

Review Article

Impact of Internet of Thing in Developing Country: Systematic Review

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Abstract: The idea to connect everything to anything and at any point of time is what vaguely defines the concept of the Internet of Things (IoT). The IoT is not only about providing connectivity but also facilitating interaction among these connected things. One of the most significant concerns of IoT is to provide security assurance for the data exchange because data is vulnerable to some attacks by the attackers at each layer of IoT. The IoT has a layered structure where each layer provides a service. The security needs vary from layer to layer as each layer serves a different purpose. This paper aims to analyze the various security and privacy threats related to IoT. Some attacks have been discussed along with some existing and proposed counter measures. In developing countries, IoT technologies have brought increased efficiency and effectiveness to existing processes. For instance, farmers are using remote sensors to monitor moisture levels and soil conditions in the fields to avoid crop failure. Similar sensors are providing remote control of micro-irrigation pumps for example in India and water pumps in Rwanda, improving functionality and reducing repair intervals. And in Haiti, healthcare professionals are using “smart” thermometers to better track vaccine delivery and storage. Totally the paper presents an overview of the enablement of IoT in developing countries and discusses the visions, general applications, opportunities and challenges of IoT in these countries. It also touches on issues relating to security, privacy, trust and the accompanied complexity. The potential applications for IoT are countless and can optimize processes with a direct impact on society. Certain challenges have to be addressed to make IoT deployment successful. It will be shown that some of the challenges can be turned into opportunities and that IoT has good chances to succeed in developing countries. This report explores the current use and potential of Internet of Things (IoT) technologies in tackling global development challenges, highlighting a number of specific instances where IoT interventions are helping to solve some of the world’s most pressing issues it presents summary conclusions on what is required for the IoT to reach billions of people living in the developing world, and also to accelerate income growth and social development as a result.

Keywords: IoT, ICT, Developing Country

1. Introduction

The idea to connect everything to anything and at any point of time is what vaguely defines the concept of the Internet of Things (IoT). The IoT is not only about providing connectivity but also facilitating interaction among these connected things [1]. Though the term IoT was introduced in 1999 but has drawn significant attention during the past few years, the pace at which new devices are being integrated into the system will profoundly impact the world in a good way but also poses

some severe queries about security and privacy. IoT in its current form is susceptible to a multitudinous set of attacks. One of the most significant concerns of IoT is to provide security assurance for the data exchange because data is vulnerable to some attacks by the attackers at each layer of IoT. The IoT has a layered structure where each layer provides a service. The security needs vary from layer to layer as each layer serves a different purpose. This paper aims to analyze the various security and privacy threats related to IoT. Some attacks have been discussed along with some existing and proposed countermeasures. The Internet of Things is fast

growing technology with business opportunities and risks. It is confluence of wireless networks, internet and computing. IoT connects the physical objects like vehicles, buildings and other devices with embedded intelligent sensors and enables these objects to exchange and collect data [2]. The domains where IoT is becoming popular are smart cities, e-health, smart grids, e-commerce, smart transportation, and e-commerce etc. The embedded and wearable computing will have greater impact in providing services in wide range of applications by 2020. The architecture of IoT is incorporated with the latest technologies of communication protocols, intelligent sensor and RFID. The security and privacy issues of IoT are crucial as it connects large number devices. In this article we analyze a state of art review of IoT with regard to technologies, protocols, application issues. The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an IP address and is able to transfer data over a network. Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business. Information and communication technologies (ICTs) such as mobile phones, Internet use and Big Data analytics are pervasively utilized in global development projects (in a field often known as ICT for Development, or ICT4D) to improve outcomes and deliver services [3].

The Internet of Things is fast growing technology with business opportunities and risks. It is confluence of wireless networks, internet and computing. In last two decades, the Internet of Things (IoT) solutions started to emerge from the initial pioneering visions to regular industrial solutions, which are present in our everyday lives. After having been coined as a term in 1999 by Kevin Ashton, and after more than a decade of discussion and anticipation, the Internet of Things is finally emerging. This is a major development, which promises to change our way of doing things through better information in real-time and improved learning opportunities. IoT is closely related to the concepts of Machine-to-Machine (M2M) communications and Wireless Sensor Networks (WSN) on the connectivity side and to Big Data in terms of the content outcomes produced. The IoT also comprises the data produced and transmitted between machines (M2M), as well as between machines and people (M2P). The IoT is not just a story for industrialized economies or industrial applications, but is equally relevant for developing countries. The IoT and connected sensors are driving improvements to human wellbeing in healthcare, water, agriculture, natural resource management, resiliency to climate change and energy (as reflected in the UN's post-2015 sustainable development

