Chapter 2
Technology Advancements in 2050 and How the World Will Look Like

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Abstract The last 100 years have shown technological progress at a tremendous pace. Simultaneously, the social, economic and political changes have also been influenced by the technological progress but at a slower pace. The present work makes the daring exercise of envisioning how the technological landscape will look like in the year 2050, not from a purely technical viewpoint, but also taking into account social, economic and political aspects. We come to the conclusion that there will be either a closed world, where access to technology is strictly controlled and innovation is possible only under a controlled environment or an open world where there is unrestricted access to technology and innovation continues to thrive, by being built on open systems.

If we take into account technology advancement in the last 50–100 years, we can imagine, unless some major setback occurs, that it will continue ever more rapidly. It is likely that discreet and unobtrusive technological advances, devices and information overlays will change how we live in significant ways. But what will all this new technology mean? Will advances in technology make us more empowered, motivated and active, rather than passive consumers of infotainment? Will threats endanger much of the openness that we now enjoy online?

Before we envision how 2050 will be like, we must start with some assumptions. The first one is that the current capitalist system remains until 2050, meaning there will still be a free market in the majority of countries, and people and enterprises will continue to innovate. The second one is that global warming impacts are not catastrophic and there will be no second ice age. Next, we assume that global economy will not be in a permanent recession and companies continue to innovate and grow. Lastly, we must assume that nanotechnology becomes effective, enabling tiny devices to be embedded inside the human body.

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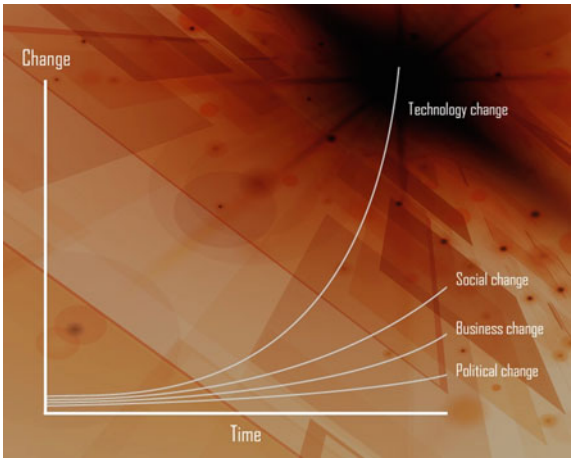

Fig. 2.1 Changes over time [2]

As highlighted in Fig. 2.1, the most dramatic change over time is the change in technology. We have already witnessed this in the last 50–100 years, and there is no reason to think it will stop. On smaller scale, in part triggered by the technological changes, we can say there are social changes, business changes and political changes. If we think about the influence of technology, social changes occur because of the possibility for people to (almost) instantly connect one with another, regardless of the geographical distance between them. Business changes are triggered, for example, by current paradigms of ubiquitous computing and rise of interconnected machines (cyber-physical systems). Lastly, political change is influenced by technological change in the sense that new technologies have to be regulated, standardized and they also influence the way politics is being made.

Our proposed exercise of envisioning how the world will look like in 2050 will, as detailed in the next sections lead to two different scenarios. One scenario is that there will be a closed, dystopian world, where people only know what stakeholders (governments, large corporations) want them to know and are served specifically tailored content, transforming them into informational "couch-potatoes". The other, more optimistic, scenario is a utopian world, where open systems continue to exist and serve as means for people to become more actively involved in the problems of society, empowering different marginalized groups and societies.

The chapter is organized as follows. Section 2.1 presents an overview of how technology and the Internet will look like in 2050. Section 2.2 present how this will shape Industry and economy in 2050, while Sect. 2.3 envisions what happens when we lose access to technology. Section 2.4 discusses open and closed systems and, based on this discussion Sect. 2.5 outlines two possible scenarios of future worlds. Finally, Sect. 2.6 draws the conclusions.

