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College of Natural and Computational Sciences
School of Information Science

Designing Readiness Assessment Guideline towards Adopting IoT: The Case of Ethio telecom

By:

Amanuel Zewdu

A Thesis Submitted to the School of Information Science in partial fulfillment of the requirement for the Degree of Master of Science in Information Systems

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Addis Ababa, Ethiopia

Addis Ababa University

School of Information Science

M.Sc. In Information Systems Programme

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Examiner

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Examiner

Dedication

This thesis work is dedicated to my lovely mom, Serkalem Ejigu. I would like to thank you for all the support and encouragement you gave me through my whole life.

Acknowledgment

First and foremost I would like to thank the almighty GOD and his mother Saint Merry for being with me this whole time and gave me the strength and courage to finish this thesis work.

Next to that, I would like to express my sincere gratitude to my academic advisor ***Dr. Million Meshesha*** for his invaluable encouragement and commitment to provide me with the support and guidance that I need. He showed me the path to conduct good research and write a good research report. It was a great honor to do my thesis under the supervision and follow up of him. I would like to thank him for his kind approach, encouraging words and empathy.

I would also like to pass my appreciation to Ethio telecom employees, for their willingness and collaboration during data collection and evaluation of the guideline. This thesis work would never be possible without your valuable inputs and support. I thank you so much.

I would also like to express my deepest gratefulness to have such a family members, who have been with me in all my darkest and brightest time. My Mom and my Spouse who always support me and gave me fond of love, words cannot express how truly amazing you are. And I would also like to thank my grandma, my sisters and my brothers for their day to day support and encouragement. I would like to thank so much my brother, Frew Zewdu Abyu, for his invaluable support and encouragement.

Last but not least, I would like to thank my work colleagues, my classmates, and best friends who have helped me to finish my thesis work.

Abstract

Internet of Thing (IoT) is a comprehensive and open network of intelligent objects which have the capacity to share information, data and resources, auto-organize, act and react when any situation or change in the environment is faced. Organizations believe that IoT can improve their performance and transform how they made business. However, as with any innovation and adoption and since organizations place a huge amount of investment, readiness of a company to adopt IoT should be strictly assessed before its widespread adoption. This study assesses the challenges involved in IoT adoption and proposes the guideline to be followed for adopting IoT.

A design science research methodology is employed to investigate the readiness of Ethio telecom to adopt IoT, to design the guideline and to conduct evaluation to prove potential applicability of the proposed guideline. The outcome of this study requires a design and design science is suitable for this. A guideline is a model artifact or a statement that shows a course of action to follow in doing something. In our context, it is a statement that shows the procedures to be followed before IoT implementation. Furthermore, a quantitative approach was used to assess the readiness of Ethio telecom as well as to evaluate the applicability of the guideline. The study used the TOE and DOI framework to design the guideline. This research used survey questionnaire to collect data for the assessment. The data was analyzed using quantitative data analysis tool, SPSS.

The main finding of the study identifies a gap that serves as a requirement to the proposed artifact. After the gap was identified the strategic guideline is designed by incorporating components from the above mentioned framework and carefully choosing the components that are inline with the identified artifact requirement. The artifact designed is a strategic guideline that could be used by the company for the successful adoption of IoT. The researcher also gets the artifact evaluated by different experts that works in different position in Ethio telecom. The result of the evaluation indicated that the guideline fulfilled the requirements of goal, environment, structure, activity and evolution. The organization can use the strategic guideline developed in this study to determine the direction, strategy, and resource allocation in their decision to migrate from the traditional to IoT based environment. This study doesn't include assessing the post factum effect of the strategic guideline after it is being applied to the real situation. Therefore, further studies that attempt to expand our understanding of the post factum effect of the proposed strategic guideline in supporting the IoT adoption need to be conducted by extending or refining the proposed strategic guideline.