agenda). The research for this report uncovered many interesting examples and applications of the IoT in developed economies. However, these are beyond the scope of this report, which focuses on impactful applications of the IoT for developing countries. When determining which IoT application fits best for a particular context, there are many trade-offs and compromises involved. Technical trade-offs include different characteristics among connectivity technologies, including, but not limited to: performance, efficiency, reliability, robustness, flexibility, range, power requirements, data throughput, cost (of sensors, connectivity modules and service) and licensed versus unlicensed spectrum. For large-scale systems including hundreds of thousands of sensors, devices and/or readers, high reliability levels are likely to prove important. Cultural context on the ground also matters, and it should be taken into account, along with technical considerations. Huge new opportunities are now opening up through improved access to and use of Big Data techniques, which offer learning opportunities to improve real-world processes and enhance decision-making over the short-, medium- and long-term in healthcare, education, emergency services and disaster response, among a variety of other application areas. Impactful IoT interventions in development can improve efficiency (achieving similar levels of impact with fewer resources) and/or enhance effectiveness (increasing impact with similar levels of existing resources). In advancing global development, IoT interventions are helping to improve research, public policy, basic service delivery and the monitoring and evaluation of programmes across a range of different sectors [4].

2. Conceptual Study

Internet of Everything

Both the idea and technology for connecting sensors and actuators to a network to remotely monitor and control physical systems have been known for many years and developed accordingly [5]. However, a little more than a decade ago the concept of the Internet of Things (IoT) was coined and used to integrate such approaches into a common framework. Technology has been constantly evolving and so has the concept of the Internet of Things, incorporating new terminology appropriate to technological advances and different application domains. This paper presents the changes that the IoT has undertaken since its conception and research on how technological advances have shaped it and fostered the arising of derived names suitable to specific domains. A two-step literature review through major publishers and indexing databases was conducted; first by searching for proposals on the Internet of Things concept and analyzing them to find similarities, differences, and technological features that allow us to create a timeline showing its development; in the second step the most mentioned names given to the IoT for specific domains, as well as closely related concepts were identified and briefly analyzed. The study confirms the claim that a consensus on the IoT definition has not yet been reached, as enabling technology keeps evolving

and new application domains are being proposed. However, recent changes have been relatively moderated, and its variations on application domains are clearly differentiated, with data and data technologies playing an important role in the IoT landscape. The Internet of Things (IoT) realizes a vision where billions of interconnected devices are deployed just about every-where, from inside our bodies to the most remote areas of the globe [6]. As the IoT will soon pervade every aspect of our lives and will be accessible from anywhere, addressing critical IoT security threats is now more important than ever. Traditional approaches where security is applied as an afterthought and as a “patch” against known attacks are insufficient. Indeed, next-generation IoT challenges will require a new secure-by-design vision, where threats are addressed proactively and IoT devices learn to dynamically adapt to different threats. To this end, machine learning and software-defined networking will be key to provide both reconfigurability and intelligence to the IoT devices. In this paper, we first provide taxonomy and survey the state of the art in IoT security research, and offer a roadmap of concrete research challenges related to the application of machine learning and software-defined networking to address existing and next-generation IoT security threats. Internet is a platform where every day devices become smarter, every day processing becomes intelligent, and every day communication becomes informative. While the Internet of Things is still seeking its own shape, its effects have already started in making incredible strides as a universal solution media for the connected scenario. Architecture specific study does always pave the conformation of related field. The lack of overall architectural knowledge is presently resisting the researchers to get through the scope of Internet of Things centric approaches. This literature surveys Internet of Things oriented architectures that are capable enough to improve the understanding of related tool, technology, and methodology to facilitate developer’s requirements. Directly or indirectly, the presented architectures propose to solve real-life problems by building and deployment of powerful Internet of Things notions. Further, research challenges have been investigated to incorporate the lacuna inside the current trends of architectures to motivate the academics and industries get involved into seeking the possible way outs to apt the exact power of Internet of Things. A main contribution of this survey paper is that it summarizes the current state-of-the-art of Internet of Things architectures in various domains systematically [7].

