Twenty Years on: A Second Look at 10 Important Social Impact Characteristics of Computer Technology

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Abstract. Twenty years ago, Liffick [38] explored 10 characteristics of computer technology that contributed to their impact on societal issues of that era. The purpose of this exploration was to "anticipate the social consequences of a new product and mitigate any potential negative effects it may have on society." Furthermore, "the intent of developing a list of these characteristics is that it could lead to a better understanding of the nature of the social impact of computers. In this way, it might be possible to examine a new computer project at the time of its design … to determine its potential impacts as a social change agent". The purpose of this current paper is to review the characteristics originally proposed to determine whether they are more or less relevant, given the enormous changes in computer technology (CT) in the last 20 years.

Keywords: Human-computer interaction · HCI · Social impact · Computers and society

1 Introduction

What was the state of computer technology (CT) in 1995? Cell phone technology was just beginning its second generation (with about 33 M subscribers in the US, 10 % of today's subscribership). Wi-Fi was still too new a technology to be available and mobile devices were limited to the new technology of unconnected personal data assistants. The typical personal computer configuration in 1995 was 8 megabytes of RAM, 33 MHz processor, 1 gigabyte hard drive, and a 28.8 K-bit modem. Today's system is about 1000 times more powerful, following Moore's Law quite closely. The first web browser was released in 1993 and the World Wide Web Consortium was formed in October 1994, so the WWW was still relatively new in 1995. Current estimates are that there are now 4.36 billion web pages [15].

Also consider that 20 years represents about ¼ to ⅓ of the entire history of modern computing. Furthermore, this timeframe represents a growth in the technology by approximately 10-fold, so this 20-year timespan is a convenient length of time for us to use for this comparison.

The list of social impact characteristics discussed in 1995 were (in no particular order):

1. *ubiquity* – CT is pervasive.
2. *magnification* – CT magnifies the amount of information available, through both collection and generation, as well as magnifying the effects of errors.
3. *accessibility* – the increased availability of information, devices, etc.
4. *reproducibility/distributability* – exact duplication of information artifacts (e.g. videos) and the ability to distribute them widely (e.g. broadcast).
5. *lack of accountability* – the link between the creator/supplier of information and the consumer of that information is masked through many layers of separation by networks, software, and lack of human participation.
6. *temporality* – CT affects both time (in both real and perceived ways) and timeliness.
7. *spatiality* – distances increasingly no longer matter.
8. *surviellability* – the ability to not only gather massive amounts of data about someone, but to watch them in near-real time.
9. *shifting relationships/changes in intercommunication protocols* – how we interact with one another on both personal and professional levels.
10. *illusion of precision* – the many ways that what is truly imprecise is masked by CT to appear precise.

2 The Characteristics Today

As can be seen in the discussion below, these issues have increased in significance right along with the increasing power of the technology that affects them.

2.1 Ubiquity

It is not difficult to recognize that with computer technology having advanced so significantly since 1995, the penetration of computers into our environment would enjoy a correlative increase, to the point that a new term has been coined along the way: pervasive computing. The numbers are staggering: by mid-2013, Apple claims to have shipped over 600 million iOS devices (iPhones, iPads, iPods), while Google claims over 900 million Android devices [27]. Considering that the first iPod was introduced in 2001, it means on average about 125 million devices per year are purchased. There is currently nearly one mobile phone subscription per person in the world. There were 296.0 million PCs/laptops sold in 2013, and 195.4 million tablets [5]. And these are just the independent mobile devices. There are countless additional embedded devices in our cars, appliances, and in every electronic device in existence.

Wearable computers appear to be the next evolutionary step, with recently introduced devices such as FitBit [23], the Samsung smartwatch [16], and Apple smartwatch [3]. Beyond the current landscape of such devices lies "implantables, disposable wearables, ingestibles, and smart prosthetic devices" [22, pp 20–22].

What's different after 20 years is certainly the penetration of CT into our everyday lives. The reality is that we now expect computers to be everywhere. More importantly, thanks to cell technology and WiFi, we expect to be connected to the entire world of computing from nearly everywhere.

