August 2018;3(1):57-76
http://dx.doi.org/10.20522/APJBR.2018.3.1.57

The Current Telecommunications Infrastructure in Ecuador is Ready to Start with the Implementation of IoT Applications?

Johanna Fernández Yépez
National Telecommunications Corporation, Ecuador

Yun Seon Kim*
Handong Global University, South Korea

Abstract

The "Internet of things" (IoT) is becoming an increasingly growing topic of conversation, it is a new emergent technology that can be present in almost every field and application. It's a concept that not only has the potential to impact how people live but also how people work. Broadband Internet and Mobile Internet are becoming more widely available, the cost of the service is decreasing, more devices are being created with Wi-Fi capabilities and sensors built into them, technology costs are going down, and smartphone penetration is growing so fast. All of these facts are creating the best environment for the IoT applications. In a country like Ecuador, is important to have a previous analysis about the feasibility of the implementation of this new technology in order to know what are the challenges the country has to face, and also to not stay behind as the other countries in the region are advancing. Currently, this kind of analysis does not exist. The Internet of Things is an innovation where business and technology models in Ecuador are relatively unexplored. The current infrastructure deployed in Ecuador and the available devices in the market are the central facts to initiate with the research, which is a starting point to show if Ecuador is ready to this technology, and if is not ready what is missing. This study shows the current telecommunications status in Ecuador, and its strengths and weaknesses to start the deployment of Internet of Things. Besides, it also will show the most likely applications that can be easily adopted for the Ecuadorian market with its respective availability, affordability, and adaptability.

Keywords Ecuador, Internet of Things, Telecommunications Infrastructure, Developing Country

*Corresponding author: sean0831@handong.edu

1. Introduction

Ecuador is one of the countries in the region that has deployed ICT infrastructure faster. For this reason, it can be a good environment to develop IoT applications. In 2011, Ecuador Digital 2.0 strategy was made as a plan of ICT develop. In the same year, HSDPA+ technology was integrated into mobile telephony, improving considerably the speed in mobile data connection, that at the time was offered with 3G UMTS/HSDPA since 2008. In 2013 The Telecommunications National Corporation CNT, launched LTE in mobile technology, being this the last technology in Ecuador. Later the two other companies, Movistar and Claro, launched this technology. In September 2013, 3.6 million mobile internet users were reported in Ecuadorian territory. As far as broadband internet infrastructure is concerned, in 2012 the Internet started using the IPV6 technology. Finally, in 2015 Ecuador accessed to a new submarine cable, the network for Internet communications between North, Central, and South America experienced improvements in its infrastructure with this cable linking the state of Florida, United States, with the port of Manta in Ecuador. The is cable 6,000 kilometers long and is known as Caribbean Pacific Cable System (PCCS). The deployment is composed by group Cable Andino (Telconet), Cable & Wireless, Star di Telecomunicazioni Service Aruba, Telefonica Global Solutions and United Telecommunication Services Curacao consortium. In addition, Florida and Manta, the fiber optic network will connect to the British Virgin Islands, Puerto Rico, Aruba and Curacao, as well as Cartagena in Colombia and Maria Chiquita and Balboa in Panama. The work demanded a public-private investment of approximately $ 300 million. The benefits to Ecuador are the expansion of bandwidth to achieve 100Mbps per user and to democratize the access to new information technologies (Xinhua, 2015).

The Internet of Things (IoT), can be also called as the Internet of Objects. It will change everything including people. This may seem like a narrow statement, but considering the impact the Internet already has had in many fields like education, communication, business, science, government, and humanity, it is becoming a reality. Clearly, the Internet is one of the most important and powerful creations in all of human history, and IoT can be considered like its evolution. The Internet of Things (IoT) is an emerging paradigm that converges aspects from different approaches, and it can be very helpful for the development of many societies, and to improve the quality of life of million people. Early in 2012, IoT was defined 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, 2012). Many experts are thinking that IoT is very powerful, but unified with communications, this technology offers the best prospects. Looking to the future, it is expected that the abundance data and applications multiply increasingly through

Internet of Things (IoT). IoT works perfectly together with communication technologies, the Internet, and smart devices, those which together make a lot of applications that are turned into smart objects to collect information, to interact and control the physical world, and to allow the exchange of data and information through the internet. There are many initiatives using IoT around the world, by research organizations, industries, and governments, the objective is to bring it to the market. The number of IoT projects are increasing rapidly since it started in 2009 on the European Commission by focusing on the development of architectures and optimized technologies for supporting IoT-based applications and services (Borgia, 2014). The IoT concept is strongly in the relation with the huge quantity of smart devices, sensors and RFID devices, that are available and connected each other by using the internet connection.

These smart objects give many opportunities to create services for the benefit of the society that can be applied in favor of the environment, to improve the economy and in many fields to help individual citizens. According to the International Telecommunications Union (ITU), the IoT can enormously accelerate the advances to achieve the sustainable goals for the development of the United Nations. Currently, IoT projects are under way that promises to close the gap between poor and rich, improve the distribution of the world's resources to those who need them most, and help to everybody to understand the planet so the people can be more proactive and less reactive. In order to achieve these goals, IoT needs the cooperation of various stakeholders in the ICT sector: from consumer electronics manufacturers to telecommunication service providers and people who will develop the applications. But not just them are required, for IoT can be used in the best way, other stakeholders outside the ICT sector should be engaged, including car manufacturers, utilities, home appliance manufacturers, medicine, public administration, among others. This is a big challenge to be considered in ITU and other organizations (International Telecommunications Unit, 2015). Currently, governments, businesses, and consumers are using the IoT to introduce new business models, to improve the delivery of services, to increase efficiency in production, and to improve human lifestyle focus on welfare. Even so, several barriers exist that threaten to slow IoT development, including the transition to IPv6, having a common set of standards, and developing energy sources for millions—even billions—of minute sensors (Evans, 2011).

