

Obstacles on the Path to the Internet of Things: The Digital Divide

John Gray

Nova Southeastern University, Fort Lauderdale, USA

jg1553@mynsu.nova.edu

Abstract: The Internet of Things holds has the potential to provide an array of technological benefits and online resources to individual users and society in general. However, the Digital Divide, the gap between information computing technology (ICT) and those who can effectively take advantage of it, presents challenges to the global implementation of the Internet of Things. Factors contributing to the Digital Divide include lack of broadband access, cost of ICT, user socioeconomic challenges, user security concerns, and political or governmental restrictions.

Keywords: internet of things, digital divide, internet access, online content restrictions, freedom of access

1. Introduction

There are varying definitions of the Internet of Things (IoT) in both the practitioner and academic communities. Gartner Research defines the IoT as “the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment”. The International Telecommunications Union states that the IoT is “a global infrastructure for the information society, enabling advanced services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies”; and the Oxford Dictionaries defines the IoT as “a development of the Internet in which everyday objects have network connectivity allowing them to send and receive data” (Teppler, 2015). The Pew Research Center defines it as a global network of information computing devices, electronics, and sensors which will provide real time data and information that can positively enhance people’s lives (Anderson and Rainie, 2014).

Others choose to break the term down – with the Internet being described as being the commercial, educational, and government information systems which form a single worldwide network which is interconnected by protocols that are determined by the Internet Architecture Board (IAB), and in which the Internet Corporation for Assigned Names and Numbers (ICANN) oversees the names and address spaces (CNSS Instruction 4009, 2015); or the Internet being termed as an internetwork that encompasses large geographical areas, “enabled and managed” by a set of common and accepted ports, protocols, services, and interconnected devices and technologies as defined by the IAB and ICANN (Oriwoh and Conrad, 2015). These commonly agreed on ports, protocols, and services facilitate communication and the exchange of information between interconnected entities and devices. Oriwoh and Conrad (2015) also clarify that “of” makes it unmistakable that the Internet is comprised of specific items or “things.” Patel and Patel (2016) build on this by defining the IoT as an environment of a variety of objects that interact with each other through wired and wireless connections to create services and applications. They advocate that the IoT includes numerous types of items – including vehicles, appliances, medical and industrial systems, buildings, and even humans which communicate and interact using common protocols and addressing schemas to achieve a particular goal.

Whichever description is used for the IoT, what is agreed upon is that connected devices will impact and improve careers, educational opportunities, health services, and overall quality of life of those individuals who participate in it. The myriad of potential uses include real time tracking of health and fitness activities, control of residential appliances and utilities, and self-reporting of equipment/device maintenance and repair needs. Envisioned future uses include incorporation of large numbers of devices that generate and require information, such as robotics, self-driving automobiles, automated machinery, and a wide range of living beings – to include animals and plants (De Guglielmo, Anastasi, and Seghetti, 2014). As illustrated in Figure 1, the IoT will touch or influence most aspects of people’s lives (Tech Team Tree, 2016).

It has been estimated that in 2020 there are currently four IoT devices for every person on earth - exceeding 30 billion connected devices worldwide, and as shown in Figure 2 the number is projected to increase to over 75 billion devices by 2025 (Greenouch and Camhi, 2016; Statista, 2020).