3. Internet of Things (IoT) Security: Current Status, Challenges and Prospective Measures

Internet of things (IoT) is a collection of many interconnected objects, services, humans, and devices that can communicate, share data, and information to achieve a common goal in different areas and applications. IoT has many implementation domains like transportation, agriculture,

healthcare, energy production and distribution. Devices in IoT follow an Identity Management approach to be identified in a collection of similar and heterogeneous devices. Similarly, a region in IoT can be defined by an IP address but within each region each entity has a unique. The purpose of IoT is to transform the way we live today by making intelligent devices around us perform daily tasks and chores. Smart homes, smart cities, smart transportation and infrastructure etc. are the terms which are used in relevance with IoT. There are many application domains of IoT, ranging from personal to enterprise environments. The applications in personal and social domain enable the IoT users to interact with their surrounding environment, and human users to maintain and build social relationships. Another application of IoT is in transportation domain, in which various smart cars, smart roads, and smart traffic signals serve the purpose of safe and convenient transportation facilities. The enterprises and industries domain encompass the applications used in finance, banking, marketing etc. to enable different inter- and intra activities in organizations. The last application domain is the service and utility monitoring sector which includes agriculture, breeding, energy management, recycling operations, etc [6].

4. Extending our Hyper Connected World Through the IoT and Big Data

As early as 2005, the International Telecommunication Union (ITU) noted that the development of the Internet of Things as a function of our hyper connected world encompassed a set of technological advances from different fields specifically, wireless and mobile connectivity, nanotechnology, radio-frequency identification (RFID) and smart sensor technologies. Advances in these technologies, when combined, could help realize a miniaturized, embedded, automated Internet of connected devices communicating regularly and relatively effortlessly. Today, governments, businesses, and consumers are using the IoT and Big Data to introduce new business models, to improve the delivery of services, to increase efficiency in production, and to enhance wellbeing and human welfare. As with many other technologies, vendors, implementers, operators, policy-makers and regulators aim to maximize the benefits of deployment while minimizing potential risks to security and privacy. Widely disparate definitions of the IoT exist. The ITU has defined the IoT as “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” (Recommendation ITU-T Y.2060). The IoT clearly includes M2M (referring specifically to communication directly between devices, used in a vast array of applications and for a variety of purposes), but broader definitions of IoT technologies also include ambient intelligence and smart environments [2].

5. Positive Impact of IoT in Developing Countries

The prospect of IoT in developing countries is huge, ranging from agriculture to smart city applications. In this section, we discuss the opportunities of IoT for the emerging sectors in the developing countries. We anticipate the promising prospects of IoT in the fields of transportation safety, agriculture, environment, utility management, health monitoring and so on. Here, we focus on some of the significant fields [8].

Precision Agriculture

According to the United States Census Bureau, the world's population is over seven billion now, and it is expected to increase more than three billion over the next few decades. As a result, the food demand will grow 1.5-2 times more than what it is at presently. Besides, the farm economy is becoming unstable due to the combined effect of the volatile nature of agricultural conditions and the uncertainty of expected income from farm products. In the developing countries, the scenario is worse and becoming more abnormal day by day. Natural calamities, lack of proper fertilization, use of excessive chemicals and pesticides, inefficient crop monitoring systems lead the crop management system of these countries to jeopardy. Moreover, usage of poisonous chemicals like Formaldehyde to prevent food from becoming rotten urges for effective food monitoring systems. The prospect of Precision Agriculture (PA) is reflected in many recent researches. According to Global PA Market Analysis & Forecast (2015-2022) by BIS Research, the global market size for PA has been estimated to grow over \$6.34 billion by 2022. These conditions necessitate the usage of modern technologies to improve crop-planning, to facilitate the better infield management decisions, to provide precise farm records, to minimize the usage of fertilizers and pesticides to the optimum level, to maximize profit margin and finally to reduce environmental pollution. In contrast, the solution remains in a very elementary stage. In fact, the adoption of sensor and actuator devices in implementing PA systems is very limited and still in research farms worldwide. PA might help in ensuring accurate utilization of plant nutrition materials, to protect them from insects and diseases, and finally to yield higher crop production. Moreover, PA actually provides better scope for the national policy makers to plan for the future production of crops and helps them to develop the right methods to maintain food security.