2.2   Magnification

It is easy to demonstrate the power of CT to magnify, as there are examples in our daily news. On the dark side of this characteristic is the ability of a single individual (or a small group) to disrupt society, including hacks that deny the use of services as well as those that steal data [25, 42, 47, 55]. The potential for devastation is enormous.

The concept of *virality* [52] has been coined to encompass those situations that, whether by design or accident, have ended up being transmitted throughout social media on a widespread scale. On the most negative side are examples of cyberbullying, identity theft, and deliberate attempts to harm someone through projecting negative information throughout cyberspace, such as through the use of revenge porn sites [11].

All this is not to say that computer technology doesn't magnify an individual's power in a number of positive ways as well. The success of George Takei to use first Twitter and then Facebook as platforms of personal promotion is a prime example. With a rise from obscurity a few years ago to some 3 million Facebook followers, Takei has used the potential virality of social media to create a distinct voice amongst the cacophony of the millions who are striving to be heard [52].

2.3   Accessibility

In 1995 the discussion centered on the ability to access unlimited information from unlimited locations, despite the fact that transmission speeds were relatively slow, graphics were still crude, and video streaming was still years away. Shopping online had yet to be realized [39]. The number of web pages available was still only in the hundreds of thousands. Most public records had not yet been digitized. Print media was still strong.

Twenty years later online shopping is a major force in the economy, with Amazon alone accounting for nearly $68 billion of total online sales of nearly $7 trillion in 2013 [17]. The number of available web pages indexed by Google tops 4 billion [15].

Another area of digital accessibility that didn't exist in 1995 is ebook publishing. Barely 8 years old, today ebooks are a $6 billion industry, with projections of overtaking print books in total sales within the next two years [43]. Ebooks provide unprecedented access to not only literature but every form of information, with interactive features impossible with printed books.

The most negative side of accessibility has been the explosion of hacking incidents, where personal information, credit card numbers, etc. are frequently stolen [1, 25, 55]. With more of our lives being lived online every day (with online shopping, banking, communication, record keeping, utilities control, social media, etc.), we have all but lost the ability to control information about ourselves. This loss of privacy is a major source of anxiety in the modern age [29].

2.4   Reproducibility/Distributability

As media has shifted toward the digital, the ability to exactly duplicate artifacts has increased so that nearly any form of publishing in text, photographic, audio, or video

form can be copied as many times as one would like, nearly instantly with the push of a button. The big fear of the media world in 1995 was digital audio tape (DAT), a technology that was quickly eclipsed and made obsolete (as a general consumer product) by compact disks (CDs). Now, CDs have been made nearly irrelevant by flash drives and through digital distribution systems such as Apple's iTunes, introduced in 2003 [37]. The ease of downloading ebooks onto mobile devices has completely changed the field of publishing, but didn't really take off until the introduction of Amazon's Kindle device in 2007 [29, 43].

Finally, the advent of the social media era has spawned a special language that encapsulates this characteristic. Terms such as retweeting or reposting indicate an ability to distribute a message to a wide audience. Even more significantly, the phrase going viral (or, as George Takei has coined, virality) demonstrates clearly one goal of those who post or tweet [52]. The new concept of the meme is another term that exists solely to describe a social media artifact that has been distributed to an enormous audience.

2.5 Lack of Accountability

The original concern revolved around customer service, where the increasing use of voice menus gave rise to the voice-mail labyrinth, from which there was little hope of escape. This allowed companies to hide from customers while the computerized system gave the appearance of providing quick, accurate service for the most mundane of customer queries. Such automated customer service systems have become somewhat more sophisticated over the last 20 years, improving the delivery of service, but in addition companies have moved customer service centers overseas.

A number of additional examples of a lack of accountability have developed over the past 2 decades. One of the more insidious is social media lurkers, known as trolls, who anonymously post nasty comments [24]. By being anonymously, the poster feels emboldened to say whatever they want, and the post is frequently intended to upset people or to start an argument. Many sites end up shutting down all comments in order to eliminate such a situation.

Similarly, the Internet has also been used to seek revenge, typically anonymously. Revenge porn sites allow ex-boyfriends (and a few ex-girlfriends) to post nude photos of their exes online, along with nasty comments and, frequently, addresses of their targets [11]. Such cyber-stalking has become an increasing problem.