The technologies that are compatible for the deployment of IoT, can be by wireless or wireline. (1) Personal Area Networks (WPAN), like Bluetooth and RFID. (2) Local Area Networks (WLAN), referring to WiFi. (3) Wide Area Networks (WWAN), where are included the mobile networks like WiMax, 2G, 3G and 4G/LTE, and satellite network. (4) The wireline technology that can be copper, DSL, or Fiber internet connection (CISCO, 2016). Is important to analyze the current status in Ecuador for these technologies infrastructure in order to find a way to implement IoT applications in the country. General data about this information is as follows, more than 50% of the Ecuador's

population has fixed Internet access. While for coverage of mobile services in 2015, Ecuador had approximately 96% of the population covered, this compared to the population coverage 2006, which was about 89%. The greatest opportunity for development and deployment of infrastructure is recorded in advanced networks, 3G and 4G networks, which in 2015 had a population coverage of 90% and 32%, respectively.

The main problem to solve is to be aware if Ecuador is a good scenario to develop IoT, by analyzing the current technologies infrastructures, both fixed internet networks and mobile internet networks, that are deployed in the country, and if the current devices that have been released to the market are affordable within the Ecuadorian market. The objectives of this paper is to identify the telecommunications technologies available in Ecuador, that can be used to deploy Internet of Things, and to find one application based on Internet of Things that can be implemented with the current infrastructure deployment. To conclude if Ecuador is ready for the mass deployment of Internet of Things is necessary to create a precedent in the analysis of the possibility of mass Internet of Things implementation in Ecuador and to analyze the availability, affordability and adaptability to implement Internet of Things applications in Ecuador.

2. Literature Review

2.1 The current enabling technologies that are currently supporting Internet of Things Implementation

Actualization of the IoT concept into the real world is possible through the integration of several enabling technologies. Communication protocols allow devices to exchange data over the network. Connecting things trough, the Internet can be accomplished with the help of various protocols and standards, either adopted from the traditional Internet and telecommunications fields like WiFi and Bluetooth, Ethernet, 3G and LTE, HTTP, or specifically tailored to meet the constraints of the connected things (ZigBee and Z-Wave, as well as IETF's 6LoWPAN, RPL, and CoAP). Specific requirements of different application domains affect the feasibility of certain technologies (Mazhelis, Warma, & Leminen, 2013).

802.11 – WiFi: IEEE 802.11 is a collection of Wireless Local Area Network (WLAN) communication standards. Theses standards provide data rates from 1Mb/s to 6.75Gb/s. WiFi provides communication range in the order of 20 m (indoor) to 100 m (outdoor).

802.16 – WiMax: IEEE 802.16 is a collection of wireless broadband standards. WiMAX (Worldwide Interoperability for Microwave Access) standards provide data rates from 1.5Mb/s to 1Gb/s. The recent update (802.16m) provides data rate of 100Mb/s for mobile stations and 1Gb/s for fixed stations.

2G/3G/4G – Mobile Communication: There are different generations of mobile communication standards including second generation (2G including GSM and CDMA), third generation (3G-including UMTS ad CDMA2000) and fourth generation (4G-including LTE). IoT devices based on these standards can communicate over cellular networks. Data rates for these standards rage from 9.6Kb/s (2G) to 100Mb/s (4G).

802.15.1 – BlueTooth: Bluetooth is based on the IEEE 802.15.1 standard. It is a low power, low cost wireless communication technology suitable for data transmission between mobile devices over a short range (8–10 m). The Bluetooth standard defines a personal area network (PAN) communication. It operates in 2.4 GHz band. The data rate in various versions of the Bluetooth ranges from 1Mb/s to 24 Mb/s. The ultra low power, low cost version of this standard is named as Bluetooth Low Energy (BLE or Bluetooth Smart). Earlier, in 2010 BLE was merged with Bluetooth standard v4.0 (Ray, 2016).

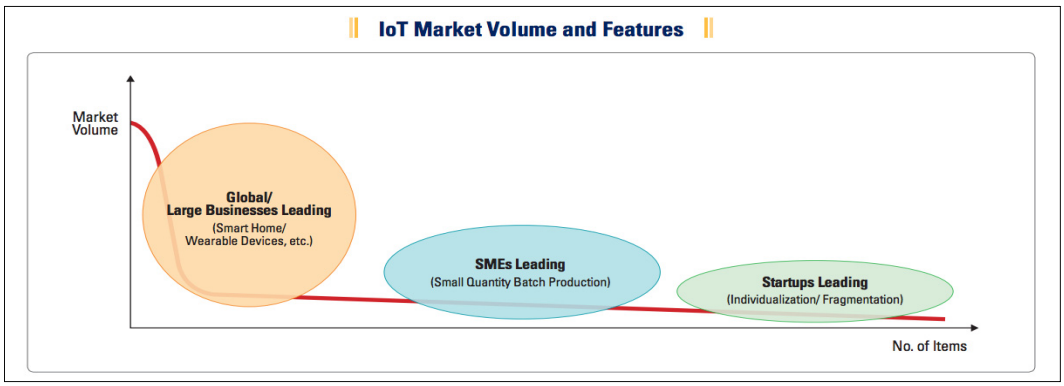
2.2 Current Internet of Things Devices

The IoT is currently going through a phase of rapid growth. The number of connected 'things' has increased in five years and is estimated about 4.9 billion in 2015. Thus, organizations expect the IoT to become an important source of revenue. Cisco estimated that the global IoT market will generate $14 trillion in profit over the next decade. The total global economic added value for the IoT market will be $1.9 trillion dollars in 2020. (Dijkmana, Sprenkels, Peeters, & Janssenb, 2015). IoT devices are already common, cheap and easy replaceable in developing markets. IoT devices costs continue to be absorbed by strong demand in developed world markets, and there is little cost associated with 'tweaking' IoT devices for the developing world. There are a variety of things or objects such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones, among others. Sensor technologies and sensory devices are present everyday. The Internet of Things (IoT) not only provides an infrastructure for sensor deployment, but also a mechanism for better communication among connected sensors. Data generated by these sensors is huge in size and continuously produced at a high rate. This requires mechanisms for continuous analysis in real-time in order to build better applications and services. Data streams produced by various sensors can be classified into three different categories, namely, (1) Physical (static) Sensors, (2) Mobile & Wearable Sensors, and (3) Virtual Sensors & Social Media Streams (Intizar, et al., 2016). These devices through unique addressing schemes, are able to interact with each other to achieve common goals (Atzoria, Iera, & Morabito, 2010). IoT devices offer huge potential for electronic component manufacturers, but this is clearly not where the value will stop. (Girardin, Bonnabel, & Mounier, 2014). The