2.1 Technology and Internet in 2050

2.1.1 Introduction

In order to make the exercise of predicting technology advancement in the next 40 years or so, we must look at how much technology has advanced in the last 40 years. In other words, we must look at the past in order to predict the future.

One of the most popular indications of technology advancement is linked with the so-called Moore's law [1]. The law represents an "observation that the number of transistors in a dense integrated circuit doubles approximately every 2 years". It is most times quoted as a "doubling of chip performance every 18 months" (as a combination of the increase of the number of transistors in a chip and the increase in their speed). Figure 2.2 shows a potential evolution of transistor size up until 2050.

It is widely considered that the asymptotic limit of the size of a transistor is 10 times the molecular size, or 10 nm. We can see from Fig. 2.2 that this limit is approximately reached in 2030. Will this hinder technology advancement? Most likely not. Of course, the "intelligence" of computers depends on program software, operating software, clock speed and how processors are organized, not just on the size of the transistors used. We can therefore easily postulate that the performance of chips will continue to double every 18–24 months, up until 2050. This will largely be owed to the occurrence of quantum computing, optical computing or a combination of both.

2.1.2 Past Versus Future

Current ways of humans to connect to the Internet is via an interface (be it a Desktop PC, laptop, tablet, or smartphone). The interface transforms the input of the user (which is usually given via an input device such as a keyboard—hardware

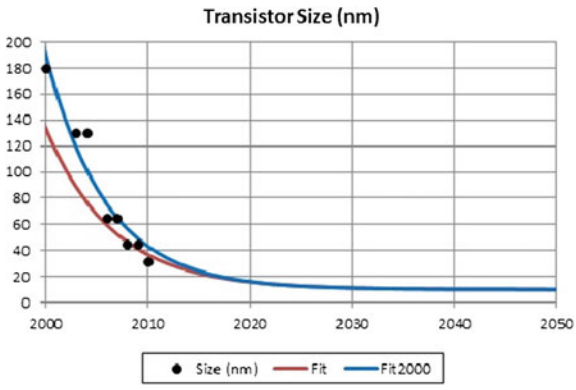

Fig. 2.2 Transistor size evolution [3]

or touch) into information that is then transmitted via a communications medium through the network of interconnected nodes (a.k.a the Internet). At the receiving side, depending on whether the user wants to retrieve some knowledge, or wants to communicate with a second user, another interface will either retrieve the information and send it back to the user, or it will transform the information into output for that second user (which is usually rendered on a screen of different sizes).

Will this way of connecting to the Internet change? Probably so. The flow described above is valid for individuals without impairments. The ones that have visual impairments, physical impairments, or even hearing impairments have to follow different paths usually involving some screen reader or other ways of inputting information. Also inputting information follows a long route, in which the brain first thinks what to input, then it commands the hand to do the motion(s) through which text is written or a button is clicked. We can easily observe that advancements (which are usually derived from the need of overcoming current human limitations) might lead to some other way of inputting and rendering information.

We can foresee that there will be no such things as phones, tablets, or computers. Instead computing will just be embedded into ourselves. There will be no need for keyboards or screens for inputting or rendering information, saving the unnecessary steps taken from the thought to the actual input. Inputting information will be as easy as thinking. The same will happen with displaying information. The visual information will not reach our brain through our eyes, but it might arrive directly at the brain, which is permanently connected to the Internet.

Given the above considerations, we can assume that there will be no such thing as "connecting to the Internet". We will be on the Internet at all times. In fact, every living and non-living thing on the planet will be on the Internet at all times. This will also mean that all of their data will be recorded onto the Internet which might have different implications which will be analysed in Sect. 2.3.

Nowadays we keep collections of pictures onto hard drives or online storage services, we keep people in digital address books on smartphones or social network accounts, we keep information about ourselves on social networks or in personal (digital) documents and, finally, we have memories that we keep in our mind. In order to share a "thing" (picture, document, link etc.) you need to press a button (share, compose e-mail or similar) and then choose via which channel you want to share. Another long route to follow.

