Opportunities and Challenges from the Milestones of Information Technology (IT)

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ABSTRACT

Information technology (IT) is to use computing equipment such as computers and smartphones to store, retrieve, transmit, and manipulate data or information. It may be the most widely used technology nowadays because no other technologies affect our daily lives as the IT does. At the same time, the IT brings a plethora of opportunities like new jobs and challenges such as digital divide with it. People do not want to miss the opportunities and like to well prepare for the challenges, but it is not easy to foresee the opportunities and challenges. However, just like the history repeating itself all the time, the same can be applied to the IT as each IT milestone creates many new opportunities and challenges. This article first reviews the previous IT milestones and their corresponding opportunities and challenges, and then tries to predict the upcoming IT milestone and its opportunities and challenges based on the previous milestones. Therefore, readers can prepare themselves for the opportunities and challenges when the next IT milestone happens.

Keywords: Information Technology, IT Milestones, 5G, Artificial Intelligence, AI, Internet of Things, IoT, Autonomous Systems.

1. INTRODUCTION

Every milestone in information technology (IT) history radically changes the human lives, and creates many opportunities, challenges, and positions for people. For example, the WWW (World Wide Web) helped the dotcom boom, which has created millions of jobs and numerous business and research opportunities, but it also produces many challenges (like digital divide) at the same time. Milestones of the IT history are divided into two sets: computer software/infrastructure and computer hardware, where the former set includes the following milestones and the years when they started flourishing:

1. (1957) Fortran, the first commercially available high-level programming language,
2. (1969) Unix, a multi-user and multi-tasking operating system,
3. (1981) DOS (Disk Operating System), a common operating system for personal computers,
4. (1989) WWW, a system connecting countless objects on the Internet, and
5. (2007) iOS, one of the two dominant mobile operating systems currently.

Moreover, the five milestones and their start years of computer hardware history are given next:

1. (1945) ENIVAC, the first electronic computer,
2. (1964) IBM System/360, a widely accepted mainframe computer,
3. (1977) Apple II, a well-received personal computer,

4. (1996) Feature phones, primitive-function smartphones like Nokia and BlackBerry, and
5. (2007) iPhone, the first full-function smartphones.

This paper gives an overview of the opportunities and challenges from the past milestones of IT. Based on the observation, the authors then propose the possible next IT milestone, and introduce the opportunities and challenges from it.

2. MILESTONES OF COMPUTER SOFTWARE/INFRASTRUCTURE

This section gives a brief introduction for each of the five milestones of computer software/infrastructure consisting of (i) Fortran, (ii) Unix, (iii) DOS, (iv) WWW, and (v) iOS, whose timeline is given in Figure 1.
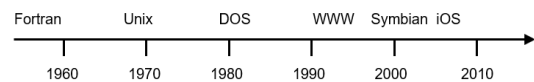

Figure 1. Timeline of the milestones of computer software/ infrastructure.

Fortran (Formula Translation)

Fortran was the first high-level programming language invented by John Backus for IBM in 1954 and was released commercially in 1957 [1]. Before that, programmers had to use assembly languages, a kind of low-level languages, to solve problems. Assembly languages allow programmers to use names instead of bits used by machine languages. In addition, programs written by using an assembly or machine language are not portable (the programs able to work on different machines without needing changes are portable). Compared to assembly languages, high-level languages offer several major benefits:

- improving programmers' productivity,
- programmers being able to think in a more natural way, and
- programs being portable.

```
C    FIND THE AREA OF A TRIANGLE.

     READ *,S1,S2,S3
     S = (S1 + S2 + S3)/2
     A = SQRT(S*(S-S1)*(S-S2)*(S-S3))
     PRINT *, "AREA = ," A
     STOP
     END
```

Figure 2. A Fortran code sample to find the area of a triangle.

