage of respondents citing TV as their main news source dropped from 68 to 52%.
2018	Social media overtook print newspapers as a source of news in the United States. <sup>28</sup>	One in five respondents often obtained news from social media compared to 16% from print newspapers.
October 2020	The IEEE Computer Society Digital Library contains 33 magazines and transactions and more than 600,000 articles.	The IEEE Computer Society Digital Library is IEEE's first-ever digital library.

In Table 1, we summarize a few major milestones from the past 75 years. As mentioned, businesses had just begun using computing technologies in the 1950s. Likewise, although several companies started selling personal computers in the 1970s,<sup>9</sup> they were not widely available and were expensive.

Fast forward to the 2020s, and consider the widespread distribution of computing technologies and the socioeconomic transformations that have occurred as a result. There is a near-universal use of computing technologies among organizations in the developed world. A 2019 survey of 1,000 U.S.-based small- and medium-sized enterprises by the accounting firm Deloitte found that 99% had used one or more digital tools in their day-to-day operations. Organizations that use computing technologies in a more sophisticated way also exhibit higher performance. The Deloitte survey found that 19% of businesses, which it described as “advanced users of digital tools,” were five times more likely to internationalize their businesses compared to less digitally advanced counterparts.<sup>10</sup>

Next, consider personal computing technologies such as smartphones. There are already more cell phones in the world than people (Figure 1). Similarly, as of 2019, 49.7% of households worldwide had a computer at home.<sup>11</sup> The proportions were about a third in developing and 82.3% in developed countries.<sup>12</sup>

## THE INTERNET AND SOCIAL MEDIA

The Internet and social media are now seen by most of the world’s population as facilitators of daily life. More than 60% of the world’s population is online, and 2020 marked the year in which more than half of the world’s population had used social media (Figure 1).

## TRANSFORMATIVE EFFECTS

In 2020, the average Internet user spent 6 h and 43 min online daily. This translates to more than 100 days per year and in excess of 40% of waking time.<sup>13</sup> Likewise, an average social media user spent 2 h and 20 min using social media per day.<sup>14</sup>

Computing has also brought a transformation to how news is consumed. Since the 1940s, pollsters have been asking Americans questions such as “Where do you get most of your news?” In the 1950s, the predominant source was newspapers.<sup>15</sup> In the 1960s, the answer shifted from newspapers to television.<sup>7</sup> Starting in the late 2000s, the Internet and social media started gradually surpassing other news media as a viable news source (Table 1). Pew Research Center’s survey in 2019 found that 55% of U.S. adults got their news from social media.<sup>16</sup> A survey conducted during April 2019–March 2020 in Australia found that the Internet was a main source of news for 60.8% of Australians (social media for 37.7%).<sup>17</sup> Just like other activities such

as in-person education and medical visits, retail, and working from the office,<sup>8</sup> digital is replacing traditional media.

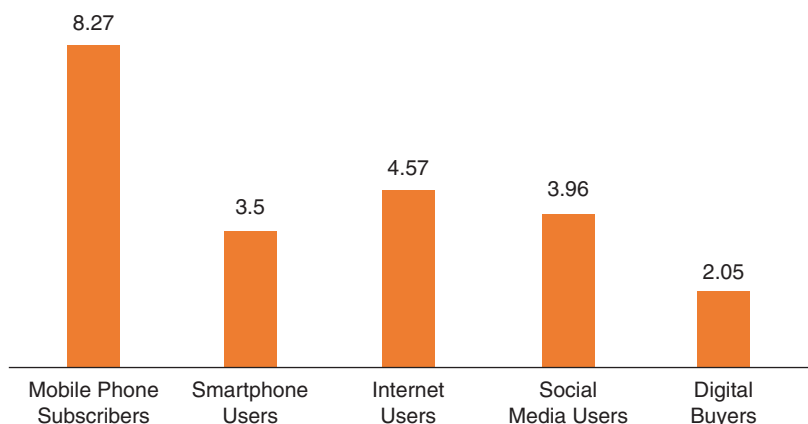
Among computing’s most transformative economic effects is e-commerce. The first e-commerce transactions took place around 1994 (Table 1). By 2019, e-commerce accounted for 19% of retail transactions worldwide. During 2011–2019, e-commerce worldwide grew by 352.3%—compared to total retail’s growth of 28.2%—and mobile e-commerce grew by 3,265%.<sup>8</sup>

The Internet, social media, and e-commerce as we know them today are a result of several breakthrough advancements starting in the mid-1960s that allowed a computer to “talk” with other computers thanks to innovative developments from the 1960s. Around the same time, *Computer Group News*, was launched. Later renamed *Computer*, it was the first magazine published by any entity of IEEE.<sup>18</sup>

**F**oundational and fundamental developments in computing and communications technologies originated from the CS and its predecessor organizations. Today, these technologies are integral parts of our lives.

Computing technologies such as artificial intelligence, machine and deep learning, augmented reality, data analytics, low-power microprocessors, blockchain and cyberphysical systems are all being used in novel and creative ways in diverse areas such as agriculture, defense, health care, environment, and manufacturing. These technologies, also referred to as Fourth Industrial Revolution computing technologies, will enable additional transformations.