large-scale implementation of IoT devices promises to transform many aspects of the lifestyle. There are some IoT products for Internet-enabled appliances, home automation components, and energy management devices, moving toward the vision of the "smart home", offering more security and energy efficiency. Other personal IoT devices like wearable fitness and health monitoring devices and network-enabled medical devices are transforming the way healthcare services are delivered.

2.3 Potentials Applications

The IoT technology makes possible the development of a huge number of applications, of which only a very small part is currently available to our society. There are many fields and environments in which new applications would likely improve the quality of our lives. Internet of Things could be everywhere, at home, while traveling, in hospitals, at work, and even when people is exercising or having fun. These environments are now equipped with objects with only primitive intelligence, most of the times without any communication capabilities (Miorandi, Sicari, De Pellegrini, & Chlamtac, 2012). Giving these objects the possibility to communicate with each other and to elaborate the information perceived from the surroundings imply having different environments where a very wide range of applications can be deployed. These can be grouped into the following fields: Smart Cities, Transportation, Smart business/Inventory and product management, Healthcare, Smart Environment (home, office, plant), Education, and Personal and Social Activities (Atzoria, Iera, & Morabito, 2010). The applications differ from country to country, and it is based on the market. For example, in South Korea the IoT market is divided in three main groups, as shown in the figure 1 below. One important strategy South Korea has to develop more applications, is to stablish an ecosystem for the start-ups that can bring their ideas into products and businesses based on open source hardware or software and where users can create their own products (Ministry of Science, 2014). The main applications in developing countries can help them to develop. IoT in developing countries is very important, it can be used from agriculture to smart city applications. The opportunities of IoT for the emerging sectors in the developing countries are on the fields of transportation safety, agriculture, environment, utility management, health monitoring and many more. To cite one application, in agriculture the conditions of the developing countries are becoming worse because of natural calamities, lack of proper fertilization, use of excessive chemicals and pesticides, among others. These conditions make essential to use modern technologies to improve the process.



Note: Adopted from http://www.kiot.or.kr/uploadFiles/board/KOREA-IoT%20Master%20Plan.pdf

Figure 1 IoT Market Volume and Features in South Korea

3. Research Methodology

To find the answer to be aware if Ecuador is a good scenario to develop IoT, it was necessary to analyze the current technologies infrastructures, both fixed internet networks and mobile internet networks, that are deployed in the country, comparing it with the networks in other countries that are using Internet of things applications. Another important thing is to investigate which kind of IoT devices that are available in the market can be used in Ecuador. To achieve the objectives and goals, described in the introduction of the paper, the research method that was used in this study is a primary and secondary approach with literature based methodology. For this specific case, the information was taken from reliable sources, in order to have a real study, with real results. It is important to use information from many sources, for this reason, the research was doing with two types of secondary research (Stewart & Kamins, 1993), in addition to the primary data.

The first one is internal secondary data. The information collected by this method consists of information gathered from previous reports and the knowledge of some people working in the telecommunications field in Ecuador. The second one is external secondary data. The information collected by this method consists of information gathered outside of the observation of the researcher and previous reports, for example, information from government, information from journal papers, or information from media sources. The information from the government was supplied from the Telecommunications Ministry and from The National Telecommunications Company in Ecuador. The Secondary Research process for this study will be structured as follows (Linh Do, 2012). First, using the objectives and goals, the sources where the information came were discriminated, so the data can be trustworthy. A list of points to be solved was detailed in order to

show it by the end of the study. Then, from some trustable sources of information the better were chosen to get the necessary data. There are many sources of secondary information. So the best institutions and companies helped with the research on the topic area. Besides, comparing information from different sources were the main model used in this paper. Like it was stated before, to achieve the objectives of this study, the information between the infrastructure and devices in Ecuador, were compared with the information of countries that are using Internet of Things Applications. Moreover, the applications were also compared in order to decide the best option that could be implemented in Ecuador. The sources for this study present official information from technical reports, universities, research institutions, journal papers, and literature review articles. Finally, the analysis of the information to conclude the purpose of this study.

It is known that the secondary approach does not replace, primary approach and it should be the starting place for any research (McCaston, 2005), however, in this study, most of the information is based on secondary approach. Whereas the primary and secondary data can help to find a valuable information for gaining knowledge, and it conducted to the comparisons, understanding Ecuador specific and local conditions, determining the direction that should be taken to implement new technologies and trends, and also for describing the current situation of the country.

For the Primary Research, the information will be given from experts who are working in the telecommunications industry in Ecuador. I will select, based on my knowledge, no more than 5 people with the enough experience and who are working in The National Telecommunication Corporation, and also is the companies which are our vendors. The telecommunications vendors are important for this study because they know about new devices that can be introduced in the Ecuadorian market. The information collected from this group of people is going to be about the current telecommunications infrastructure deployment and technology implementation, with the current trends. Besides, I would ask information about the devices that could be used for certain applications.

After this analysis, the results are focused on the identification of the telecommunications technologies available in Ecuador, that can be used to deploy Internet of Things, and the suggestion of one application based on Internet of Things that can be implemented with the current infrastructure deployment. Besides, this study looks to conclude if Ecuador is ready to start the deployment of Internet of Things, what weaknesses have to be overcome in order to make some Internet of Things applications successful in Ecuador, and if it is available, affordable and adaptable.