Figure 2 shows a Fortran code sample, which finds the area of a triangle. Since the introduction of Fortran, many problems could be solved easily and the need for programmers was suddenly increased. However, Fortran is not a true general-purpose language. It is good at scientific or numerical calculation. Other high-level languages were therefore developed to solve more problems in an efficient way. As a pioneer, Fortran paved the way for tens of high-level languages being created. Figure 3 shows the evolution of high-level languages, which starts from Fortran.
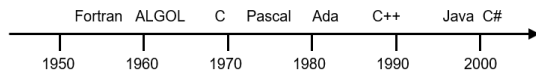

Figure 3. Timeline of high-level programming languages.

Unix (UNiplexed Information Computing System)

The Unix operating system was developed using high-level programming language at AT&T's Bell Labs Research Centre in 1969 [2]. Unix was inspired from Multics operating system which was far advanced from its time but could barely support a few users as it was based on single-level memory. Also, there was a TOPS-20 operating system which lacked to provide portability to its users. Unix brought unique features such as multitasking, multi-user, portability and hundreds of Unix applications made by various programmers. Multiple users can work simultaneously with protected memory doing full multitasking using a Unix system. Opportunities of Unix include:

1. Access rights and security as users can decide whether to provide read, write, or execute access to their files,
2. Flexible and approachable environment for businessman, scientist, industrialist, or students due to its portability, and
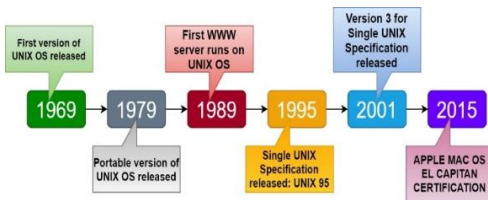3. Powerful unified file system.

Figure 4. The evolution of Unix OS.

The evolution of Unix is given in Figure 4. It is a powerful operating system with so many opportunities for the programmers, however, regular users found it to be hostile. The user needs the understanding of how to make text-interface commands and programs interact with each other. The cryptic names of commands make it hard for user to understand what they are executing. Figure 4 shows how Unix has evolved over the time. It has inspired many operating systems such as Android, Mac, Chrome, PlayStation, etc. also known as Unix-like operating systems.

DOS (Disk Operating System)

DOS is the dominant operating system for the personal computer developed by Timothy Paterson for Intel Corporation's 8086 microprocessor in 1980 [3]. Earlier, computers were hard-wired to perform certain specifications and had limited memory space. DOS allows its users to run an operating system through a disk

drive (hard disk) making it a single-user operating system. Due to its small size, it runs in only smaller systems but is much faster than any other windows version. Disk Operating System has direct access to BIOS calls and is enough for administering the MS system but failed to keep up with the technology. Unlike other operating systems, DOS has no multitasking and multi-user feature. It has difficult access to significant memory storage limiting to a command-line interface. Even though, DOS acted as a role-model for windows based operating systems such as Windows 3.1, Windows 95, 98 and ME. It gave a new face to other operating systems by providing a platform to Graphical User Interface in its initial time.

WWW (World Wide Web)

The World Wide Web was envisioned and implemented by Tim Berners Lee in the early 1990s [4]. The Web is a layer of various protocols on the Internet and was first introduced at CERN in 1991 [4]. It was developed with a vision to retrieve information using the Internet. It provides users with a massive array of documents that are connected via hypertext or hyperlinks. Through Web's initial stage, it consisted simple text pages which were difficult to navigate and inaccessible to most people. But with the release of Mosaic web browser, people accepted WWW broadly. In today's information age, it is nearly impossible to imagine our lives without the WWW and the Internet. During difficult situations such as COVID-19, the WWW makes it possible to connect people and provide all necessary information. Opportunities provided by the WWW include:

- Easy and cost-effective access to information,
- Platform to various browsers and social networking sites, and
- Available for anyone, anywhere and anytime.

Table 1. Computers and Internet access by world population.