During the past 75 years, the contributions of the CS and its predecessor organizations have been invaluable in the development of computing technologies. The CS has contributed by engaging in a wide range of activities such as organizing conferences, publishing papers, compiling glossaries, and helping in the development of standards. Since the beginning of the



**FIGURE 1.** The number of users of digital technologies (in billions).

first journal in 1952 and the first conference in 1947, the activities of the CS have grown dramatically. As of October 2020, the CS Digital Library, the IEEE's first-ever digital library, contained 33 magazines and transactions and more than 600,000 articles.<sup>19</sup> These publications provide resources to understand timely computing technologies. ■

## REFERENCES

1. "The Computer Society Timeline: The 1950s and 1960s." IEEE Computer Society. <https://www.computer.org/about/cs-history/1950-1969> (accessed Oct. 30, 2020).
2. "Colossus." <https://tinyurl.com/y6vwur8l> (accessed Oct. 30, 2020).
3. "The history of computers in a nutshell." <https://tinyurl.com/y2gozhut> (accessed Oct. 30, 2020).
4. M. G. Smith, "Four decades of service, 1951-1991," *Computer*, vol. 24, no. 9, pp. 6-12, 1991. doi: 10.1109/2.84894.
5. E. Comen. "Check out how much a computer cost the year you were born." USA Today, June 22, 2018. <https://www.usatoday.com/story/tech/2018/06/22/cost-of-a-computer-the-year-you-were-born/36156373/>
6. N. Dholakia, R. Dholakia, and N. Kshetri, "Global diffusion of the internet," in *The Internet Encyclopedia*, H. Bidgoli, Ed. New York: Wiley, 2004, pp. 38-51.
7. W. Burns and R. Roper, *Trends in Attitudes Toward Television and Other Media: A Twenty-Four Year Review*. New York: Roper Organization, 1983.
8. J. Voas and N. Kshetri, "Online eats 'food courts'," *Computer*, vol. 54, no. 3, 2021, to be published.
9. "Personal computer." Britannica. <https://www.britannica.com/technology/personal-computer> (accessed Oct. 30, 2020).
10. "The performance of small and medium sized businesses in a digital world." Deloitte. <https://www2.deloitte.com/content/dam/Deloitte/es/Documents/Consultoria/The-performance-of-SMBs-in-digital-world.pdf> (accessed Oct. 30, 2020).
11. "Share of households with a computer at home worldwide from 2005 to 2019." Statista. <https://www.statista.com/statistics/748551/worldwide-households-with-computer/> (accessed Oct. 30, 2020).
12. "Share of households with a computer at home in developed countries from 2005 to 2019." Statista. <https://www.statista.com/statistics/748557/developed-countries-households-with-computer/> (accessed Oct. 30, 2020).
13. "Digital trends 2020: Every single stat you need to know about the internet." <https://tinyurl.com/tel3en6> (accessed Oct. 30, 2020).
14. "More than half of the people on earth now use social media." <https://tinyurl.com/yxggf4w> (accessed Oct. 30, 2020).
15. "Executing Abbott: 50 years later." Berkeley News21. <http://berkeleynews21.com/behindbars/history/microfilm/> (accessed Oct. 30, 2020).
16. "Americans are wary of the role social media sites play in delivering the news." Journalism. <https://www.journalism.org/2019/10/02/americans-are-wary-of-the-role-social-media-sites-play-in-delivering-the-news/> (accessed Oct. 30, 2020).
17. "It's official: Internet is Australia's main source of news; TV remains most trusted." Roy Morgan. <http://www.roymorgan.com/findings/8492-main-sources-news-trust-june-2020-202008170619> (accessed Oct. 30, 2020).
18. W. K. King and S. K. Land. "A historical perspective of the IEEE Computer Society." ETHW. <https://ethw.org/w/images/e/eb/2009-king-land.pdf> (accessed Oct. 30, 2020).
19. "IEEE Computer Society Digital Library (CSDL)." IEEE. <https://www.ieee.org/about/ieee-india/ieee-computer-society-india/csdl.html> (accessed Oct. 30, 2020).
20. K. A. Zimmermann and J. Empsak. "Internet history timeline: ARPANET to the World Wide Web." <https://tinyurl.com/yynq75rf> (accessed Oct. 30, 2020).
21. I. Peter. "The history of email." <https://tinyurl.com/yxjt9fvv> (accessed Oct. 30, 2020).
22. M. Bryant. "20 years ago today, the World Wide Web opened to the public." <https://tinyurl.com/y5593uc8> (accessed Oct. 30, 2020).
23. Sixdegrees. [sixdegrees.com](https://www.sixdegrees.com) (accessed Oct. 30, 2020).
24. I. Ahmad. "The history of social media [infographic]." <https://tinyurl.com/ycd7clhh> (accessed Oct. 30, 2020).
25. "King of Bhutan giving people TV, Internet for silver jubilee." <https://tinyurl.com/y5lp8g8l> (accessed Oct. 30, 2020).
26. "Internet overtakes newspapers as news outlet." <https://tinyurl.com/y4ssmdqf> (accessed Oct. 30, 2020).
27. "Internet gains on television as public's main news source." <https://tinyurl.com/y3cc4ohw> (accessed Oct. 30, 2020).
28. E. Shearer. "Social media outpaces print newspapers in the U.S. as a news source." <https://tinyurl.com/y5pywhds> (accessed Oct. 30, 2020).

## DISCLAIMER

The authors are completely responsible for the content in this article. The opinions expressed here are their own.

**NIR KSHETRI** is a professor of management in the Bryan School of Business and Economics at the University of North Carolina at Greensboro, Greensboro, North Carolina, 27412, USA, and the "Computing's Economics" column editor for *Computer*. Contact him at [nbkshetr@uncg.edu](mailto:nbkshetr@uncg.edu).

**JEFFREY VOAS**, Gaithersburg, Maryland, USA, is the editor in chief of *Computer*. He is a Fellow of IEEE. Contact him at [j.voas@ieee.org](mailto:j.voas@ieee.org).

**RAVI SHARMA** is a professor of technological innovation at Zayed University, Abu Dhabi, United Arab Emirates. Contact him at [rsharma@ceide.org](mailto:rsharma@ceide.org).