Keywords: IoT; Ethio telecom; Readiness Assessment Guideline; IoT adoption

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List of Acronyms

3GPP	3rd Generation Partnership Project
6LoWPAN	IPV6 Over Low-Power Wireless Personal Area Network
CAD	Computer Aided Design
CoAP	Constrained Application Protocol
CVOL	Composite Virtual Object Layer
D2D	Device-to-Device
D2S	Device-to-Servers
DMM	Digital Maturity Model
DOI	Diffusion of Innovation
DSR	Design Science Research
DTLS	Datagram Transport Layer Security
ESH	Eclipse Smart Home
EXI	Efficient Xml Interchange
GDPR	General Data Protection Regulation
GMM	Group Mobility Management
HTTP	Hypertext Transfer Protocol
IERC	European Research Cluster of Internet of Thing
IETF	Internet Engineering Task Force
IoT	Internet of Things
IPV4	Internet Protocol Version 4
IPV6	Internet Protocol Version 6
LoRaWAN	Long Range Wide Area Network
LPWAN	Low Power Wide Area Network
LTE	Long Term Evolution
M2M	Machine to Machine
mDNS	Multicast Domain Name System
NFC	Near-Field Communication
QoS	Quality of Service
RFID	Radio Frequency Identification

RPMA	Retail Packaging Manufacturers Association
S2S	Server-to-Server Communications
SL	Service Layer
SOA	Service Oriented Architecture
S-PCE	Service-Oriented Path Computation Element
TCP/IP	Transmission Control Protocol/Internet Protocol
TDWI	Transforming Data With Intelligence
TLS	Transport Layer Security
TOE	Technology, Organization, and Environment
TRI	Technology Readiness Index
UDP	User Datagram Protocol
VOL	Virtual Object Layer
WSNs	Wireless Sensor Network
XML	Extensible Markup Language

CHAPTER ONE
INTRODUCTION

1.1 Background

Imagine a world where almost all objects are connected to each other in order to exchange information. Further, objects are being able to interact with their users using the internet and other communication networks. It is not only people who get connected but products are also exchanging information and things are getting interconnected as a result of the internet. This interconnectedness of things is referred to as Internet of Things (IoT) [1]. IoT sectors growth prospects are largely confirmed. Globally, it is estimated that the number of IoT connections will reach 25 billion by 2025 [1].

According to Vermesan [2], the Internet of Things term was first coined by Kevin Ashton in 1998 at the Massachusetts Institute of Technology (MIT); it is defined as a technology that allows people and things to be interconnected at Anyplace, Anytime, with Anyone and Anything, preferably using Any path or network and Any service [2].

In addition, the IoT systems can be described as the collection of interconnected objects and smart devices that are given unique identifiers and able to transfer data and communicate without any human or computer intervention with the purpose of fulfilling the desired goal. It holds a variety of technologies, services, and standards [3].

As Andersson & Mattsson [4] state, in today's world, we are talking about connected health, smart banking and smart homes as new services that bring changes in consumer behavior. The IoT is considered to impact the way normal activities are performed and also provide variety of benefits for businesses like enabling multiple functions that include security, payment, tracking and tracing [4]. The IoT system is complex, heterogeneous, highly variable, rapidly changing, extremely dynamic and prone to risks and failures.

The Internet of Things has evolved through five phases (see Figure 1.1). It starts with connecting two computers, and then large number of computers gets connected with the creation of World Wide Web (WWW).

Then there comes the mobile-internet connection which is the connection of mobile devices to the internet, after that the people-internet emerges which is the connection of people through social networks. Finally, Internet of Things was born; the interconnected objects world [5].

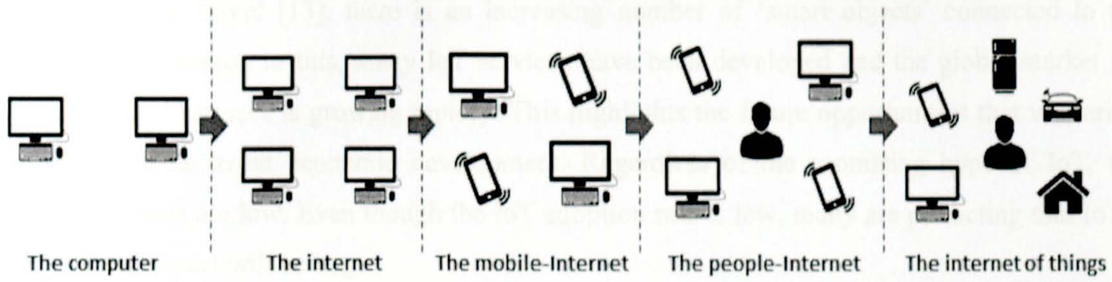

Figure 1.1-The evolution of the Internet of Things [6]

