

Ubiquitous Connectivity

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Abstract

7.5 billion people and hundreds of billions of devices will be connected to the Internet. Ubiquitous connectivity. This will be achieved through fiber infrastructure, cellular networks, weather balloons, drones, and low orbiting satellites. The Internet will scale exponentially with new advances in network hardware to sustain the incredible growth. Constant cyber attacks will occur against organizations, systems, and devices. An insecure world will be the default state if people constantly treat security as an afterthought. People will be enabled through learning and education to innovate, create, and develop. All people will be provided the tools to create a better future. A fully connected future will shape people and society, however humankind must determine, with intention, what that future will look like.

1. Introduction

Connectivity has existed between devices for many years: long haul radio waves enabled by the discovery of the ionosphere, development of the telegraph and telephone systems, and most recently the Internet. Even with this incredible development during the last two centuries, the world has yet to reach a point of ubiquitous connectivity. There are many roadblocks to ubiquitous, worldwide connectivity such as geography, cost, and logistics. These problems have not stopped people and organizations from envisioning a future where there is global Internet connectivity for everyone, at any time. The Internet has become an integral part of modern society and is increasingly being depended upon for services, entertainment, and convenience. To highlight this, in 2016, the Canadian government's telecommunications regulatory commission (CRTC), deemed that the Internet should be accessible to all Canadians as a basic service for modern society [5]. The recent development of the Internet of Things (IoT) [11,12] is further fueling the need for a ubiquitous Internet; devices everywhere from city infrastructure to household items are being digitized and connected to the Internet. The future envisioned will have all devices and people connected. All people will have equal access to knowledge and learning, advancement of the human condition through collective empowerment, and improving quality of life in an interconnected world. This empowerment was succinctly expressed by Sebastian Thrun, founder of the massive open online education program Udacity, "my dream is to go and give every human being a chance and the best way to do this is education" [9].

2. Background

2.1 Historical Perspective

The initial attempts to connect people over long distances started with the telegraph. The telegraph expanded to achieve intercontinental coverage through transatlantic submarine cables. However, the telegraph did not allow individual ownership, allowing personal communication over the network. The telegraph existed in common public service areas such as postal offices where telegrams could be sent. This was mainly due to the complexity in actually sending a telegram. Trained telegram operators were needed in addition to the fact that the telegram was a half duplex operation - the operator must wait until the line was silent before transmitting. In parallel, radio technology was being developed quite significantly, and soon radio was deployed throughout countries. Even though the radio was widely deployed, it was a broadcast medium only; serving the narrow role of entertainment and information. The first major breakthrough in mass personal connectivity was the invention of the telephone and deployment of the switched telephone network. For the first time, people were able to connect to another person from their home, simply and quickly, with a dialing of a phone number. The public switched telephone network was a convenience that people learned to depend on daily in their personal life and in business. It has even been theorized that the telephone enabled the growth of large corporations in the early 20th century [17]. The telephone network in certain countries did not spread as fast and wide as it did purely out of want, government policy and funding played an important role. In Canada, the public telephone network was subsidized by the government to ensure everyone has reasonable access to the telephone network. The growth and deployment of the public telephone network is being mirrored by the development of the Internet. From the convenience and efficiency gains realized, to business growth and government mandates [5]; the Internet is becoming a basic service for all.

2.2 Current State

The current Internet has been the most significant societal communication technology since the adoption of the telephone. The Internet is viewed as an essential service for modern society; the by-product of this is driving increased connectivity worldwide. In developed worlds, there are major deployments of fiber to the home; enabling commodity Internet speeds which satisfy government mandates for high bandwidth connectivity. This has also allowed for the Internet of Things (IoT) explosion [11,12]. However, even with the current level of connectivity, only 47% of the world's population is connected to the Internet in some way [14]. There is still a large population that does not have Internet access. Due to infrastructure challenges, the connectivity mediums go beyond traditional wired DSL connectivity. A large part of the world's connectivity come from cellular mobile networks. Additionally, remote areas need to be serviced in unique ways. Recent attempts by technology companies are being made to further connect users - Google has created Internet connected weather balloons to provide wireless connectivity to remote areas [8] and Facebook has a project to create a series of unmanned drones to provide network service