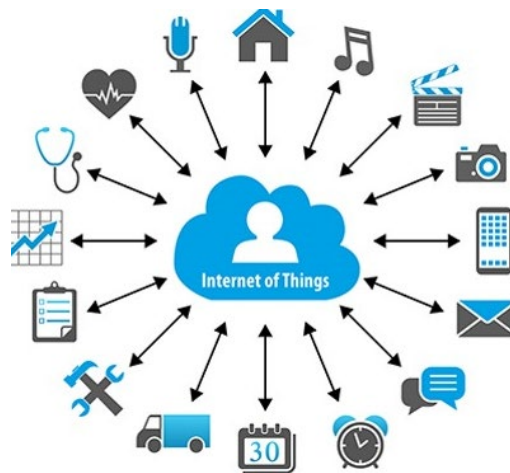


Figure 1: Internet of Things

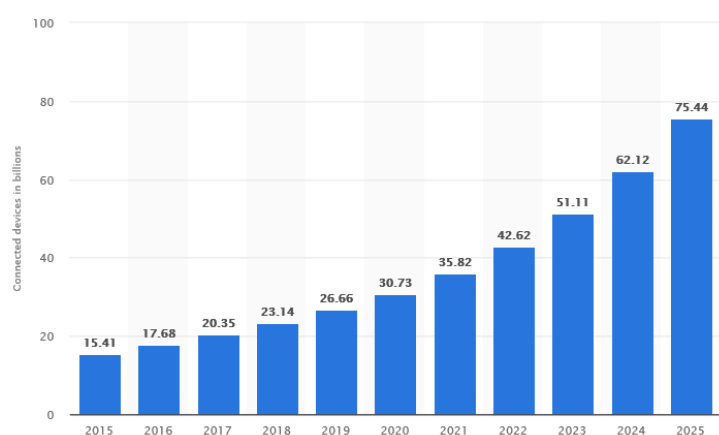


Figure 2: IoT connected devices in billions – 2015 to 2025

The benefits of the IoT will be to provide tools to effect positive changes to individual behaviors such as making healthier choices, safer decisions, and being more efficient in various activities (Anderson and Rainie, 2014). However, the growth, use, and effectiveness of the IoT also has the potential to contribute to and be affected by the so-called Digital Divide.

2. What is the Digital Divide?

The concept of what the Digital Divide is has changed over time. Previously it was characterized as the disparity between people who had access to Information Computing Technology (ICT) – the computing hardware, software, and access to the Internet, and those who did not (Goth, 2005). This early definition meant that the divide was based primarily on factors such as income, education, occupation, and geographical location (van Dijk and Hacker, 2003).

While access was described as having a computer connected to the Internet, van Dijk and Hacker (2003) further interpreted access to include a person's lack of experience with ICT due to not having an interest in being a user, users having a fear of the technology, insufficient user skills due to lack of education or social support, or individuals having few opportunities to use the technology.

Currently the definition of the Digital Divide includes that of users having poor quality ICT devices, not having an affordable connection to effectively use devices, or having dialup or restricted wireless connections versus high speed access as a person's connection to the Internet (Crawford, 2011). Soltan (2019) advocates that while information technology improvements and increased internet access have addressed many of the technology's earlier accessibility issues – a divide still exists based on the financial income levels of users, with "poor" people having less access to various digital resources – particularly those that are bandwidth intensive.

At present, ICT is described as consisting of information, resources, applications, and services; including computers, software, digital television, mobile phones, and telecommunication and broadband technologies (Selwyn, 2004). Emerging uses include devices for security controls, health monitors, sensors, traffic management controls, fitness trackers, and household appliance/device controls. While physical access to these devices may be available, the issue of sufficient user skills and knowledge to effectively use and take meaningful advantage of the available resources and information which users can access remains an issue. Additionally, the absence of a high-speed connection can limit how effectively digital resources can be used (Soltan, 2019).

Early social and political opinion was that the Digital Divide would be eliminated once every individual had a computer connected to the Internet. In 2016 approximately 88.5% of the United States population - representing 8.4% of the world's Internet users, had access to the Internet; however, only 40% of the world's population had an Internet connection (Internet Users, 2019); and a high-speed connection was not available to all of those users. By mid-2019, as detailed in Table I, during the years of 2000 to 2019 the percentage of world Internet users had increased by 1,157 percent. While the number of Internet users has increased to 58.8% of the world population, that still leaves over 40% without access to the IoT (Internet World Stats, 2020). Moreover, of the 58.8% who can get online many have limited or restricted access to digital resources.

These numbers indicate that a significant portion of the world's population did not have the opportunity to benefit from the emerging technology of the IoT. And events have shown that just because an individual has access - if they choose not to utilize it or if the bandwidth or access to digital resources is restricted, then the Digital Divide remains (van Dijk and Hacker, 2003). Consequently, the Digital Divide could more accurately be characterized as who can benefit from the IoT technology and who cannot.