Environment Monitoring

Environment monitoring is a growing paradigm in the field of the Internet of Things and is becoming a key feature of modern environment management systems. Reusable hardware and software platforms and energy harvesting sensors can be exploited to facilitate IoT application requirements for ameliorating the current environment monitoring systems. In developing countries, the necessity of modern environment monitoring is very high. There, the rate of air pollution, noise pollution, industrial pollution, and a range of human created environmental pollution is formidable.

To mitigate the pollution level, we need to monitor the environment both in urban and rural areas. In the developing countries, it is important to monitor the environment regularly to predict the climatic changes and to deal with the natural calamities like, cyclones, flood, drought, etc. In these countries, the system needs to be fairly cheap and easily maintainable. So, usage of IoT in environment monitoring can open a new era of opportunities to maintain the consonance of nature, climate and civilization.

Utility Management

Utility Management is one of the most prominent fields in respect to the application of IoT in the developing world. In addition to electricity, gas, trash removal, etc., water network monitoring and quality assurance of drinking water is considered as a significant application of IoT. To ensure high water supply quality, sensors that measure critical water parameters are installed at prime locations. The whole monitoring system is managed by an Internet backbone consisting of high speed fiber optic networks and Cloud services. In developing countries, there is virtually no utility except electricity, which is being managed utilizing modern monitoring systems. Even for electricity, the whole system needs a lot of manual inputs from management personnel. So, in these countries, it is important to implement smart and cost-effective systems that will benefit people with efficient utilization of available resources and minimize the resource wastage.

Intelligent Health Management (mHealth or eHealth)

In this age, the cliché of global aging and chronic diseases is becoming a regular phenomenon. To deal with the situation, many developed countries are focusing on reducing hospital beds and in contrast, they are building up intelligent home health-care systems. These kinds of systems are the combination of Hospital-centric services and Home-centric environments. Implementation of the systems by developing practical and advanced health related technologies by exploiting IoT is becoming a burning research issue. Developing intelligent health monitoring systems is becoming important for some other reasons, such as, real-time health monitoring which helps to detect and predict formidable health issues and to take precautions. Moreover, almost 25% of young people do not intend to follow the proper prescriptions from the doctors. Consequently, the necessity of continuous health monitoring is gaining significance day by day. IoT enables the easy access of Internet to health sensors, actuators and other devices and provides Cloud services to manage data and system integrity. Thus, IoT creates an opportunity to utilize ICT in respect to develop health intelligent management systems. In developing countries, the scenario is grimmer than the developed world. Here, from the birth of a child, ending up to the chronic diseases of aged persons, the degree of irregularity in health management is immense. People are not really concerned of their health and they do not even bother to preserve their medication history. People often come to see doctors when they are in the final stage of cancer. So, the scope of utilizing intelligent health management systems is huge. IoT envisions a way to

implement eHealth with robust and affordable services in developing countries.

Workplace Safety Enhancement

In developing countries like Bangladesh, Vietnam, India, etc., work safety is often ignored to save capital and invest in production more. Although the governments impose strict laws to prohibit disasters and accidents in workplaces, it is a very common practice of the industry authorities to bypass the restrictions with the help of corrupted officials. So, the situation asks for a solution that should be cost effective, easy to use and well-integrated. A well organized workplace monitoring system can ensure reliable and corruption mitigation procedures for meeting the safety standards in industry. In recent years, a number of industry incidents happened that point to serious safety ignorance and lack of modern safety monitoring systems. The 2012 Dhaka fire killed more than 117 garments workers at the Tajrin garments factory in Bangladesh. Again, the Rana Plaza incident in 2013 killed an overwhelming number of more than 1100 people and injured more than 2500 people in Bangladesh. These incidents indicate the substantial necessity of well integrated safety monitoring and warning systems. In these circumstances, IoT opens the door of hope to sort this problem out.

Social Security Management

The current conditions in developing countries reflect the lack of Social Security. The situation, especially in India and Bangladesh, indicates an unsafe state for general people, especially for women. The rate of street harassment to women is very high and the condition is becoming grimmer day by day. Nights are becoming dangerous due to an uncountable number of thefts, robberies, hijackings, kidnappings, murders, rapes and so on. In fact, the growth of terrorism and civil unrest in developing countries put things to their worst. To get rid of them, we need to provide a whole new system of social security networks. The technologies ranging from a central CCTV network to personal safety devices can be used to make cities safer. We have all the technologies in hand to integrate and the platform is IoT. So, it is a great prospect for IoT to develop social security ensuring systems.