[10]. This increase in Internet connectivity brings to light many societal and technical questions. Cyber insecurity is currently exploding as a result of increased Internet adoption. There has been an increase in cyber crime ranging from identity theft, denial of service attacks, nation state warfare, and hacktivism. Internet performance is also an increasing topic of concern. As more and more devices, people, and systems connect, the Internet must scale to accommodate the future growth [4,15]. From a purely societal view, Internet rights have been a major topic for policy makers, philosophers, and visionaries. Has the dependency on the Internet reached a critical point where it should be considered a human right, or should only the rights of a person be upheld while online, not the access itself [7,16,18,19]? Our world is being shaped by our connectivity, however a fully connected future of people and devices will bring an exponential increase to the current issues we face, bring about new challenges, and allow for a brighter future by enabling human capabilities.

3. Ubiquitous Connectivity

3.1 Getting Connected

A fully connected future will heavily rely on novel technical implementations to overcome geographical challenges to enable a fully connected world. There is a reason why a large chunk of the world's Internet connectivity is through cellular carriers - wireless connectivity. The reduced cost and increased coverage solves many issues in connecting people. In the near future, companies will be launching satellites that will provide high speed terabit connectivity to the ground base stations [1]. This will enable Internet connectivity in remote areas of the world where it is impractical to run fiber optic infrastructure. However, high orbiting Internet connected satellites have existed for many decades; there are even many hobby Internet satellites available. The future of satellite connectivity however, lies with Elon Musk and his company SpaceX. Elon Musk, a billionaire and Internet visionary, has ambitious plans to truly connect the world. Realizing that fixed Internet connectivity is cost prohibitive due to geographical constraints; he plans to launch 4,425 low orbit satellites to provide global Internet connectivity, from the equator to the north and south pole [2]. This will be a major advancement for satellite connectivity, not only because it provides global coverage, but also because of its minimal latency. Current satellites orbit high above the earth causing large latency which limits its use, unable to support real time applications such as voice over IP, video conferencing, and online gaming. SpaceX's satellites will be low orbit, providing latency equivalent to traditional infrastructure. The significance in this project can be inferred purely by the number of satellites that are going to be launched. The current active satellite count at the end of 2015 was 1071 [3]. The planned number of low orbit satellites is 4,425, a quadrupling of the number of current active satellites. These ambitious plans will enable global connectivity alone, something that is yet to be achieved.

3.2 The Internet

More and more people and devices are being connected at an increasing pace. Eventually all people on the planet will be connected to the Internet, almost 7.5 billion people. The massive

amounts of data being generated and consumed will continue to increase at an exponential rate due to more bandwidth intensive content being created and consumed. Cloud computing will continue to explode adding to the massive reliance on large data transfers. The Internet of Things (IoT) movement, digitizing and connecting any and all devices where any benefit is realized, will continue exponentially as well. Internet visionaries such as Vint Cerf, the 'father of the Internet', calls for a re-envisioning of the Internet; not just a place for information and innovation, but for a lifestyle revolution enabled by IoT [11]. Imagine connecting not just people with smartphones, but hundreds of billions of devices connected to the Internet providing data to cloud based information systems for analysis. Imagine not only your home fully connected, but entire cities' infrastructure and other analog devices digitized and connected. This future will push the boundaries of bandwidth usage of the Internet. Constant research and development is happening to push hardware limits for increasing bandwidth. The future of the Internet is constantly demanding more and more bandwidth: terabit, 10 terabit, 100 terabit, petabit. The future will constantly demand more as ubiquitous connectivity is achieved. Even during the age of ubiquitous connectivity, the demand will continue to grow. More innovation, creation, and consumption will forever demand exponential bandwidth increases within the Internet. There may be a time when Internet performance plateau's, however it will coincide with the plateauing of the entire computing industry and surely will be long after ubiquitous connectivity is achieved.