Table 1: World internet usage 2019 mid-year estimates

World Region	% World Population	% of World Internet	% of Pop. Penetration Rate	% Growth 2000-2019
Africa	17.1	11.5	39.6	11,481
Asia	55.0	50.7	54.2	1,913
Europe	10.7	16.0	87.7	592
Latin America	8.5	10.0	68.9	2,411
Middle East	3.3	3.9	67.9	5,243
North America	4.7	7.2	89.4	203
Australia	.05	.06	68.4	276
World Total	100	100	58.8	1,157

3. Does the divide exist?

The existence of the Digital Divide has been well documented by researchers since the mid-1990s. Shortly after the Internet began being used by the public, the Digital Divide was recognized as an issue. As a result of the United States (US) technology sector leadership being challenged by then President Clinton to address Information Computing Technology disparities between those citizens who had access and those who did not, in 1999 the Digital Divide Network was established by the National Urban League and the Benton Foundation (Goth, 2005). While government policy has addressed many of those issues in the US, as noted by Goth (2005) they continue to be issues in many other areas of the world. Numerous nations have established policies and programs to ensure their citizens do not get "left behind" as a result of the implementation of ICT, particularly in the areas of access to technology and information. These policies and programs address Digital Divide issues between social groups within each specific country and in the global economy (Selwyn, 2004). The United Nations ICT Task Force was established to address the Digital Divide problem worldwide; and while it was originally thought that the task force would not need to exist beyond 2004 (Goth, 2005), the task force is still currently in existence with the ongoing mission of offering policy advice to world governments and to assist in establishing

partnerships between technology companies, nations, private industry, and other organizations in bridging the Digital Divide.

A high-speed Internet connection has become a key tool for participation in society. The expectation that job seekers, employees, students, patients, and consumers to use the Internet have evolved broadband from a luxury into a necessity. Institutions are increasingly assuming that their customers have online access, and they changing their service and business models accordingly (Anderson and Rainie, 2014; Crawford, 2011; Shapiro, 2016).

Numerous national governments around the world utilize technical, regulatory and censorship strategies to regulate access to online content. Politically imposed restrictions and obstacles to Internet freedom and information access create another category of users considered to be among those who are digitally divided.

4. Who are the digitally divided?

In 2000 the Digitally Divided were generally defined as the people who had access to the necessary ICT and associated connection to the Internet as opposed to those who did not; termed as the information haves and have-nots (Wresch, 1996). This has been further expanded to include the “information want-not’s”, those individuals who either have a fear of or a feeling of insecurity when interacting with information technology, or that they have no interest in its use (van Dijk and Hacker, 2003). It has been estimated that the digitally divided population numbers exceed four billion people (Smith, 2010).

Even within technologically developed countries such as those in Southeast Asia, the US, and in Western Europe there remain geographic or social groups where citizens would be classified as digitally divided (Selwyn, 2004). They are deprived of the benefits of meaningful access; usage that either can provide them an escape from poverty, that would empower them to improve their lives, help sustain the world’s markets, or provide solutions to their problems and issues (Smith, 2010). Lack of access makes it harder for them to find work or to train for in-demand skills job skills that would qualify them for good-paying jobs.

Other characterizations include people who have access to the information, but who do not use it for meaningful benefit or do not understand how to effectively use it in order to create real benefit to themselves. These individuals comprise a significant portion of the population of Third World countries, but it also includes various social groups and geographic regions in technologically advanced countries such as the US.

There are four primary areas that contribute to the digital divide – listed in Table II.

Table 2: Digital Divide categories

Lack of Broadband Service
User Socioeconomic Challenges
Affordable Information Computing Technology
Political and Governmental Restrictions

Each category has specific issues that prevent or restrict access to IoT resources. Individuals that fall into one of the four categories of the digital divided are prevented from fully participating in and benefiting from the Internet of Things.

4.1 Lack of broadband

A key aspect of achieving digital inclusion is the availability of broadband service with the speed and reliability required by users to make the capability worthwhile. In many sparsely populated, rural, or low-income areas broadband connectivity is unavailable, unreliable, or the required infrastructure is underdeveloped (Crawford, 2011; Bates, Malakoff, and Kane, 2012).