6. Challenges of IoT in Developing Countries

The prospect also brings a whole bunch of challenges. In developing countries, the administrative and financial systems run by mostly without any integrated and automated system. The level of technology usage is low, and the investment on research and development is very little. In the following sections, we focus on various IoT challenges in detail in respect to developing countries [6].

7. Technical Challenges

Internet Connectivity

Internet Connectivity is a prime issue, when we want to enable IoT. Internet of Things demands flawless and adequate

connectivity among every particular *thing*. To sustain flawless connectivity, it needs fast internet speed, a continuous power supply, robust backup systems and reliable and scalable infrastructure. Facilitating the end users with high speed internet in developing countries is a huge challenge. To deploy wired backbone throughout the whole country is formidably costly, and it is kind of impossible for them to develop a countrywide wired network to facilitate every end-user. An easy alternative is to provide internet access through wireless technologies, like 3G WiMAX, 4G-LTE, etc. This invokes other kinds of problems concerning lower internet speed, high power consumption, high cost per unit usage ratio, etc. So, the authorities can deploy a hybrid model of internet backbone over the whole country, consisting of a fiber-optic national data-highway, local and national data centers, regional WiMAX and 4G service points, etc. The main challenge here is to deploy a hybrid backbone over the country that trades-off with the problems and facilitates the end-users with optimal utility that can be sufficient to enable IoT in these countries [9].

Data Centers

The creation of unmatched amounts of data is one of the most important off shoots of the IoT. Since the Internet consumes up to 5% of the total energy generated today and with IoT demands on the rise, energy consumption is guaranteed to rise as a consequence. Data centers in developing countries that are run on harvested energy and are centralized will cater for energy efficiency and reliability. The storage of data thus has to be implemented intelligently so that smart monitoring and actuation can take place.

Power Resources

Compared to developed countries, the planning of electricity for developing countries presents itself as a complicated dilemma. The challenge surpasses the mere acquisition of financing for energy related investments. Energy development is challenging as electric power industries are among the most intensive in an economy. This leads to the severe draining of financial resources. IoT for developing countries (IoT4D) will aid in providing power solutions by enabling clean energy technologies, creating smarter energy markets and by optimizing the implementation of existing products. For example, to improve these of energy in homes, the IoT will automate and promote energy efficient practices such as the running of appliances at off-peak times. In terms of a solution presented by IoT, servicing customers with information regarding utilities, devices known as smart meters can provide real-time, two-way communication between customers and devices in their perusal. Benefits involve granular detail to customers about their electricity usage. Smart meters also aid customers in modifying their energy consumption in relation to current prices. A smart meter also allows the collection of data automatically. This negates the need for a company needing to send out an engineer to manually collect data readings from such a meter. It also serves as an effective means to detect outages and the necessity of repairs.

Human Resources

A great challenge is the lack of technically knowledgeable

personnel. They include Engineers, Scientists and Technicians. IoT is a state-of-the-art term and implementing the technologies to build up IoT platforms requires learned personnel. In developing countries, the numbers of research centers are very low. The funding and investment to innovations is critically at nadir. *Device Reliability* IoT devices for developing countries need to be robust, energy efficient and able to run on batteries for months at a time. They also need to be able to make use of the solar radiation present for recharging capabilities (e.g., photo-voltaic panels). Even the sensors connected to motes in areas where they are exposed to environmental factors need to be of a high quality and have a reasonable life span. These devices should be designed in a modular fashion that makes components easily replaceable, almost in a plug-'n-play manner. It is important to know when an IoT device drops off from a network and goes offline. Knowing when the device comes back online is equally important. It is in this domain that presence detection is able to give an exact and up to date status of all devices that form part of a network. The monitoring of IoT devices in this way lends the ability to correct any problems that have arisen within a network. It subsequently boosts its reliability [10, 11].