Spam may be the ultimate example of a lack of accountability. An entire industry has been created just to try to filter out spam email.

2.6 Temporality

Computer technology has a great impact on our perceptions of time. In 1995 it was nothing to wait upwards to a minute or more for a web page to load, and many minutes for the typical download, with a maximum transfer speed of 56.6 K bps. Still, our ability to actually transfer files in a relatively short amount of time (compared to sending disks through the mail) was considered a significant improvement in efficiency.

Today, with speeds measuring in gigabits, we routinely expect near instantaneous data transfers and page loads. Our sense of time has become somewhat warped by our ability to place an order for a product and have it delivered the next morning. Indeed, it seems that now, in the era of 3-D printing, we don't even need to wait that long [54]. This "instant consumerism" already pervades our thinking. We expect every transaction to result in instantaneous access to the product we just bought (or at least instantaneous shipping). When we have medical tests, we expect the results to be available, if not immediately, then within a relatively few days. Online, we can instantly not only purchase but compare products, services, and prices that in 1995 still required traveling to possibly multiple stores to accomplish.

One of the most significant changes in society is the immediacy of communication. With cell and Wi-Fi technologies, one can be in continuous communication (text, voice, or video) with anyone. The mobility of devices introduced in just the last 10 years has made it possible to carry our communications devices with us at all times. The delay of communicating by mail, or even email, has all but disappeared. Our modern expectations include being able to access nearly all of our accounts (banking, phone, utility, car, insurance, taxes, medical records, etc.) at any time we choose, any day we choose.

2.7   Spatiality

Just as with temporality, distances have continued to shrink in a number of ways. While in 1995 it was already easy to make a long-distance phone call, such calls still cost extra money at the time. Today, the ability to call nearly anywhere in the world for the base cost of a phone plan is fairly standard.

We have also been able to collaborate with colleagues even more easily than in 1995, when about the only option was to transfer files back and forth. Today collaborative systems such as Google Docs, Dropbox, and the like make it easy to "write, edit, and collaborate wherever you are" [6]. Other tools make it possible to attend meetings using "web conferencing" instead of being physically present [7].

Perhaps the most dramatic example of the spatiality characteristic is when NASA "emailed a tool" to the International Space Station [55]. Of course, what they emailed was instructions that could be used to construct the tool using a 3D printer. But 3D manufacturing shows great promise as a technology that brings buyers and sellers even closer together [12].

2.8   Surveillability

There were few public concerns about digital privacy in 1995, since in general the public was still not very connected. The Electronic Privacy Information Center had just been founded "to focus public attention on emerging civil liberties issues" [4], but with the public being almost entirely computer illiterate, their impact was limited at the time. In the past 20 years, however, issues of privacy have become a significant public concern. In 2008, EPIC released a report on a proposal from Homeland Security for a

national ID program [4]. Concerns about the commercial mining of data has grown [20], [48]. The revelations about massive government surveillance programs continue to surface [31]. Even celebrity watching has been enhanced to the point of electronic stalking [18].

2.9 Shifting Relationships/Changes in Intercommunication Protocols

The way we communicate has changed significantly since 1995. At that time the main form of electronic group interaction was still bulletin board systems [26]. But it would be nearly ten more years before social networking websites became popular, with Facebook finally being introduced in 2004.

With the introduction of more sophisticated social media, a more indirect form of mass communication has become commonplace. Rather than sending direct messages to individuals as is generally done with email, these new tools provided a different model of communication: multicasting (posting to a group). This one-to-many form of communication uses networks of "friends" to create a "personal and private community" [9]. This dynamic is much more like a party than traditional forms of communication (one-to-one). Concepts of posting, having followers, creating channels, and using likes, shares, and ratings as a means of communicating interest have all been introduced within the last 10 years.

Another way in which CT has changed channels of communication is through "computer-mediated communication and interaction", where context is often missing or altered [33, p. 8]. Developing trust through computer mediation has become a commonplace occurrence online [21, 28, 51].