In other instances, cost may not be a barrier to use, and users may be willing to pay, but a broadband service may not be available. Nations with rural or isolated areas are particularly prone to an uneven distribution of quality service. In some cases a quality broadband connection may be available but the benefits of the connection to a first time user are outweighed by the cost.

Previously connected users who have subsequently cancelled their broadband service cite the high cost of maintaining the connection, the increasing availability and opportunity to access the Internet elsewhere such as in a community library or other public locale, and the inadequacy of their ICT equipment or service as reasons for discontinuing their use of broadband. These types of users are termed “un-adopters” by Whitacre and Rhinesmith (2016).

The result is that a significant number of people are unable to benefit from the technology.

4.2 User socioeconomic challenges

Social and economic factors such as age, education, financial income, gender, occupation, and geographic location are demographic determinants in whether an individual is considered to be digitally divided. In many cases, the cost for a high-speed connection is prohibitive – even though the user may understand of the value of home broadband and the service is available, they simply cannot afford the price. Therefore, they either use a connection that is not broadband or do not have any type of connection at all (Crawford, 2011; Bates, Malakoff, and Kane, 2012; Rhinesmith, Reisdorf, and Bishop, 2019). Low-income households have historically had poor broadband adoption rates, and the number is even more pronounced along ethnic lines (Soltan, 2019; Shapiro, 2016).

Online education relies heavily on streaming videos and live feeds that require a high-speed connection to be effective as an educational tool. While broadband access may be available at their educational facility, many students from low-income households lack an adequate connection at home. This hampers their ability to participate in many learning activities. Teachers of low-income students reported more obstacles to effectively using this technology as a teaching aid because of inadequate access (Crawford, 2011; Soltan, 2019; Shapiro, 2016). Ultimately, this places the students at a learning disadvantage.

Van Dijk and Hacker (2003) and Idiegbeyan-Ose et al. (2018) also point out that learned cultural and social skills play a role in processing the meaning and taking advantage of any information that is accessed. The meaning of available information and how to use it is lost on many people if they cannot relate to it or place it into context with their cultural background and experiences. Not having these skills is a contributing factor in who is termed as digitally divided.

4.3 Affordable ICT

Related to the cost of a broadband connection is the affordability of ICT. The cost for ICT equipment such as computers, internet modems, and software is out of reach for many users and subsequently contributes to the digital divide (Idiegbeyan-Ose et al., 2018). Additionally, the design model of the IoT and the wide range of devices that make up the IoT introduces security concerns at the physical, transport, and application layers (Patnaik, Padhy, and Raju, 2021).

Growing end-user concerns about data and privacy protections contribute to the digital divide. Reports of cybersecurity breaches and user data being lost, stolen, or compromised are frequently in the news. The cost of data protection tools, solutions or services, and the associated user skills required to provide effective security for their personal devices, data, and privacy are a challenge to many users (Lee and Ahmed 2021). The result is that many users choose not to fully engage in the benefits of the IoT because by doing so they feel that they may be placing their sensitive data or personal privacy at risk of being compromised.

The general consensus is that there is a growing inequity in ICT user skill levels because of the types of technology being produced (2003). This is exacerbated by the perception among technology companies that there is very little profit in selling products that are inexpensive and only have basic functionality. It is contended that producers of ICT make production decisions based on profit motives. This is based on the fact that 80% of technology profits are made from marketing products to the most affluent 20% of society (Smith, 2010). This results in the development of more advanced products for experienced users while the “have-nots” continue to be denied access to current technology.

The result is that high-end products are not affordable to a significant number of users, and that less experienced users lack the skillset required to use the advanced technology. Consequently, their use may be restricted to

outdated, less capable technology or that they may not have access to any form of ICT. These decisions ultimately affect user access to digital technology.

4.4 Political and governmental restrictions

An interesting perspective is that some political groups and governments may actually promote the existence of the Digital Divide (van Dijk and Hacker, 2003). The claim is that the divide increases income, occupational, education, and social class differences which can be exploited for political gain. It is not uncommon for political groups or governments to promote the divide in order to advance their specific agendas by restricting free communication, religious and political participation, and economic activities (Shirazi, Ngwenyama, and Morawczynski, 2010) or other online content restrictions.