3.3 Trading Connectivity for Insecurity

The current security issues are but a small glimpse of a fully connected world. As more devices and people are connected, the current issues will increase exponentially and new, unforeseen issues will emerge. The Internet of today is an insecure and unforgiving place. The design of the early Internet was for a trusted community [9]; a malicious participant was relatively easily detected and could be denied access. However, once the Internet became a commodity resource, a utility, connectivity was expected and preventing abuse became almost impossible. The future ubiquitous Internet will almost guarantee security and privacy for hackers and malicious users, not intentionally, but as a by-product of the Internet's design. Security of the Internet is opt-in only, which unfortunately falls victim to human nature. From a technological standpoint, there will be an almost overwhelming increase in malware, viruses, and software exploits. More IoT devices being connected means increased attack surface for malware to exploit resulting in larger and more frequent denial of service attacks on organizations. More people being connected and educated in technology results in an increase of hackers. Internet insecurity today is just the beginning of a troubling future, one where society will struggle to keep safe. However, the future threat will be worse than single hackers or organized crime. Nation states will increasingly wage technological warfare. There have been many current instances of nation state cyber warfare such as the stuxnet virus in 2010 causing damage to Iran's nuclear infrastructure. There may even be a future when a soldier will not be required for warfare, only cyber attacks executed against a nation's infrastructure, economy, and services. Countries will increasingly look inward as well; as seen even today with the National Security Agency collecting bulk Internet traffic [13]. Complete and thorough surveillance of the people and citizens will exist. The surveillance will affect all nations, whether rationalized for security reasons or simply to control the people. An Orwellian like future will be the default, not the exception. Internet security will

forever fall behind innovation and development, an issue that needs to be considered more than it is now.

3.4 A Brighter Future

The connected future is multi-faceted, bringing with it the possibility of a better world. The human capability for improvement has been proven throughout the test of time. Connecting people to the Internet, a resource unlike anything before it, will enable people to achieve new and different things. When these people collaborate in increasing numbers, greater discoveries and accomplishments will be realized. Current collaborations such as protein folding games played by thousands of people is helping the medical community advance disease research [9]. Innovations such as these enabled by connectivity will continue, a future where hard problems plaguing the world can be solved improving human life. The development of many poor countries will be accelerated through connectivity. Education of people through distance learning will empower people to industrialize their own nation. The quality of life of all people will significantly increase. Beyond that, increase in communication, contact, and collaboration with other people groups will hopefully foster tolerance. A tolerant, developed, and educated world has the chance to breed prosperity and peace. The stimulation of the human condition through connectivity can have a real, tangible effect on society. These views of the future are shared by many Internet visionaries. Vint Cerf believes that the power and freedom that the Internet gives outweighs the negatives [6]. Other people like Sebastian Thrun share in the vision of a better future through connectivity; enabling people through education to create a better world. And finally improvements and efficiencies to our current systems and infrastructure through IoT can help solve real issues of the future. Imagine solving the world's clean energy crisis by leveraging IoT [11]. The connected world of the future can indeed be a world of progress and improvement, one just needs to enable it.

4. Conclusion

The Internet is simply a technology that enables connectivity. It is unique in that it has the capability to connect everyone and every device. Whether we are connected through DSL, fiber, cellular networks, weather balloons, drones, or satellites; we will share in a connected world. People will create and consume content like never before. All services will be provided through the cloud creating a dependency on the Internet as important as electricity itself. All people will be enabled to discover, learn, and develop. New creations and innovations will occur and hard societal and technical problems will be solved collaboratively. Efficiencies will be realized through the digitization of devices and systems. The future will be enabled through ubiquitous connectivity. It is this connected future that as humans must not blindly stumble into. Forethought into what our future will look like should be the most important topic going forward. With intention, a fully connected people can create a better world that overcomes the future issues of security, surveillance and cyber crime.

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