Therefore, we can foresee that each person will have its own collection of people, memories, experiences, information, all of which will be shareable by "connecting with others". Sharing will be done just by thinking. The Internet will be like an ever-present intelligent *entity* that can be tapped into at any time by anyone or anything on the planet. Being an intelligent entity driven by artificial intelligence, it will also enable humans just to think of an outcome and the Internet figures out how to achieve that outcome. It's similar to programming today, but the work of the programmer is made easier.

2.1.3 Ubiquitous Connectivity

To enable what has been described above it is most likely that at a fairly early age we might have tiny, nanoscale devices placed in the body. These will be small transmitters for connecting (actually *being connected*) wirelessly to the Internet. But there will also be sensors. These would have the role of interpreting brain signals, but also the role of performing diagnosis of the health status of the human. There will be real time big data analysis sent to medical centres or other similar entities which will enable earliest possible detection of disease to ensure optimal medical tracking.

Items purchased will, by default, have Internet connectivity enabled. Therefore, any prized item will not be able to be lost or stolen, because it will be always connected to the Internet, and will be able to be tracked. We might even get its location instantly in our brain. This is something that will certainly be a reality if we think about what is happening nowadays. It only took 10–15 years' time to dismiss the idea of the lost friend. You can, most likely, find him via a social network or via Google search.

Homes, and, more generally, buildings will be made smart by the cluster of web enabled devices that come and go within the home. The devices inside the buildings will perform different roles and will enable the building, overall, to be *intelligent*. The devices will interact with each other, driven by the *intelligent* Internet, in order to perform different roles and contribute to the intelligence of the entire building. For instance, the building will be able to have self-sufficiency, self-optimization and self-healing. Devices in the building will be able to create their own social networks within a space.

Not only building or other structures will be self-healing. The entire web will develop in resiliency and mobility. The (core) network nodes will no longer be limited to being fixed and the traffic limited to going through a limited number of routes. There will be devices that come and go inside a network in a plug-and-play manner, and the higher layers in the protocol stack will be oblivious to how the physical layer is made up.

All of these scenarios will be enabled as mentioned above by the proliferation of nanotechnology and optic computing, and also by advances in brain science. It will also be complemented by such concepts as software-defined radio, virtualization, software-defined networking etc.

2.2 Industry and Economy in 2050

Again, in order to predict economy and industry, we have to look back at the past and present. If the 50s through the 70s brought about the third industrial revolution [4], which was the change from analog, mechanical and electronic technology to digital technology, current times (2010s) are bringing about the notion of *Industry*

4.0 [5] or the fourth industrial revolution. This is a term that embraces a number of automation, data exchange and manufacturing technologies. It can be viewed as 'a collective term for technologies and concepts of value chain organization' which draws together current concepts such as Cyber-Physical Systems (CPS), the Internet of Things (IoT) and the Internet of Services (IoS). We see the use of Information and Communication Technologies (ICT) in all fields, starting from industry, and going to labour, health and, most of all economy.

We can postulate that the information and industrial economy will have joined up entirely by 2050. Almost all economic activity starts at ICT work which creates intellectual property (IP). The main human activity will possibly be Computer-Aided Design (CAD) and design work. The creation of physical things will be done by all-purpose or special machines, similar to what 3D printing is producing nowadays. Therefore, there will be an *idea-driven economy* as opposed to a *production-driven economy*. Due to the instantaneous nature of communicating and connecting, the economy will be profoundly global on ideas. People from any corner of the planet will take part in the knowledge sharing and idea producing activities. Also, the economy will also be local on production, since a physical device will be able to be produces anywhere.

This is the opposite of what is happening nowadays, where production is done in different facilities across the globe (economy is global on production) and then products are shipped to different destinations, and ideas are produced by central teams or management (economy is local on ideas).