Companies usually look forward to have a cutting-edge and an innovative technology, which give support to enhance business efficiency while also reducing costs so they can survive in the market for an extended period of time. IoT is an innovative technology, which builds a company worthwhile improving operational profitability [7][8]. The determinants affecting IoT are the intention to adopt and ten independent factors: those are technology readiness, complexity, compatibility, effective management support, regulatory support, firm size, security concerns, cost saving, compatibility and relative advantage, These factors are found by combining the diffusion of innovation (DOI) and technology Organization environment frameworks [9][10]. Through the literature audit, elements that influence IoT adoption were discovered.

1.2 Statement of the problem

Consumer's expectation is growing due to the presence of IoT in their everyday lives. And it is stated that the consumers will insist on this technology through their purchases in the future [11], which proves the significance of this research topic. The IoT revolution helps telecommunication network providers in creating value in exceptional new ways. As consumers' behavior and expectations change, service providers need to provide increasingly sophisticated services going forward.

To keep up with the consumer demand for connectivity and data, telecom companies must adopt new strategies that hit the power of next-generation mobile devices. They need to embrace new technologies such as machine learning, for example, to predict failures before they happen [12].

According to David [13], there is an increasing number of 'smart objects' connected to the internet. In relation to this, many IoT services have been developed and the global market for such kind of services is growing rapidly. This highlights the future opportunities that will arise, and contribute to an economic development. Regardless of the promising hype of IoT, the adoption rates are low. Even though the IoT adoption rate is low, many are predicting that IoT's economic impact will be huge.

In order to function successfully IoT relies on data processing and connectivity. Developing countries, including Ethiopia, are still in the near beginning stages of developing an efficient network. For instance, broadband connections of both low and high speed are considerable and most important part of how the developed countries are engaging with IoT.

IoT enables telecom companies to monitor and plan maintenance more effectively, optimize bandwidth and coverage to boost download times, and improve customer service by reducing dropped calls and service wait times. This in turn will minimize revenue lost to service disruption[13]. The presence of IoT will ensure to realize all its benefits. This research was intended to design a readiness assessment guideline to guide a successful implementation of IoT.

Since telecom infrastructure is very expensive and is subjected to the theft of major and core components, an IoT enabled intrusion detection system and access management would provide a lot of value [14]. Many remote sites exist in harsh environments, consequently water, fire and air quality sensors would play a significant role in avoiding long term exposure to elements which might damage core infrastructures irreplaceably and create a network downtime.

In developing countries, investment in technology and software development is still low. IoT can help Telecom companies decrease their operational expenditure and capital on core infrastructure by monitoring their owned assets like base stations and cell towers. IoT must be integrated with telecom in the right way to achieve new opportunities for profit. And when a network infrastructure is being planned, IoT can be introduced to ensure optimization and efficient network design[14].

Currently, Ethio telecom is in the process of building an IoT/Machine to Machine (M2M) ecosystem to deliver end to end solution in partnership with platform and service providers towards a broad range of expertise and solutions. Ethio Telecom was in the process of building an IoT ecosystem and assessing their readiness before the actual implementation saves a lot of resource.

Becoming an IoT connectivity service provider and offering Machine to Machine (M2M) connectivity can open up new streams of revenue for Ethio telecom. In order to achieve this broad objective, Ethio telecom has developed a comprehensive IoT roadmap with incremental implementation approach towards an End to End service delivery [15]. The roadmap helps in defining the time frame in which the initiatives of technological processes will be implemented. Due to this reason, the IoT readiness assessment guideline becomes necessary for the company.

The current literature regarding IoT adoption framework falls short in the following ways: first and foremost, this thesis contributes with further exploration of challenges of IoT adoption. The selection of IoT adoption is based on previous research mainly from IoT and smart device literature. This thesis has an adoption view, where previous research also looks at SMEs readiness on IoT [16], IoT adoption readiness [17], IoT readiness in smart-government and organization [18], adoption of IoT in business [19], Indian readiness for IoT [20], consumer resistance [21], non-adoption resistance [22] and purchase intention [23].