Politically motivated blocking of digital communication and knowledge acquisition occurs in numerous societies across the globe. Governments implement various tools and controls to censor speech and restrict access to information. Various groups and organizations from countries including Turkey, Saudi Arabia, Mongolia, Iran, and China struggle to access and post content on-line. The blocked or restricted information includes political information and content critical to the ruling political faction, content on embarrassing medical conditions, and controversial social issues (Nekrasov, Parks, and Belding, 2017). Freedom House is an independent, nongovernmental organization that conducts research on political freedom and human rights. In 2018 Freedom House ranked 65 nations for their degree of online freedom with zero being the most free and 100 with the most restrictions (Shahbaz, 2018). A subset of those nations are listed in Table III to illustrate that nations with authoritarian governments have the worst score for online freedoms. China scored the worst, having the most restrictions, and Iceland had the lowest score indicating they have the least restrictions to online resources.

In China government policies, businesses, and scientific institutions collaborate to control the development direction and management of the nation's IoT industry (Zhang et al. 2021) The People's Republic of China (PRC), as a sub-project of its Golden Shield Project, has instituted a combination of legislative actions, regulatory barriers, and technology solutions to institute Internet surveillance and control – commonly known as the “Great Firewall of China”. This government controlled gateway provides censorship and control over the international connections to the global Internet and any information that is considered politically inconvenient or inappropriate to the ruling communist political party (Shahbaz, 2018; Lv and Luo, 2018). Local and foreign companies are required to cease transmission of what the government considers “banned” content as well as adapt to and abide by Chinese Internet regulations. The latest PRC directed effort is to ban all virtual private networks (VPNs) not under government control, which opponents state could erode Chinese scientists ability to stay connected with peers outside of the country (Shahbaz, 2018; Normile, 2017).

Additionally, PRC officials have worked with 36 of the 65 nations listed in the Freedom House survey in order to establish a network of countries that will “follow its lead on Internet policy” and laws. The result is that several nations with primarily authoritarian governments have introduced cybersecurity and cyber media laws that mimic those of the PRC (Shahbaz, 2018).

China's censorship system, and similar blocking/censorship systems of other nations, prevents their citizens from unencumbered access to digital resources – in effect creating a digital divide to scientific research, innovation, free thought, and commerce.

Table 3: Online freedom score chart

Nation	Score
Peoples Republic of China	88
Iran	87
Syria	87
Ethiopia	83
Cuba	79
Vietnam	76
Saudi Arabia	72
Russia	65
Turkey	61
India	43
Mexico	40

Nation	Score
United Kingdom	24
Japan	22
USA	19
Canada	16
Iceland	6

5. Addressing the Divide

Broadband and broadband enabled products and services are now the key to addressing the Digital Divide in order to shape the behavior of individuals and transform governments, businesses, education systems, and communities (Bates, Malakoff, and Kane, 2012). It is the opinion of digitaldivide.org that eliminating the divide will require that nations restructure their telecommunications infrastructure so that broadband is available to the majority of their population, not just the most affluent. Addressing user security concerns and ensuring that affordable Information Computing Technology and services are available to underserved or less economically well off populations are also important factors for closing the divide. While many nations have integrated technological training into their educational systems, others still struggle to provide basic educational services, which typically do not include instructing about or actually utilizing ICT. Consequently, the cost to obtain information is much more to impoverished peoples whose limited funds may be otherwise needed for day-to-day survival. Additionally, if they are also geographically isolated from access to ICT then their information isolation increases as the cost to travel or purchase technology to bridge the difference is more than they may be able to afford (Wresch, 1996). Another aspect to consider is that the uses of ICT technology must be meaningful to users or the Digital Divide could grow even wider (Smith, 2010). Digitaldivide.org contends that a significant number of users become caught up in the entertainment aspect of the technology and thereby waste time, cease their education efforts, and subsequently fail to contribute to society. This ultimately promotes continued poverty and ultimately results in increasing the divide. In short, inappropriate or un-meaningful access could be as damaging as no access at all. Moreover, while ICT may offer the benefits of automation and reduction of manpower requirements for businesses, it can result in the loss of jobs due to those reductions. If closing the Digital Divide is characterized as being benefits derived from access, then these losses could be considered a negative effect.