	06/2005	06/2010	06/2015	06/2020
# of users (million)	938	1,966	3,270	4,833
% world population	14.6%	28.7%	45.0%	62.0%

Table 1 depicts that 62% of the world population can access computers and Internet whereas 38% of people are still not on the Internet. People are using it for various purposes such as online shopping, online transactions, searching for jobs, Research & Development, etc. Although, Web brings a significant threat of security. It is easier for anyone to access the Web from anywhere, which leads to fake profiles, fake information, and no privacy. Nowadays, it is much easier to track anyone from anywhere in the world. The World Wide Web needs regulations and quality control on existing data. Figure 5 shows the revolution of Internet where the WWW went mainstream in 1991.
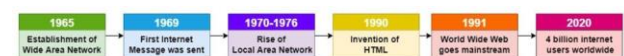

Figure 5. The revolution of the Internet [4].

iOS (iPhone Operating System)

iOS is the first full-functional mobile operating system developed by Apple Inc. in 2007 [5]. Former operating systems were palm, windows, and blackberry. These operating systems were little

complex and less-user friendly. iOS brought better user experience and secure environment for users. It was much faster and featured multi-tasking. iOS changed the landscape of smartphones by enhancing its capabilities. Apple inc. has released 14 versions with the latest release of iOS 14 on September 16, 2020. iOS is used in various Apple products such as iPod, iPad, and iPhone. iOS provides various features and access to multiple applications to its users. Some of the opportunities of the iPhone operating system are given as follows

- It offers excellent security and has 24/7 support.
- Suits both professional and personal.
- Faster processor than their competitors.

iPhone operating system is only limited to apple products. This is good from security point of view but, it suppresses new innovations as iOS is not open source. It is operated and managed by Apple Inc. employees only. Open source nature of android made smartphones using android operating system more popular and affordable. Android is not only limited to one brand like apple; therefore, it is widely used.

3. MILESTONES OF COMPUTER HARDWARE

This section introduces the five milestones of computer hardware consisting of (i) ENIAC, (ii) IBM System/360, (iii) Apple II, (iv) feature phones, and (v) iPhone, whose timeline is given in Figure 6.
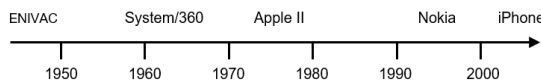

Figure 6. Timeline of the milestones of computer hardware.

ENIAC (Electronic Numerical Integrator and Computer)
The ENIAC was the world's foremost programmable general-purpose electronic computer developed during World War II by American physicist John Mauchly and his colleagues [6]. ENIAC was specially designed for computing values and could be used for a broader range of problems. ENIAC was huge, and it occupied the 50/30-foot basement of the Moore School at the University of Pennsylvania. It used to run continuously generating 174 kilowatts heat, therefore required its air conditioning system. Although, the use of vacuum tubes made it possible to make a digital computer which could calculate in milliseconds.
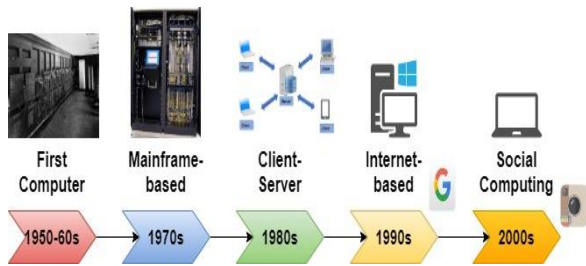

Figure 7. The evolution of computing.

Figure 7 shows how computing have evolved over the decades from acquiring a huge basement to a small place in the corner. The world's first computers had some limitations as it had very narrow functions. Its capability was small compared to today's computers. In addition, its speed was slow, and still used vacuum tubes that require replacements from time to time. Besides, it was the pioneer of today's prevailing computers, which are used for almost anything and anywhere.