In addition to this, some studies specifically focused on smart objects such as smart watches [21], Smart Cars [24], and Smart Homes [25]. Reports from Acquity Group [11], Accenture [26], Assurant Inc [27], Business Insider [28], Cisco [29], and McKinsey Global Institute [30], which have discussed on IoT and Smart Objects. These reports are not scientific research but they can give a ground or serve as a basis for the literature. There is no such similar study found therefore it is not possible to use any nonexistent result. As part of the research question assessing the challenges in IoT adoption had to be assessed. To the best of our knowledge, there is no previous research that attempts to develop a guideline for telecom industry for the purpose of assessing their readiness to adopt IoT.

This study is focusing on issues on IoT readiness of Ethio telecom. Therefore, the aim of the study is to design a guideline for assessing the readiness of Ethio telecom to adopt IoT.

It is because Ethio telecom is on the verge of building an IoT ecosystem for the first time. And as any technology and specially this one will take up huge investment so the company readiness has to be assessed. Similar study could not be found so there is no way of adopting their guideline but design a new one.

1.2.1 Research questions

This study attempts to investigate and answer the following research questions.

1. What are the potential challenges towards IoT adoption by Ethio telecom?
2. What are the requirements of Ethio telecom for adopting IoT?
3. What suitable guideline can be designed to assess and guide the readiness of Ethio telecom for adopting IoT?

1.3 Objective of the Research

1.3.1 General objective

The main objective of this research is to design a strategic guideline for assessing the readiness of Ethio telecom in support of adopting IoT technology.

1.3.2 Specific objectives

The specific objectives that are accomplished to achieve the general objective of the study are stated as follows.

- To identify the potential use of adopting IoT in telecom industries by reviewing literature.
- To identify the challenges in adopting and using IoT.
- To identify requirements for the design of the strategic guideline
- To evaluate the current readiness of Ethio telecom using different parameters.
- To present the report finding for future research

1.4 Significance of the study

These are significances which will be achieved after using the guideline for assessing their readiness. Organizations that take time to plan and insure they are ready for implementing IoT are much better positioned for success. Therefore, after the guideline is developed it will be significant to transform organizations into IoT ready companies before the real implementation begins. Because the guideline could help Ethio telecom to be aware of the prerequisites, requirements and will help to assess the preparedness of the company before the actual adoption. This in turn will help in successful adoption of IoT.

This study will help the service provider, Ethio telecom, to offer personalized services to its customers, and to implement IoT successfully so as to achieve company's goal in increasing revenue, gaining competitive advantage and improving quality of services. The guideline is for assessing the readiness of Ethio telecom. At the later stage, successful adoption, Ethio telecom could deliver better service and personalized service to its customers. It is indirect significance, which can be achieved after assessing their readiness, get prepared for, and adopting IoT. In addition to this, with the help of data analytics, Ethio telecom can analyze the huge amount of data and can draw interfaces and better understand its customers, doing this will increase the customer experience to a new level.

The customer will get customized and personalized services, since the connectivity demand will be fulfilled. Customers will get enhanced data communication with low latency, better speed, and low error rate. It is indirect significance, which can be achieved after assessing their readiness, get prepared for, and adopting IoT.

Therefore, this thesis contributes to the literature in designing a strategic guideline to guide in measuring the preparedness of the company to undergo a major change or take on a significant new project.

It is difficult to jump into a big change without knowing if the company has the resources to accomplish it effectively. Since this area is relatively new in our country, other researchers can extend this research by testing the strategic guideline develop in real world setting. The outcome of this research is a readiness assessment guideline. Putting this guideline in place and testing it in IoT readiness and seeing the workability of it could be another research.

1.5 Scope and limitation of the study

The scope of this research is limited to the organization, Ethio telecom; this means that other business types are excluded. Primary and quantitative data was collected. This data collection was conducted from Ethio telecom headquarter and particularly from information system division only. For the design of the strategic guideline, quantitative data was collected. This division, *information system division*, is selected because this is the division concerned with the implementation of IoT. Managers and executives were also part of the respondents, as can be seen on the data collection result. The main focus and communication was with information system division.