Job schedules will be made up of intense bursts followed by days of downtime (you could think of this in terms similar to today's medical residents). People will not be able nor will want to work 8–9 h continuously, under a strict schedule and then resume the next day. This is becoming more and more prevalent right now, because of the amount of social networks that many browse during work hours, and because company e-mail and computing is becoming available on personal smartphones, and will only continue to rise in the future. Only some critical task can keep employees focused or busy from the temptation which is social networking. Process automation will therefore have to focus on maintaining a near constant productivity despite alternating intensity of work effort. We can imagine there will be such scenarios of job sharing, where a job is made up of different small tasks that an employee can carry out in a short burst of productivity, but also job or task offloading, where a critical task can be carried out in an automated fashion, and the decision to offload is taken on-the-fly.

Working remotely also might become the norm. It is enabled just by the mentioned advancements, such as instantaneous connecting to the Internet and sharing of thoughts, ideas, and memories.

There will be new types of jobs for new type of economy and industry. The key among these skill sets will be the transition away from management towards leadership. The manager will be the leader of a set of people in the Internet. If nowadays, the manager's role is focused more on organization and planning, he

will transition to that of a leader, where a leader's role is to inspire and motivate. The critical tasks of organization and planning will be done in an automated way, optimized and taking into account all possible job-related metrics.

2.3 Losing Access to Technology. Security and Privacy Aspects

Today, technology and, especially, access to Internet, is already entrenched in many of the people of this planet. It is not quite uncommon now for people to become restless if they do not have access to their Internet-enabled mobile phones (e.g., nomophobia [6]). Also, there are scientific studies that link Internet addiction to modifications in brain structure [7]. We can envision that, without the Internet, in 2050, one is functionally useless and at a great disadvantage when earning income or fostering relationships.

Imagine, therefore, that in 2050, a criminal sentence might become to lose access to technology. We can imagine that, similar to drug or alcohol addiction, the lack of Internet use might bring side effects such as anxiety and stress.

Criminals, the unintelligent, and delinquents might, therefore, make up the majority of unskilled jobs where physical presence is required. They will be thought of as second class citizens and there will be something that can be called a digital divide between the so-called upper or middle class citizens and lower class.

There could, also, be, people that willingly choose to be "disconnected", because of not wanting to be tracked. There will, likely, also be a proliferation of the dark web where more and more people (either criminals or people that simply do not want to be tracked) will take refuge from tracking that could be done by corporations or governments.

So, to summarize, in 2050, not being connected might be punishment for committing crimes, or it might be a choice done by some people, whether criminals, or people that do not want to obey the rules.

However, losing access to technology might happen not by a sentence or by voluntary choice, it might happen as a result of a technological threat or virus. Worse, connectivity might be lost between machines that perform critical tasks. We know that, nowadays, security is ensured by different measures such as encryption and authentication or maintaining certificate authorities. What will security measures look like in the networks of the year 2050?

We have already determined that a variety of intelligent systems, operating with varying and controlled degrees of autonomy, will continue to proliferate by 2050. Sensing, communicating, collaborating intelligent entities will densely populate the technological space exhibiting a range of sophisticated capabilities. We have to think also that nations, rogue groups, and malicious individuals will step up their hacking games. The hacks could affect banks, businesses, and private data, but also do tangible damage to a world increasingly reliant on technology. Citizens will

most likely divide between those who prefer convenience and those who prefer privacy, as is much the case already today.

We can most likely say that security will be embedded in devices from the design stage, and it will be compulsory. Every device that is manufactured will have natural cybersecurity. Also, threat and vulnerability information will be shared and coordinated across devices in order to increase the security and privacy of devices and humans.

Regardless of all these, there will be an exponential increase in the number of cyber-attacks, but there will be fewer such successful attacks than we have now. However, the attacks will be much more devastating, with the ability to bring to a standstill even an entire country. There will be so-called "threat prediction" mechanisms in place, but, as is the case with security nowadays, a threat will always appear and wreak havoc before the solution to this threat emerges.