IBM System/360
In 1964, IBM announced the System/360 mainframe with various models after investing $5 billion. In the era of technology and business creativity, S/360 marked a turning point in the field of information science and understanding of complex systems. Earlier, there was no software market for the users but a programming world. The mainframe made data-intensive or complicated processing such as weather forecasting, census, and enterprise resource planning possible. That was the beginning of a new generation, not only for computers, also for their applications in science and business.
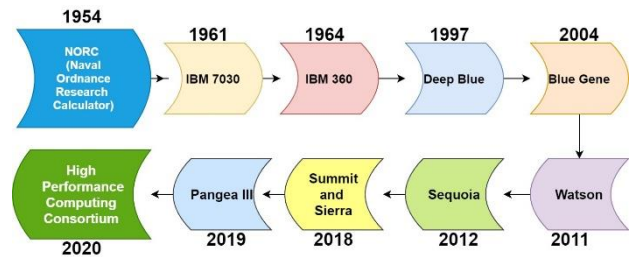

Figure 8. Timeline of IBM computing.

Figure 8 represents the computing timeline for IBM systems. S/360 was a massive success for IBM as they expanded to $8.3 billion by 1971 from $3.6 billion in 1965 [7]. IBM saved lots of resources by designing a common architecture as there was no more prolonged need for individual components such as processors and memory. The customers benefited from the system as they were able to move their S/360 code to another system without rewriting it. But IBM system was only for corporation use because of the high price and limited applications available.

Apple II
Apple II was the first computer launched in 1977 for low cost, high volume, and high reliability [8]. The machine usually was equipped with 64 KB RAM, a mouse, floppy disk drives, and a backport accessible DE-9 joystick connector. Apple II was the first computer to have BASIC (Beginner's All-purpose Symbolic Instruction Code) with sound graphics and came completely assembled. Earlier, companies used to rely on a spreadsheet that was a large paper ledger file, but after the release, the spreadsheet was software in a computer with no more requirement physical ledgers. The Apple II made personal computing possible. The Apple II was a huge revolution in the computer's world for Apple. However, the functions provided by Apple II were limited, and it was mainly used for hobbies. Apple designed the Macintosh OS from scratch, and it had only a handful of good games at that time. Also, the unique sound graphics used in the Apple II were not simple to use. The user had to go through a particular set of set-ups before using it for real sounds.

Feature Phones

A cellphone has made a significant change with the evolution of technology. It has transformed from brick-like mobile phones of 1995 to sleek, stylish, and compact smartphones of 2020 [9]. Earlier, mobile phones were huge with long antennas and weighed over a kilogram. Other than appearance, cellphones lacked the advanced features like navigation, media streaming, email, touchscreen, etc. and were mainly used for phone calls and short messages.

Figure 9. The evolution of Feature Phones [9].

Figure 9 depicts the evolution from feature phones to smartphones. There is a massive change in terms of appearance, size, and features. Nowadays, smartphones are an essential part of human lives and will be naturally in sync with human's biological reflexes like eye movement, cultural preferences and, thought processes. Features Phones were used for just calls, but smartphones have replaced calculator, alarm clock, watches, calendar, and various other devices. There are huge companies like Apple, Samsung, Motorola, which are bringing new technologies and appearances to the cellphones with lots of options for the users. The growth of cell phone from the past decade is so rapid that anything one can imagine is possible for the future. The feature phones have paved the way for various cell phones companies presenting opportunities to human lives.