The research focused on designing a strategic guideline for assessing the readiness of Ethio telecom to adopt IoT. It is out of the scope of this study to design a framework and implement as per the strategic guideline proposed in the current study. The study planned to measure post factum effect of the strategic guideline after it is being applied to the real situation. But due to time constraint this couldn't be done in this study. The research focused on designing a strategic guideline for assessing the readiness of Ethio telecom to adopt IoT

This study is limited to accessible materials in the literature review and data collection in the assessment and guideline evaluation. During the data collection, it was very difficult to get the consent of the respondents since they enquire approval letter from Ethio telecom higher officials to collect the data. After reviewing the data collection instrument, it takes them a lot of time to give grant for collecting the data. Even after that in fear of the Covid-19 pandemic the respondents were not available all the time and this takes longer time to finalize the data collection.

The findings of this study may not be generalized to other organizations since its context is different-telecom sectors. The survey from 6 Directors, 19 Executives, 19 Engineers, and 21 Consultant in the company provide us the opportunity to gain understanding of their readiness to adopt IoT. Every organization has unique context even they are operating in the same industry. The findings of this study could be applied in similar companies in the telecom industry however, some assessment has to be conducted to align the context. Therefore, more case studies need to be conducted in other organizations in order to determine whether the experiences of this organization can be replicated in.

1.6 Ethical Considerations

The data we collected from Ethio telecom employees was only to be used for academic purposes and maintain confidentiality and anonymity of the respondents. No identifying information was requested from the respondents. Legal matters and privacy was valued and respected by the researcher. All works of other academicians and scholars used for the purposes of this study will be properly cited and referenced.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

The purpose of this literature review is to present the review of relevant literatures on the theoretical definition of IoT related concepts, the technologies used for IoT, the potential use of IoT in the telecom industry, the challenges of using IoT in the telecom industry, IoT adoption, previous works on IoT adoption, and previous works on IoT framework. This review defined key terms, definitions and terminologies related to the Internet of Things (IoT) in the Ethiopian telecom industry to answer the main research questions.

2.2 Overview of IoT

In the concept of IoT, things could refer to several devices such as people, computers, sensors, actuators, refrigerators, TVs, vehicles, mobile phones, food, books, medicines, etc. These 'things', in order to have the capability of addressing and communicating with other things and verify their identities, should be identified using some kind of unique way of identification. And after having the unique identifier the 'thing' will be referred to as 'object' [31].

The term Internet of Things is continuously evolving due to the change in the technologies and ideas that drives IoT. Due to the change in IoT drivers a clear definition of Internet of Things doesn't seem to exist yet [32][33]. Different scholars attempt to provide definition to Internet of Things.

The European Research Cluster of Internet of Thing (IERC) [34], defined IoT as a "dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual "things" have identities, physical attributes, and virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network" [34].

Besides, Ramaswamy & Tripathi [35] defined IoT as, a comprehensive and open network of intelligent objects which have the capacity to share information, data and resources, auto-organize, act and react when any situation or change in the environment is faced.

Ramaswamy & Tripathi [35] mentioned that, IoT allows to have a communication between human-to-human, human-to-things, and things-to-things.

Similarly, Whitmore et al., [33] state that, the core concept behind IoT is the communication, objects will be able to communicate with each other and other devices and services with the purpose of achieving useful objectives in which they are intended to achieve.

IoT is also defined as the interconnection of sensors and actuators providing the ability to share information and resources across various platforms through an integrated framework, developing a unified operating picture for enabling innovative applications. And this is achieved through seamless ubiquitous sensing, data analytics and information representation with cloud computing as the unifying framework[36].

Moreover, Zancul et al.,[37] explain IoT as an emerging paradigm in which objects are provided with radio frequency identification (RFID), sensors, actuators, tags, etc through the use of unique addressing schemes to allow the devices interact with each other and cooperate with other devices to attain a common goal.