In countries that impose constraints, restrictions, and repression of access to IoT digital resources, affected citizens subsequently resort to various technical skills, digital applications, tools, and other circumvention techniques and methodologies in an attempt to access restricted content - particularly if those techniques provide anonymity. User workarounds to technological blocking of information flow is countered by new governmental blocking methods or regulatory enforcement, including punishment of violators. This results in a back and forth effort to block or gain access to content

6. Conclusion

The concept of a Digital Divide that consists of haves and have-nots is likely oversimplified. As can be seen by the changing definition and interpretation of the Digital Divide and the impact and consequences of the access to and the use of information technology on the quality of users' socioeconomic status - the problem is dynamic, multi-faceted, and complex. How that one defines the divide drives the definition of who is considered to be among the digitally divided. The numbers of the people considered as divided changes as well since the cost and approach to solving the issue depends on the definition used. What is not disputed is that a significant portion of the world population cannot or is not able to, or chooses to not take advantage of one of mankind's greatest achievements. The Internet of Things is poised to be a core component of personal, economic, and political life across the world. Successful implementation of the IoT is dependent on being able to bridge the Digital Divide by providing consumers with the required yet affordable broadband backbone necessary to support the myriad of connected devices; development of economically priced information computing technology which possesses ease of use qualities, compelling features, security, and benefits which promote user desirability; and education efforts which demonstrate the benefits of those devices to potential consumers. Additionally, the ability of world citizens to fully participate in digital information access and exchange in order to take advantage of the cultural, economic, educational, political and social opportunities the IoT affords remains vulnerable to the actions of political and governmental regulators. Certain aspects to enable reaching the digitally divided will need to be addressed through policy, regulations, and subsidies, international diplomacy, and public – private partnerships and cooperation.