4. Analysis and Results

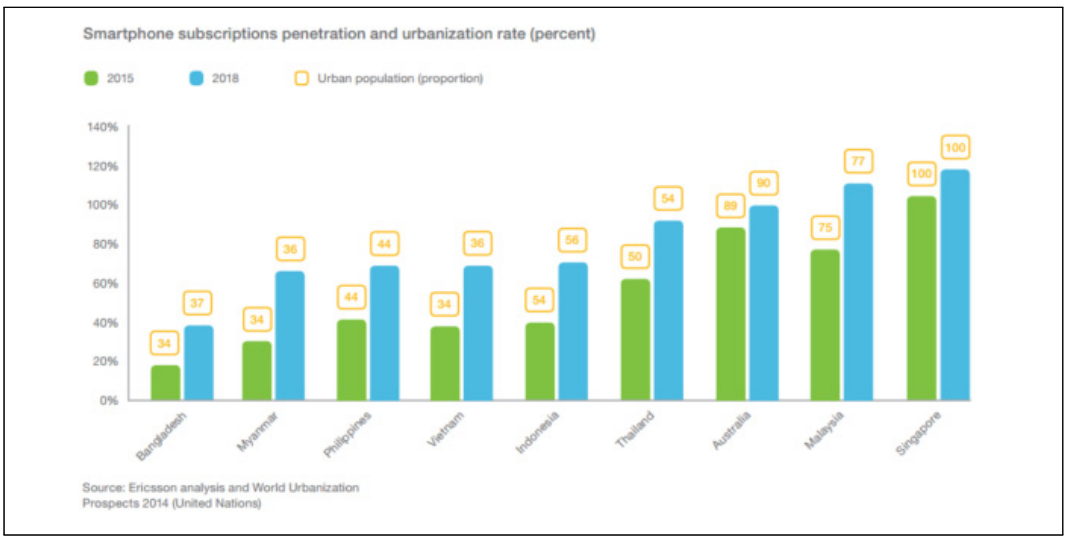
Countries in Southeast Asia have reacted to the emergence of IoT in different ways, with governments spearheading initiatives in some countries, and businesses taking the lead in others. Besides, some markets, the private and public sectors are working together. The current Analysis is based on a comparison between one of the Southeast Asian countries, Malaysia, with Ecuador. Malaysia already started to prepare in order to implement IoT applications, the country started with the implementation of pilot projects. This country is emerging with this technology, and the environment was analyzed in order to be aware of the best ways to do it. Since this is not a very high technology country like other countries in the region, South Korea or Japan, is a good example to follow taking in mind the current situation of Ecuador in this field. Thus, it is a good scenario to take, in order to compare with the potential possibilities of Ecuador. Moreover, in Ecuador do not exist an analysis from the government or from other sectors that can show the possibilities in Ecuador to start with IoT applications.

The study of Malaysia case was doing in 2015 in collaboration with the government and with the Technology Park of Malaysia, and it included aspects like the market potential, readiness, and the implementation strategies. The vision of Malaysia is to create a national ecosystem to enable the proliferation of use and the industrialization of IoT as the new source of economic growth. The mission is to make Malaysia the premier regional IoT hub in the region. It would also be the wanted future in Ecuador, therefore, this is a good example to follow. According to this study the communications and networking are just the 5% of the components of IoT. The most important components are the applications and services. Malaysia and its region have a bunch of opportunities with business, however, the IoT market presented some important challenges. The same situation could be addressed for South America, and more specifically to Ecuador.

4.1 Current Infrastructure Situation in Malaysia

The initial IoT market potential for Malaysia will be USD $2 billion by 2020 and it is expected to experience exponential growth after 2020 and reach USD $9,7 billion. Technology opportunities can be created by IoT in Malaysia with forecast technology for many applications. Malaysia has a strong environment and starting point to foster and deploy IoT within the domestic market due to the high mobile penetration at 143.7 % and observation of multiple handset ownership. Besides, the 67 % of Malaysians are Internet users with 59 % of active users, their social media penetration is 45%, and their domestic ICT consumption is high and it is increasing (Mosty, 2015).

The penetration of smartphone subscriptions in Malaysia was 75% in 2015, and for 2018 it will increase to 77%, according to an analysis made by the Ericsson company. This can be appreciated in figure 2.



Note: Adopted from Ericsson analysis and World Urbanization Prospects 2014 (UN)

Figure 2 Smartphone subscription penetration (Malaysia)

Currently, Malaysia possess the infrastructure necessary for the deployment of IoT, and its government started to spread various initiatives. The government seeks that IoT contributes to the economy of the country. Nevertheless, the country also faced some weaknesses, showed in the table 1, that are being overcome. This table is retrieved from the Strategic Roadmap for IoT developed by the country.

Table 1 Strengths and Weaknesses for IoT deployment in Malaysia

Factor	Strengths	Weaknesses
Technology	Well-established mobile operators and five operators licensed to provide 3G services	Technology complexity Legacy systems Security and privacy concerns Data accessibility and knowledge sharing availability
Resource	Creation of new MSC cyber-cities and cyber-centers SMEs as source of endogenous growth and innovation	Fragmented funding instruments unable to generate required impact Barriers to free market competition exist

Factor	Strengths	Weaknesses
	E&E industry is leading in terms of investment, industrial output, value add, exports and employment	
Societal	High phone and Internet penetration rates Sophisticated consumers are eager to use mobile data and value-added services	Rural adoption and adaptation fear - technology phobia
Political	Various incentives like pioneer status, tax exemptions and allowances to promote ICT investment Intellectual property protection and cyber-laws	Dedicated performance management entity exists to monitor and drive performance of innovation initiatives Broken linkages across industry and public institutions Multiple public agencies working in silos on innovation initiatives

Note: Retrieved from http://mimos.my/iot/National_IoT_Strategic_Roadmap_Summary.pdf

4.2 Current IoT applications in Malaysia

In spite of the weaknesses that the country faces, Malaysia has implemented the IoT technology in many fields. The current applications in Malaysia have and an impact to the society, and the were developed by the Malaysia Digital Economy Corporation (MDEC). They include Smart Manufacturing by elevating the competitive edge of Malaysian manufacturers. Public Safety with the expansion coming via private participation and collaboration. Smart Transportation by transforming this sector through connectivity and intelligence. Smart Agriculture by booting the sustainability and livelihood of farmers.