Financial Challenges

The IoT provides a great opportunity for developing countries to leapfrog from poorly prepared to scientifically and technologically equipped countries which can use the IoT technology to face their current and future challenges by tapping into the potential provided by this technology. However, such opportunity may become reality only if the developing world is ready to embark into this technology at the same pace as scientists and technologists of the developed world and financial challenges related to these technologies are addressed. These include low cost of acquisition, maintenance and financial sustainability. As currently perceived, sensor devices are the raw material of the IoT. Such devices are still expensive for many countries of the developing world when accounting for the cost of acquisition and shipping from the manufacturing companies which are mainly located in the developed countries. This may hamper their wide and ubiquitous deployment in the developing world. Furthermore, for such devices, cost and field-readiness are still closely related while the most field ready devices are usually proprietary devices with vendor locked software, sometimes updated frequently at recurrent fees or cost. This leads to higher cost of maintenance and operation which also leads to a challenging financial sustainability situation for those operating IoT businesses. Many of these challenges may be addressed through local IoT expertise, the use of open source hardware and software, and strong collaboration between scientists and technologists of the developed and developing world. Such collaboration will enable the IoT4D dream to become reality [10, 12].

Security, Privacy and Trust Issues

IoT security is a topic that is still in its development stage, though there exists a rather large volume of research that analyzes the challenges it presents and possible means of safeguarding against attacks. These challenges must be

overcome in order for the IoT to be ready for real world deployment.

8. Report of the Finding

In developing countries, IoT technologies have brought increased efficiency and effectiveness to existing processes [13]. Today, the Internet of Things is improving the day-to-day lives of citizens around the world. In cities from, Internet Protocol (IP)-connected sensors are monitoring traffic patterns, providing city managers with key data on how to improve operations and communicate transportation options. Similar information flows are improving hospitals and healthcare systems, education delivery, and basic government services such as safety, fire, and utilities. Sensors and actuators in manufacturing plants, mining operations, and oil fields are also helping to raise production, lower costs, and increase safety. In both developed and developing countries, the Internet of Things is also helping monitor critical vaccines through the use of IP-connected thermometers. Moisture sensors in agricultural fields now alert farmers to the exact needs of food crops, and acoustic sensors in protected rainforests are helping to curb illegal logging. For the IoT to have an even greater impact, there is still more we can do to improve the deployment of these technologies in developing countries. Network deployment, power requirements, reliability and durability are all uneven, at best, and policy considerations concerning access to data, legacy regulatory models, standards, interoperability, security, and privacy need to be addressed. We are in the early stages of IoT adoption and are pleased to see the great impact that the IoT is already making for people, companies, industries and countries around the world. This report aims to serve as a guide for how the IoT can be fully utilized to improve the lives of people everywhere. The application of the IoT to solve many of the world's challenges is limited only by our imagination. The Internet of Things (IoT) has become one of the unprecedented research trends for both academic and commercial organizations. Every day, the publicity of the IoT is increased [14]. This is because the unlimited benefits that the IoT can bring to our environment. The IoT has the ability to connect almost all objects of real-world to communicate and cooperate with each other over the Internet to facilitate generating new applications and services that can improve our quality of life. This paper provides an overview of the IoT system with highlighting its applications, challenges, and open issues. It starts with discussing the state-of-the-art of the IoT system and its layered architecture in developing country [15]. Different IoT applications and challenges are also discussed. At the end, open research directions related to the IoT are also presented. Reliable power supply is a big challenge in most of the Developing World. Solar and Wind are clearly the effective solutions. In contrast, establishing the power plants of Solar and Wind are not linear in cost [16]. For example, if you double the size the cost will be more than double. IoT nodes require very little energy, so small solar panels are suitable and are very cheap. In addition, energy harvesting sensors are

adding a new paradigm to the play-field. Deploying and maintaining energy harvesting sensors is cheap and easy. It can conveniently ease the demand of power. Generally the embedded and wearable computing will have greater impact in providing services in wide range of applications by 2020 [17, 18].