2.10 Illusion of Precision

In 1995 I wrote about the general lack of understanding by lay persons regarding how computers actually work, specifically that most people don't understand that computers in reality are amazingly imprecise in several important respects. This concern was based on many years of experience working with computer novices who had no idea that (1) there was finite space in which to store numbers, and that therefore many numbers were approximations, and (2) because numbers are actually stored in binary, some decimal numbers cannot be accurately represented. One textbook demonstrates this to beginning programming students by showing how Java calculates the sum of 0.1 and 0.2 as 0.30000000000000004 [46], but for the vast majority of computer users this fact is unknown.

Today there are many more examples of how the computer supports the illusion of precision. Consider Auto-tune, which "corrects intonation and timing problems in vocals or solo instruments" [2]. This tool gives musical performances the illusion of precise playing or singing. Not that adjustments to recordings didn't happen before auto-tuning; errors such as a missed note were often fixed manually by manipulating the various tracks to add or subtract sounds. With auto-tuning, however, the automatic forcing of notes to be perfectly on pitch can lend an artificial quality to the sound, and

many listeners consider the process cheating to make up for an artist's lack of skill [41]. Regardless, its use still pervades pop music.

Search engine results are another example of the illusion of precision. Those who provide search engines use various algorithms to present results to searchers, ranked in what is hoped will be the most relevant pages at the top of the list [40, 44]. To users, this presented ranked list gives the appearance of precisely finding those pages that will be of most interest to the searcher and ordering the list from most to least relevant. However, in fact there is nothing precise about such searches, and biased results are a frequent problem [53]. Indeed, one of the significant imprecisions about this process is the fact that users typically look at only the first page of results, even when more relevant pages might be further down the list [36].

3   Where Things Stand

Twenty years ago I compiled the list of what I felt were the 10 most obvious characteristics of computer technology in an attempt to get a handle on how CT impacts society. Upon the above reflection of the state of computing today, these characteristics are clearly even more prevalent, and represent deep issues related to how computing affects society. Even the characteristics for which there was perhaps minimal evidence in 1995 (e.g. the lack of imprecision or the changes in communication) have advanced to the point where there is more than ample evidence for them – in some cases almost too much evidence, as countless examples are available from which to choose.

4   So What's New

In researching the characteristics above, one additional area quickly surfaced as a major issue related to the social impact of computer technology: the computer as weapon. There are two meanings to this. The first is weapon systems that would not be possible without the computer as an integral component. Nearly all modern weaponry, from rockets to smart bombs, to aircraft and drones, incorporate computer technology to assist in the delivery control systems. There is no doubt that modern weapons would not be possible without computer technology.

The second sense in which "computer as weapon" is meant is in using computers to attack an opponent's digital infrastructure. Some of these attacks are clearly being perpetrated for financial gain, creating substantial economic losses for hacked companies and loss of confidence by consumers [42]. Rather than robbing banks, these criminals are looking for vulnerable companies to loot.

Of perhaps greater concern, however, is the use of hacking as an actual tool of warfare, as a means of causing terror and attempting to destabilize entire countries. This latter form of "computer as weapon" has been in evidence for just the past 10 years [8]. Cyberwarfare is playing an increasing role in how wars are being fought globally [32].

5   Conclusions

There is no doubt that computer technology continues to have a tremendous impact on society, for a number of reasons. The characteristics noted above provide a clear picture of many of the sources of that impact. Revelations of widespread effects of the failure of technology are a weekly, and sometimes daily, occurrence. It is somewhat surprising that the ten characteristics described twenty years ago are not only still relevant, but are actually much easier to articulate – they have become increasingly important rather than having been resolved. And certainly the added eleventh characteristic – the computer as weapon – is the most anxiety-inducing of them all. Does this mean that the future looks bleak, considering that computer technology will continue to have an increasingly negative impact on society?

That is not a preordained conclusion. Indeed, the intent of this list is to try to gain a deeper understanding of the ways in which this technology provides the means of influencing society so that safeguards might be designed into systems rather than just added on once an emergency prompts a response. Future research in this area can focus on providing remedies for each of these characteristics. At the very least, it should be possible to anticipate what social impact a potential computer product might have by mapping its features to these characteristics. In this way, it may be possible to minimize the negative impacts that plague our current use of computer technology.

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