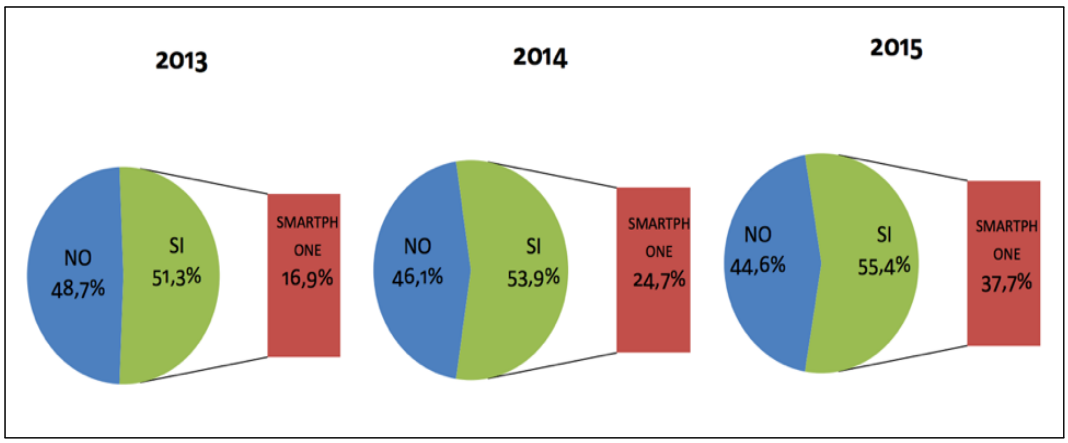
They are also looking to innovate with IoT in Healthcare industry, and in a short future in other fields like energy and logistics. Malaysia is going hand-by-hand with technology, the country is aware that IoT along with Big Data Analytics, E-Commerce, Data Centers and the Cloud are catalysts that will kick-start and sustain an ecosystem of digital innovation (Norhizam, 2016). Malaysia has a number of successful use cases. For example, a smart parking project for Sunway Pyramid Shopping Mall, which is one of the largest in Malaysia. Moreover, a smart apartment project for one of Malaysia's leading property developers; a heavy vehicle monitoring system for Kuala Lumpur City Hall, and a smart chili irrigation system for a farming area in Negeri Sembilan. In addition, MDEC has a healthy IoT project pipeline that currently includes development in the areas of quality control and assurance, traffic management system, smart waste management and smart streetlights among others.

4.3 Current Infrastructure Situation in Ecuador

In Ecuador does not exist a plan to support the IoT applications, some private small companies are trying to start in this market. In the last years, Ecuador has deployed backbone infrastructure, increasing the basic telecommunications services in rural and urban areas. As for the population coverage of mobile services in 2015, Ecuador had approximately 96% of the population covered, this compared to the population coverage 2006, which was about 89%. The greatest opportunity for development and deployment of infrastructure is recorded in advanced networks, 3G and 4G networks, which in 2015 had a population coverage of 90% and 32%, respectively; while in 2006 the population coverage of the 3G network was 53%, growth has been reflected in the increase by four times. Another services can be offered and improved because the penetration of fiber optics has grown significantly since 2006, in which only 3,500 km lines were available, compared to approximately 60,000 km that were reported in 2015, which undoubtedly contributed to the growth of almost seven times in fixed broadband subscriptions since 2006 until 2015 (Mintel, 2015).

Even the big deploy of the telecommunications infrastructure in the last ten years, the access to most of the people still minimum, more of them in the rural areas. Analyzing the status between the countries of the region, differences are also produced between rural and urban areas. The percentage of rural households with Internet in Costa Rica, Uruguay, Brazil and Chile is greater than the percentage of covered urban households in Guatemala, Bolivia, Dominican Republic, Peru, Ecuador, Paraguay and El Salvador (BBC, 2015). One of the causes of this situation is due to the cost of fixed and mobile broadband, this is high for an economy like Ecuador. Taking into account that the minimum wage is USD $364, the cheapest cost of a fixed internet plan is more than 5%. Moreover, Ecuador has one of the most expensive cost of a month mobile plan with at least 1GB in Latin America, comparing with 2014 data. Bolivia is the only country with a higher cost (Aguero, 2015). Another aspect that is not achieved yet with all the infrastructure is the speed of fixed internet. Ecuador has an average download speed of 5,63 Mbps, this information is with data from 2015. However, the strongest growth in Internet penetration in recent years is in four Latin American countries, one of them is Ecuador.

The growth of the population that use the Internet is increasing rapidly in Ecuador. According to the World Bank, 48.9% of population has Internet Access. This is almost 20% less than the penetration in Malaysia. The penetration of smartphone subscriptions in Ecuador is 37,7% according to data of 2015. The increasing of smartphones is growing rapidly. Since 2013, it has grown in more than 20%. This can be appreciated in figure 3.