9. Discussion

The Internet of things (IoT), or its sibling, Internet of everything (IoE), has gone from being a buzzword to almost an imperceptible part of our lives. It is so prevalent that we barely notice it anymore. In this paper, mainly focus on the prospects, challenges and the probable solutions to the problems for enabling IoT in developing countries. In developing countries, people face a lot of problems to have access to the communication technologies in terms of poverty, lack of Internet speed, low levels of expertise, and overall lack of infrastructure. The authorities face enormous challenges to improve the current systems to make the infrastructure capable of deploying IoT as a whole. We identify the positive impact of IoT in developing countries in the 21st century context. We state the challenges to exploit the opportunities for deploying IoT in developing countries in this era. We discuss the possible solutions to the challenges and provide guidelines to ameliorate the current condition to enable IoT in developing countries [19]. IoT is one of the most important technologies of everyday life and it will continue to pick up steam as more businesses realize the potential of connected devices to keep them competitive. The internet of things helps people live and work smarter as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their companies' systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations. IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods as well as offering transparency into customer transactions [20, 21].

IoT touches every industry, including healthcare, finance, retail and manufacturing. Smart cities help citizens reduce waste and energy consumption and connected sensors are even used in farming to help monitor crop and cattle yields and predict growth patterns. Developing countries are already investing in IoT for farming, amongst other agri-tech, deploying affordable and user-friendly mobile and web solutions that are directing data straight to the farmers. This is providing real time information on weather conditions and market information, as well as providing accessibility to general farming information that's shared between communities. For low-income or illiterate farmers or those still practicing the traditional methods of farming, accessing and sharing this data can educate them on what crops to grow, when to plant, how to fertilize, when to sell and for what price, with the ultimate goal of increasing crop yields and income.

Ultimately, the success of IoT for farming in such countries is still heavily reliant on investment in digital literacy as well as reliable connectivity solutions. Cellular is one such solution; able to reach even the most remote locations, and with data costs continuously lowering, it can be effective even in developing countries. Narrowband IoT (NB-IoT) in particular, though still relatively new, is set to offer farmers and rural communities low cost, long range and long battery life connectivity, creating hyper-connected farms that could monitor every asset from the soil to livestock [22, 23].

10. Conclusion

In developing country IoT, both as a technology and as a governance practice, is still in its infancy, and while there is tangible excitement about it within both government and the private sector, evidence of success remains patchy. Governments have a vital role in catalyzing the space and contributing as partners/leaders in the long term. The future focus will be on connecting devices, software and people. Leveraging AI + IoT to create intelligent automation agents that can monitor learn about and control systems. IoT is also expected to generate large amounts of user data, giving rise to the need to aggregate, index and store collected data. Many devices collect useful information while others may in turn resell it for marketing purposes with or without a user's permission. A recent example is the lawsuit filed against Bose for collecting and selling subscriber usage data from headphones without permission. Based on the findings and the characteristics of successful pilots, we present a conceptual toolkit containing ideas and resources for government agencies that want to implement IoT-based initiatives within their jurisdictions. The toolkit is structured using three pillars. The IoT has the greatest potential to advance society since the Industrial Revolution: a world where all kinds of things are interconnected, smart, communicating, and improving our quality of life [24, 25].

Our future is connected and smart world. Exponentiated hardware capabilities allow for an explosion of connected devices. We are seeing reduced power consumption and increased computing power. Using IoT, it would be possible to extend cost-effective health care services to people in rural and remote areas, as well as in developing countries with mobile communication infrastructure. Researchers are now thinking of smart cities, however, with proper IoT infrastructure, it may be possible to develop "smart villages" in the future. IoT infrastructure, framework, wireless communication, embedded sensors, advanced data management, Big Data analytics, decision support, machine learning, data fusion etc. are all technologies applicable in medical science. In addition to data privacy, challenges can include the deployment of devices using proprietary hardware and platforms that make it difficult and expensive to integrate and interconnect. But the biggest identified risk is security allowing unauthorized and unsecured access to enterprise systems through personal and IoT devices without certification, testing or network segregation can increase

vulnerability to cyber-attacks, denial of service (DOS) attacks and system outages. Impactful IoT interventions in development can improve efficiency (achieving similar levels of impact with fewer resources) and/or enhance effectiveness (increasing impact with similar levels of existing resources). In advancing global development, IoT interventions are helping to improve research, public policy, basic service delivery and the monitoring and evaluation of programmes across a range of different sectors. This report discusses examples of use cases of the IoT in healthcare, water, agriculture, natural resource management, resiliency to climate change and energy. The IoT has regulatory implications across the areas of licensing, spectrum management, standards, competition, security and privacy only some of which are the familiar territory of telecom regulators, compared to other domains where non-telecom regulators may typically take the lead.

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