iPhone

iPhone is the first fully functional and ubiquitous smartphone launched in 2007 by Apple Inc. iPhone 1 was a leading touchscreen smartphone with a built-in MP3 player and a full operating web browser. It had a sale of more than one million units worldwide [10]. Since 2007, Apple Inc. has made approximately 26 models of iPhone with the latest release of iPhone 12 in 2020. It is capturing 32% of global revenue and 66% of all profit according to the latest report from Counterpoint research. iPhone sales made up about 60% of apple's total revenue. iPhone is a revolutionary device for the mobile industry. Nevertheless, it is one of the most expensive smartphones. Sometimes, users find it frustrating to operate with other common issues such as short battery life, poor dexterity, less storage, etc. Also, it limits the functions due to its low data transmission rates. Therefore, the iPhone is not for everyone, but the iPhone has many more years to offer with its advance technology for its users. Figure 10 shows the timeline of smartphone evolution.
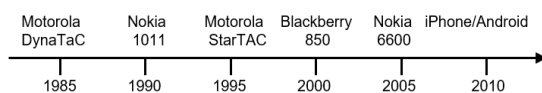

Figure 10. Timeline of the smartphone evolution.

4. POSSIBLE NEXT MILESTONE OF INFORMATION TECHNOLOGY

The IT milestones did not happen instantly. Instead, they were normally created by the gradual development. Since the last milestone of iPhone and iOS launched in 2007, there is no clear picture of what the next milestone will be. The drought has been the longest in the IT history. The reason may be because the IT is mature and new revolutionary technology is hard to come by. Nevertheless, the authors try their best to give the possible next milestone of IT explained in this section as follows.

5G or above networks

The first generation or 1G was launched in 1979 by Nippon Telegraph and Telephone in Tokyo [11]. Motorola's DynaTAC was the first cellphone to see extensive usage. Networks use has been an essential part of human's daily lives, however, claim for higher speed never stops. Earlier, there was no roaming support, poor coverage, and low sound quality [11]. Today, 5G networks promises to deliver multiple-Gb/s peak data speeds, ultra-low latency, more reliability, enormous network capacity, expanded availability, and better user experience to users.
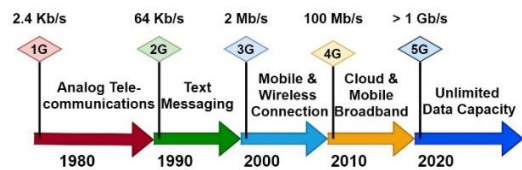

Figure 11. Timeline of networks.

Figure 11 shows how the network has evolved over the decades from 1G to 5G. The ultra-high speed of 5G has great potentials. For example, it can connect virtually everyone and everything, including machines, objects, and devices. It also makes businesses more efficient and allows consumers to access more information quickly. Besides, many of the advanced technologies like connected cars, smart communities, and homes, IoT, immersive education all will rely on 5G. Still, there are many challenges right now for 5G including:

- The 5G concepts are ready, but its technology and research are still in progress.
- The claiming speed of 5G has not yet been achieved mostly because complete technical support is needed to achieve the speed.
- Old devices may not work for 5G.
- Infrastructure needed could be costly.
- Potential security and privacy issues may exist.

AI (Artificial Intelligence)

Artificial Intelligence also is known as human-like intelligence was founded in 1956 by John McCarthy [12]. The term artificial intelligence is not that simple, scientists and researchers are still exploring this field. Nowadays, research is more focused on Deep Learning which is a huge part of artificial intelligence. AI has been expanding widely in various fields and according to 2019 report of IDC and Forrester [13]:

- AI spending will increase from $35.8 billion in 2019 to $79.2 billion by 2022.

- 53% of global data and analytics decision-makers say they are using or plan to use AI.
- 29% of global developers have worked on AI/machine learning (ML) software in the past year.
- 16% of global B2C planned to increase spending on data technologies, including AI, by 10%+ in 2020.

IDC forecasts 12.3% growth for AI market in 2020. Artificial Intelligence is changing the world by indulging technology into human lives, however, there are hurdles to achieve the desired outcomes. The implementation cost for AI is very high, Apple is spending $200 million to acquire SIRI. Also, AI has not successfully replaced humans so far and needs re-assessing, re-training and re-building to improve performance. Lastly, with the increasing population, there is a major risk of unemployment. According to McKinsey Global Institute, approximately 30% of the current human labor will be replaced by AI by 2030.