Note: Retrieved from National Institute of Statistics and Census Ecuador

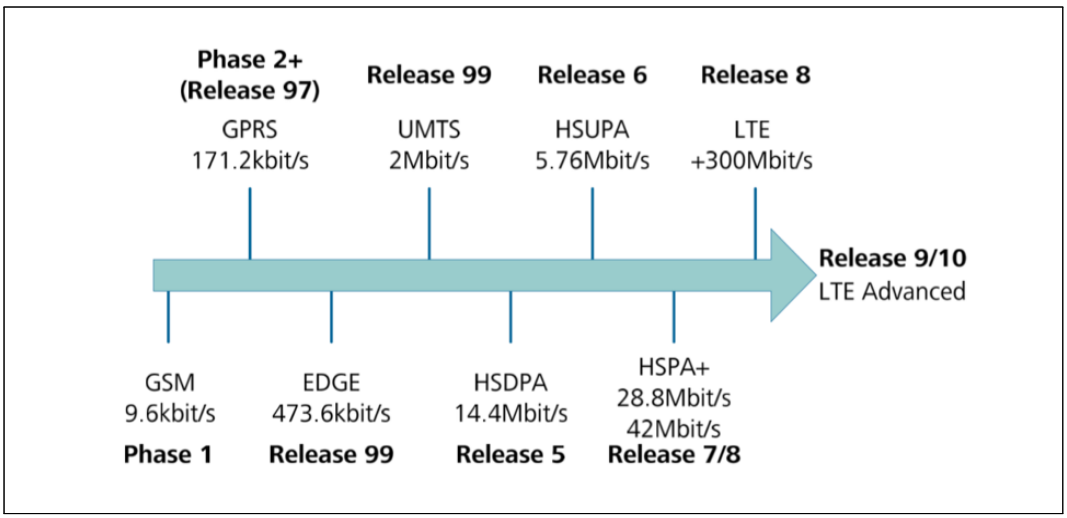
Figure 3 Smartphone subscription penetration (Ecuador)

Currently, Ecuador possess a potential infrastructure for the deployment of IoT applications, however, not the public or private sector have started to propose applications for the economy growth or for the benefit of a specific sector. On the other hand, Ecuador has many weaknesses. The same model used in Malaysia to show the strengths and weaknesses can be appreciated for Ecuador situation, in the table 2.

Table 2 Strengths and Weaknesses for IoT deployment in Ecuador

Factor	Strengths	Weaknesses
Technology	Well-established mobile operators, three operators licensed to provide 3G and LTE services. IPV6 technology deployed for broadband Internet	Technology complexity Legacy systems Security and privacy concerns Data accessibility and knowledge sharing availability High cost of services Low wideband Internet penetration in rural areas
Resource	Public and Private Investment	High cost of resources Big Barriers to free market competition Lack of start-ups in technology and innovation
Societal	Medium smartphone and Internet penetration rates Sophisticated consumers are eager to use mobile data and value-added services	Low adoption of technology in rural areas Low knowledge in the use of internet applications
Political	Government policies to support the deployment of ICT infrastructure	Lack of policies to decrease the cost of technological equipment High tax rates in technological equipment

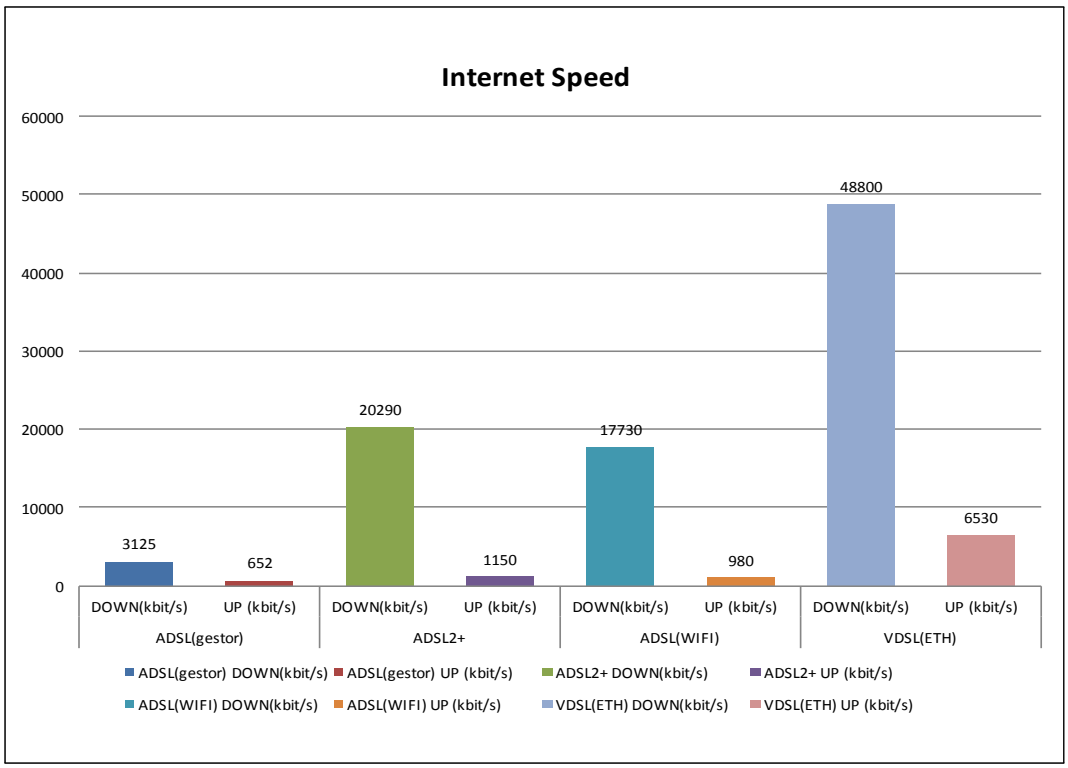
The Mobile Network in Ecuador is almost all over the country, thus this network environment for IoT applications is a strength. The current newest technology is LTE release 8, and Ecuador is in it way to go for LTE advanced Release 9. The evolution of this technology is showed in figure 4.