2.4 Open and Closed Systems

Looking at the previous sections, we have to think about the Internet and systems in general how much openness can be preserved.

We can say that a major part of the innovative value of today's systems stems from the openness to novelty and experimentation. As we use it right now, the Internet means not having to ask anyone for permission or (sometimes) pay to access a resource or information.

There are some companies committed to preserving openness, releasing open source software that can run on different types of hardware. There are also others committed to closing it down, by requiring special hardware for its closed source software to run. Each parties have their motivations for this, ranging from ideology to user experience, profits etc.

We can however, from these observations, outline two distinct evolutions, or two distinct futures of the Internet.

The best scenario is that there will continue to be open systems and their advantages (but also disadvantages) can be highlighted in comparison with closed ones. Their advantages come from the open features and experimentation that can be performed, but also disadvantages like lack of interoperability between different producers, different user experience for different hardware etc.

Another scenario is when all systems become closed, and cannot operate in open way. There might be different reasons for that. It could come through government intervention or as a threat from viruses. It could even come from the public pressure. Technological threat (viruses) as a result of the existence of openness might become unbearable for the average citizen and the system, at the request of the public, can be closed down. Meaning all applications have to go through a censorship committee or no application can be released without satisfying some criteria possibly having to do with it being perfectly compatible with the rest of the system.

Table 2.1 Comparison between open and closed systems

	Open systems	Closed systems
Support	More prompt, less specialized	Less prompt, more specialized
Customization	Available	Possible, with likely breach of terms and conditions
Security	More prone to threats, but security bugs can be fixed more rapidly	Less prone to threats, security bugs are fixed in slow update cycles
User privacy	Less	More
User experience	Different experiences for each user, non-tech users may have bad experience	Users have similar experiences, even the non-tech savvy users
Operator financial gain	Less	More

We can argue that the average citizen has zero ideological commitment to the openness, only to utility. And this could be used as a pretext for restricting the openness of technological systems (Table 2.1 presents a comparison between open and closed systems in terms of several key parameters).

2.5 Discussion: Two Future Worlds

Taking into account the two scenarios outlined in Sect. 2.4, we can say that there will possibly be two worlds. There might be a world where open systems continue to exist. They are ways of empowering groups and societies, marginalized groups. Take, for instance, a mobile application that enables citizens in a community or city to report problems in that area. It is produced by a developer and released in an application store and downloaded and used by hundreds or thousands of people. This puts pressure on the leadership of the city to take actions against those issues. This wouldn't have been possible if the application was subject to some audit and it might have been stopped from being published.

Opposite to this, there might be a world where everything is closed and people know only what large stakeholders (e.g., governments, large corporations) want them to know. People that believe and accept without question, what is being served to them. It can be clearly stated that there is no easy way of dealing with the informational deluge, filtering important topics of interest from all the heap of distractions that are served via social media or other channels. It is what is happening even today, and it will be happening on a larger scale in 2050. Many people on the planet have become content producers, either low quality or high quality. And the advent of social media has enabled the content that is produced to be instantaneously shared with a large mass of people.

2.6 Conclusion

Part fact and part fiction, the present paper has been written as an exercise of envisioning how technology advances and how the world will look like in 2050. It is based on analysis of current trends, advances in technology such as Moore's Law, future medical breakthroughs and much more. Where possible, references have been provided to support the predictions.

The analysis has outlined two different scenarios that might become a reality in 2050. One scenario is that there will be a closed world, where people only know what stakeholders (governments, large corporations) want them to know and are served specifically tailored content, transforming them into informational "couch-potatoes". They have access only to the systems and information sources that they are allowed, and any content that is produced has to be approved. The other, more optimistic, scenario is a world where open systems continue to exist and serve as means for people to become more actively involved in the problems of society, empowering different marginalized groups and societies.

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