IoT (Internet of Things)
Internet of Things, the concept of inter-connected devices was introduced in the early 80s [14]. The IoT is a system of interconnected computing, digital, and mechanical devices/machines in which each is provided with a unique identifier. The devices in an IoT can share and transfer data without requiring human-to-human or human-to-device interaction. Figure 12 depicts the basic concept of IoT.

Figure 12. Concept of IoT.

IoT is developing rapidly and will soon dominate the world. IoT developers are focusing on the designs for industries to reduce costs and improve quality. IoT will be merged with other technologies such as the Internet of Medical things, Industrial Internet of Things, etc. Table 2 depicts the worldwide IoT market from 2018-2020 [15].

Table 2. IoT endpoint market by segment from 2018-2020.

Segment	2018	2019	2020
Utilities	0.98	1.17	1.37
Government	0.40	0.53	0.70
Construction	0.23	0.31	0.44
Security	0.83	0.95	1.09
Manufacturing	0.33	0.40	0.49
Automotive	0.27	0.36	0.47
Healthcare	0.21	0.28	0.36
Retail	0.29	0.36	0.44
Information	0.37	0.37	0.37
Transportation	0.06	0.07	0.08
Total	**3.96**	**4.81**	**5.81**

As the IoT is emerging, and there are various challenges faced by the manufacturers such as high cost of implementation due to its high complexity. There is security and a privacy issue as it connects your devices to the various networks. Still, interconnected technology is evolving rapidly despite increasing cybersecurity issues, and IoT will change the way we live today. Figure 13 shows the major barriers in the way of IoT adoption.

Figure 13. Top challenges for investment in IoT [13].

Autonomous systems
Autonomous systems use software that sends out the instructions automatically based on real-world conditions. They differ from traditional automation that operates based on predictable conditions. Autonomous systems will replace humans in carrying out various functions, becoming central and essential in human lives [16]. Some examples of autonomous systems include:

- Autonomous robots
- Self-driving cars, trucks, and aircrafts
- Collaborative production assistants
- Socially enabled domestic robots
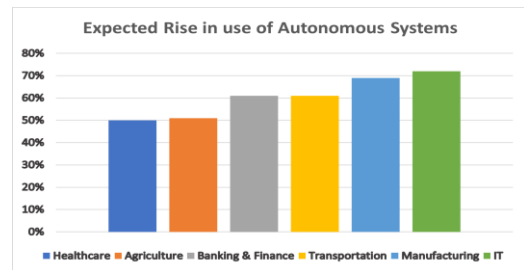- Non-physical work such as customer services

Figure 14. Expected use of autonomous technology.

According to the survey conducted by Forbes, Figure 14 shows the expected rise in the use of autonomous systems within five years in a variety of industries. It is evolving rapidly and will be broadly prevalent. Although, there are some significant challenges such as the specification of autonomous system behavior, faithful analysis concerning the rich environment, including humans, physical artefacts, etc. Also, the current autonomous systems need continuous human supervision as they are difficult to rely upon.

5. SUMMARY

Information technology (IT) may be the most widely used technology these days because no other technologies affect our daily lives as the IT does. For an example of a typical daily routine, we read news by using tablets during the breakfast, use smartphones to pay for mass transportation, prepare the presentations by using PCs in offices, and watch movies on demand before going to bed. It shows how deeply the IT has involved with our daily lives. This article gives an overview of the opportunities and challenges from the past milestones of IT. Based on the observation, the authors then propose the possible next IT milestone, and introduce its opportunities and challenges. Every IT milestone has great impacts on human lives both in opportunities and challenges, and a milestone happened about every 12 years. However, since the last milestone iPhones were launched in 2007, there is no clear picture what the next milestone will be. The long drought of milestones may be because the IT has become a mature discipline and new discovery is difficult to come by.

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