Note: Retrieved from National Telecommunication Corporation CNT E.P

Figure 4 Mobile Technology Evolution in Ecuador (CNT. E.P)

For the broadband infrastructure, The National Telecommunications Corporation CNT E.P, made tests to prove the highest speed that could be provided with IPV6 technology. The maximum speed was with VDSL, with 48.8 Mbps of downlink and 65.3 Mbps for uplink. Figure 5, shows the results of the test. The data belongs to CNT E.P, which is the company that has the biggest infrastructure in the country. The last technology implemented in Ecuador regarding the broadband infrastructure is Gigabit-capable Passive Optical Network (GPON), this is the choice of many carriers in the international market. GPON supports high-bandwidth up to 1.25Gbps/2.5Gbps and long-reach up to 20km. Nevertheless, the deployment is limited, according to the National Telecommunication Corporation, by the end of 2016 the network will be ready for 200.000 houses around the country. The connected subscribers are around 80.000. Currently, this technology is around all the provinces in Ecuador, except the Galapagos Islands.



Note: Retrieved from National Telecommunication Corporation CNT E.P

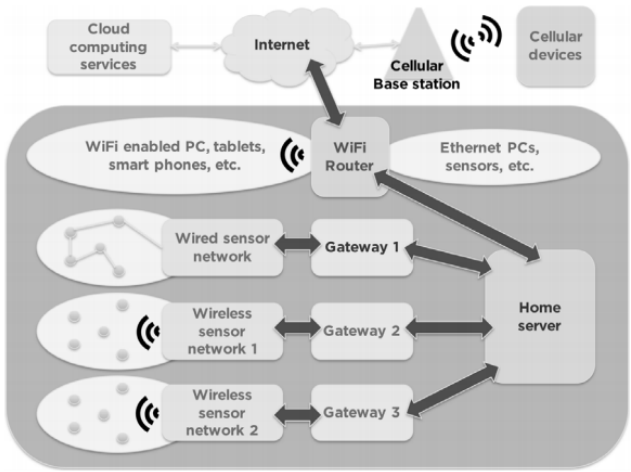
Figure 5 Broadband Internet speed in Ecuador (CNT. E.P)

On of the most important components in IoT is the server where all in the data will be kept. Currently in Ecuador there are some companies that offer cloud computing services, however, there are two big data centers, one in the capital city Quito, and one in Guayaquil. These data centers belong to the government, specifically from the National Telecommunications Corporation CNT E.P. The data centers allow to implement cloud computing services, as well as value-added services, IT managed services, unified communications, and virtual processing and storage. The facilities offer services to government, corporate clients and citizens in general.

The data of mobile network, broadband internet speed, and political strengths, showed in table and figures below, were taking from the information given from people working in the telecommunications sector in Ecuador. Specifically, the information for figures, came from real data, and it belongs to the National Telecommunication Corporation CNT E.P.

4.4 Potentials IoT applications in Ecuador

The basic model to implement IoT applications, is a heterogeneity network, where different types of connected electronic devices (things) exchange information. The devices may have different processing power, different input–output facilities, different scale of resources, different connectivity technologies, and different communication protocols. In figure 6, a typical heterogeneous network can be appreciated (Hui, Sherratt, & Díaz, 2016).



Note: Retrieved from (Hui, Sherratt, & Díaz, 2016)

Figure 6 Typical heterogeneous network.

Bearing the model of the network in mind, some IoT applications could be integrated in Ecuador. Since the current telecommunications infrastructure keep spreading, and new technologies are accessing. Comparing with Malaysia current situation, Ecuador has opportunities to start with IoT. It is true that Malaysia has more penetration of broadband and mobile Internet, however, according to the typical heterogeneous showed below, is possible for Ecuador to start. Ecuador has the most important components to deploy this technology, and the business opportunities are big. The potential applications in Ecuador would be focused on transportation, and public safety. These two fields are very important for the country. Moreover, investors and government would be interested if a deep analysis is done. One big challenge for Ecuador is the cost for new devices that have to be used, like sensors and other smart devices, and how the market would face it.

5. Discussion and Future Study

In this study the comparison of Ecuador with Malaysia was addressed in order to identify if Ecuador has a good environment for the deployment of Internet of Things. The contribution of this paper has been the analysis for the current infrastructure in Ecuador, to the deployment of IoT technology. As well as its strengths and weaknesses that the country has in this moment, which is important to start with a specific plan for the integration of IoT applications in the Ecuadorian market and environment. Moreover, the comparison made with Malaysia can clarify the actual opportunities and potential that Ecuador has at the moment. Thus, this paper reveals that is possible to start by identifying the best applications that can give the best benefit to the country. However, the country has many challenges and weaknesses that could impact on the way to the deployment, these challenges are the cost of the devices, the low penetration of internet in rural areas, and the lack of knowledge, of some part of population, in technology.

While this paper has shown the current situation of Ecuador, its strengths and weaknesses to start with mass IoT applications, and some fields where it could be applied, further analysis in applications and market remain unexplored. It is important to make a deeper study on three main aspects. First, the devices that can be integrated with the current infrastructure, Second, what features should be integrated into the network, so the IoT technology can be more exploited for a better development of the country. Third, the analysis of public policies that can help to increase the benefits of the applications, since this technology can help enormously to accelerate the advances to achieve the sustainable development. Currently, IoT projects are under way that promise to close the gap between poor and rich, improve distribution of the world's resources to those who need them most, and help to everybody to understand the planet so the people can be more proactive and less reactive.

6. Conclusion

The potential IoT applications in Ecuador would be focused on transportation and public safety. These two fields are very important for the country because so many problems are being faced in public transportation and in the security of the citizens. Thus, this kind of applications would be a big interest for investors and government if a deep analysis is done. Moreover, these applications give many opportunities to the governments, businesses, and consumers because it allows to introduce new business models, to improve and to increase many services, and the most important, to improve human lifestyle.

One of the biggest weaknesses in Ecuador is the cost for new devices that have to be used, like sensors and other smart devices. The high taxes that are imposed on electronic devices is very high,

thus it increases the price for potential solutions. For this reason, public policies that support the development of this new technology in the Ecuadorian market have to be proposed and deeply analyzed, so the country can have the highest benefit. Currently, Ecuador does not have an electronic industry that can develop IoT devices, the policies also should be focused on the population incentive to start with this kind of manufactures.