References

- Anderson, J. and Rainie, L. (2014) "The Internet of Things will Thrive by 2025", Pew Research Center, [online], <http://www.pewinternet.org/2014/05/14/internet-of-things/>.
- Bates, K., Malakoff, L., and Kane, S. (2012) "Closing the Digital Divide: Promoting Broadband Adoption Among Underserved Populations", Port of Clarkston, [online], <http://portofclarkston.com/uploads/Benefits%20of%20Broadband.pdf>.
- CNSS Instruction 4009 (2015) *National Information Assurance Glossary*, Committee on National Security Systems.
- Crawford, S. P. (2011) "The New Digital Divide", *The New York Times*, Vol. 12, No. 03.
- Goth, G. (2005) "Digital-Divide Efforts are Getting More Attention", *Internet Computing*, Vol. 9, No. 4, pp. 8-11.
- De Guglielmo, D., Anastasi, G. and Seghetti, A. (2014) *A step towards the Internet of Things. In From IEEE 802.15. 4 to IEEE 802.15. 4e: Advances onto the Internet of Things*, Springer, Berlin.
- Greenough, J. and Camhi, J. (2016) "How the 'Internet of Things' will affect the world", Business Insider, [online], <https://www.businessinsider.com/internet-of-things-2015-forecasts-of-the-industrial-iot-connected-home-and-more-2015-10>.
- Idiegbeyan-Ose, J., et al. (2018) "Digital Divide: Challenges for Library and Information Services Provision in Developing Countries," *Proceedings of 11th annual International Conference of Education, Research and Innovation, ICERI 2018, Seville, Spain*, pp. 0717 – 0722.
- Internet Users. (2019) Internet Live Stats, [online], <http://www.internetlivestats.com/internet-users/>.
- Internet World Stats. (2020) Internet World Stats, [online], <https://www.internetworldstats.com/stats.htm>.
- Lee, C. and Ahmed, G. 2021. "Improving IoT Privacy, Data Protection and Security Concerns". *International Journal of Technology, Innovation and Management*, Vol 1, No. 1, pp.18-33.
- Lv, A. and Luo, T. (2018) "Asymmetrical power between Internet giants and users in China", *International Journal of Communication*, Vol. 12, pp. 3877–3895.
- Nekrasov, M., Parks, I. and Belding, E. (2017) "Limits to Internet Freedoms: Being Heard in an Increasingly Authoritarian World", *Proceedings of the Third Workshop on Computing Within Limits, ACM LIMITS 17*, pp. 119-128.
- Normile, D. (2017) "Science suffers as China plugs holes in Great Firewall" *Science*, Vol. 357, No. 6354, pp. 856.
- Oriwoh, E. and Conrad, M. (2015) "'Things' in the Internet of Things: Towards a Definition", *International Journal of Internet of Things*, Vol. 4, No. 1, pp. 1-5.
- Patel, K. K. and Patel, S. M. (2016) "Internet of Things-IOT : Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges", *International Journal of Engineering, Science, and Computing*, Vol. 6, No. 5, pp. 6122-6131.
- Patnaik, R., Padhy, N., and Raju, K.S. 2021. *A Systematic Survey on IoT Security Issues, Vulnerability and Open Challenges. In Intelligent System Design*, (pp. 723-730). Springer, Singapore.
- Rhinesmith, C., Reisdorf, B. and Bishop, M. (2019) "The Ability to pay for Broadband", *Communication Research and Practice*, Vol. 5, No. 2, pp. 121-138.
- Selwyn, N. (2004) "Reconsidering Political and Popular Understandings of the Digital Divide", *New Media & Society*, Vol. 6, No. 3, pp. 341- 362.
- Shahbaz, A. (2018) "Freedom on the Net 2018. The rise of Digital Authoritarianism", Freedom House, [online], <https://freedomhouse.org/report/freedom-net/2018/rise-digital-authoritarianism>.
- Shapiro, I. (2016) "FCC Broadband Initiative Could Reduce Barriers to Low-Income Americans' Advancement and Promote Opportunity", Center on Budget and Policy Priorities, [online], http://www.cbpp.org/sites/default/files/atoms/files/fcc_broadband_initiative_could_reduce_barriers_to_low-income_americans_advancement_and_promote_opportunity.
- Shirazi, F., Ngwenyama, O., and Morawczynski, O. (2010) "ICT Expansion and the Digital Divide in Democratic Freedoms: An Analysis of the Impact of ICT Expansion, Education and ICT Filtering on Democracy", *Telematics and Informatics*, Vol. 27, pp. 21-31.
- Smith, C. W. (2010) "Digital Divide Defined (Hint: It's not About Access)," Digital Divide Institute, [online], <http://www.digitaldivide.org/digital-divide/digitaldividedefined/digitaldivide/>.
- Soltan, L. (2019) "Digital Divide: The Technology Gap Between the Rich and the Poor," Digital Responsibility, [online], <http://www.digitalresponsibility.org/digital-divide-the-technology-gap-between-rich-and-poor>.
- Statista. (2020) "Internet of Things (IoT) Connected Devices Installed Base Worldwide from 2015 to 2025", Statista Inc., [online], <https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/>.
- Tech Team Tree, (2016) "IOT Devices to Touch 34 Billion By 2020", [online], <https://www.techtree.com/index.php?q=content/news/10889/iot-devices-touch-34-billion-2020.html>.
- Teppler, S. (2015) "The Internet of Things and Liability. Let the Lawsuits Begin...," *ISSA Journal*, Vol.13, No. 1, pp. 38-40.
- van Dijk, J. and Hacker, K. (2003) "The Digital Divide as a Complex and Dynamic Phenomenon", *The Information Society*, Vol. 19, No. 4, pp. 315-326.
- Whitacre, B. and Rhinesmith, C. (2016) "Broadband Un-adopters", *Telecommunications Policy*, Vol. 40, No. 1, pp. 1-13.
- Wresch, W. (1996) *Disconnected: Haves and Have-nots in the Information Age*, Rutgers University Press, New Jersey.
- Zhang, Z., Li, X., Xiong, J., Yan, J., Xu, L. and Wang, R. (2021) A Global Race to Dominate the Internet of Things: How China Caught Up. *Journal of Business Strategy*.