Ecuador has the most important components of the network to deploy this technology, and the business opportunities are big. In Ecuador the existing mobile and broadband network is well-stablished. The three mobile operators are licensed to provide 3G and LTE services, and the coverage of the country is 90%. Referring to broadband, the 40% of the country is covered. The current technology that is used complies with the parameters needed for a future implementation of IoT applications. Thus, the existing infrastructure can support the deployment of IoT technology in the country. However, the big challenge is to start with a shared network, where all the necessary hardware and software are connected in order to develop the applications. A hard work has to be done in Ecuador in order to take advantage of existing technology and start with IoT applications that can have a great impact on the society. Moreover, a structured plan of the building of IoT should be developed, with the integration of public and private enterprises and institutions. The objective of this plan would be, to create a good environment to enable the use of IoT as a new source and opportunity of the economic growth in the country.

Received 04. April. 2018, **Revised** 01. August. 2018, **Accepted** 30. August. 2018

References

Aguero, A. (2015). Retrieved from Banda Ancha en America Latina: Precios y tendencias del Mercado. Instituto de Estudios Peruanos.: http://es.slideshare.net/Mclanfranconi/banda-ancha-en-amrica-latina-precios-y-promedio-2015.

Atzoria, L., Iera, A., & Morabito, G. (2010). The Internet of Things: A survey. *Computer Networks,* 2787–2805.

BBC. (2015, August 9). *Las conexiones de internet más rápidas y más lentas de América Latina.* Retrieved November 2, 2016, from BBC Mundo : http://www.bbc.com/mundo/noticias/2015/08/150819_difusion_internet_america_latina_cepal_ac

Borgia, E. (2014). The Internet of Things vision: Key features, applications and open issues. *Computer Communications,* 1-31.

CISCO. (2016). *Harnessing the Internet of Things for Global Development.* Ginebra: ITU.

Dijkmana, R., Sprenkels, B., Peeters, T., & Janssenb, A. (2015). Business models for the Internet of Things. *International Journal of Information Management,* 672–678.

Evans, D. (2011, April). The Internet of Things: How the Next Evolution of the Internet Is Changing Everything. *Cisco,* 1-11.

EY. (2015, dn dn). *Global telecommunications study: navigating the road to 2020.* Retrieved from EY Building a Better World: http://www.ey.com/Publication/vwLUAssets/ey-global-telecommunications-study-navigating-the-road-to-2020/$FILE/ey-global-telecommunications-study-navigating-the-road-to-2020.pdf

Girardin, G., Bonnabel, A., & Mounier, E. (2014). *Internet of Things Technologies & Sensors for the Internet of Things: Businesses & Market Trends 2014-2024.* Yole Development.

Gomezjurado, J., Nunez, J., Cordero, J., & Uyguari, F. (2014). *Historia de las Telecomunicaciones en Ecuador.* QUITO: PPL Impresores.

Hui, T., Sherratt, S., & Díaz, D. (2016, October). Major requirements for building Smart Homes in Smart Cities based on Internet of Things technologies. *Future Generation Computer Systems,* 1-12.

Instituto Nacional de Estadisticas y Censos. (2013). *Tecnologias de la Informacion y Comunicaciones.* Quito: INEC.

International Telecommunications Unit. (2015). http://www.itu.int/en/ITU-D/Statistics/*Documents/publications/misr2015/MISR2015-w5.pdf.* Geneva: ITU.

Intizar, M., Onoa, N., Kaysar, M., Shamszamana, Z. U., Le Phama, T., Gaoa, F., et al. (2016). Real-time data analytics and event detection for IoT-enabled communication systems. *Web Semantics: Science, Services and Agents on the World Wide Web*.

Linh Do, T. (2012). *Design Research Techniques.* Retrieved from Secondary Research: http://designresearchtechniques.com/casestudies/secondary-research/

Mazhelis, O., Warma, H., & Leminen, S. (2013). *Internet-of-Things Market, Value Networks, and Business Models: State of the Art Report.* University Of Jyväskylä.

McCaston, K. (2005, June). Tips for Collecting, Reviewing, and Analyzing Secondary Data. *HLS Advisor.*

Ministry of Science. (2014, August 08). *Master Plan for Building the Internet of Things (IoT) that leads the hyper-connected, digital revolution.* Retrieved November 24, 2016, from http://www.kiot.or.kr/uploadFiles/board/KOREA-IoT%20Master%20Plan.pdf

Mintel. (2015). *Plan Nacional de Telecomunicaciones y Tecnologías de la Información 2016-2012.* Quito: Mintel.

Miorandi, D., Sicari, S., De Pellegrini, F., & Chlamtac, I. (2012). Internet of things: Vision, applications and research challenges. *Ad Hoc Networks,* 1497–1516.

Mosty. (2015). National Internet of Things (IoT) Strategic Roadmap: A Summary. *Mimos Berhad,* 1-24.

Norhizam, A. (2016, Julio 27). *IoT Now.* Retrieved November 10, 2016, from Building Malaysia's digital future: http://www.iot-now.com/2016/07/27/50355-building-malaysias-digital-future/

Ray, P. (2016, July). A Survey on Internet of Things Architectures. *Journal of King Saud University - Computer and In- formation Sciences.*

Recommendation ITU-T Y.2060. (2012). *Overview of the Internet of things.* ITU.

Stewart, D. W., & Kamins, M. A. (1993). Secondary research: information sources and methods. *Thousand Oaks, CA: Sage Publications, Inc.*

Xinhua. (2015, September 02). *Opera cable submarino de conectividad que une Florida con Ecuador.* Retrieved October 09, 2016, from America Economia: http://www.americaeconomia.com/negocios-industrias/opera-cable-submarino-de-conectividad-que-une-florida-con-ecuador