Also IoT represents the future communication and computing. Further development of this technology depends on technology innovation in radio frequency identification (RFID), sensor technologies, nanotechnology, smart things/objects, and miniaturization[38]. According to the cluster of European projects on the Internet of Things [2], IoT is expected to change business, social processes, information and provided many unanticipated possibilities.

In the next 5-10 years it is expected that there will be growth in the use of connected devices and in addition IoT is anticipated to quickly disrupt lots of business sectors [39].

IoT is also referred to as internet's next generation, holds the potential to change people lives using the global system of interconnected computer networks, sensors, actuators, and other devices through the use of the internet protocol [37].

Business sectors need to foresee the potential opportunities that become possible when the physical world is merged with the virtual world, where potentially every physical object can possibly be both intelligent and networked. And when objects become networked, it has a significant impact on how actual value is produced.

These days the focus has been shifted from industrially manufactured goods to the web-based service in which user's access through those devices. Also IoT is considered to have a huge potential for developing new intelligent programs or applications in different fields. This is primarily due to its ability to gather information about natural phenomena, user habits, medical parameters and to offer consumers tailored and targeted services [32].

Various names have been given to Internet of Things (IoT), such as Internet of Objects, Machine-to-Machine interaction, embedded intelligence, and Human-computer interaction [35]. Despite the fact that Internet of Things has been referred by using several names such as the above mentioned, the objective is still the same.

2.2.1 Smart objects

Smart objects can be seen as the building blocks of Internet of Things. These objects can collect information from their environment and interact with the physical world through their actuators in order to exchange data and information. Smart objects link people, machines, houses, enterprises, transportation, production lines, natural resource, and logistic networks in the interconnected network[40]. In addition to this, Rifkin[41] found out that every things or object can be turned into a smart object by putting intelligence into them. IoT is a paradigm which links everyone with everything within an integrated network environment. IoT uses the internet platform to form a large network of connected smart objects.

It integrates devices and objects with embedded sensors and actuators to allow them to communicate autonomously over the internet, while the conventional communication over the internet allows people in the exchange of information[42].

2.3 IoT Technologies

Several studies were conducted on the topic of IoT that primarily focused on the disruptive technological aspects of IoT. However, for the traditional business and industries it is most important to look away from this disruptive technology hype and make an attempt to realize that sensors, machine-to-machine (M2M), telematics and other IoT devices and technologies are the fundamentals in order to move towards an IoT-based business model.

What counts most is the infrastructure which holds the important and required technologies like the services, applications, and APIs all together. Using this, business model disruption comes as well as a new way of creating values[41][42].

According to Mohapatra et al.,[43], constrained IoT devices in M2M area networks includes personal area network technologies like Bluetooth, ZigBee Pro, ZigBee SE, Thread, and NFC. Constrained devices are devices which uses low power platform and wireless, low bandwidth, limited computation and memory. These devices are expected to use UDP, 6LowPAN, CoAP protocols, and DTLS in higher layer. High performance IoT devices are expected to support cellular (2.5G/3G/4G (LTE)), Wi-Fi, and Ethernet Technologies. And at higher layer, high performance IoT devices are expected to use IPV4/IPV6, TLS, TCP/UDP, and HTTP.

RFID systems are considered as the key components that make up the IoT. These systems are made up of readers that trigger the transmission of tags and signals better equipped with unique identifiers in the objects, sensors, tags, and actuators[7][44] Similarly, Wang et al.,[43] discussed that, the key technologies in IoT includes RFIDs and WSNs and next to these technologies are ubiquitous computing and cloud computing.

IoT paradigm exists because of the conversion of different visions. Figure 2.1 below depicts the classification of technologies that make up the IoT; which includes things oriented visions, internet oriented visions and semantic oriented visions.

The first one is things oriented vision, which concentrates on sensors, actuators, and wireless sensor networks. The definition of IoT drives from a **things oriented perspective**. The first vision is things oriented vision, the idea behind this is smart objects take center stage where each object is given a unique identifier to make objects distinguishable from each other[36]. An industry driven global standard is mainly used to improve objects visibility that is the traceability of an object and awareness of its current location and status. This is a key component of the path to the full deployment of the IoT vision but it is not the only one.

The second vision is **internet-oriented vision**, which involves internet services as the main focus while the data are contributed by objects[33]. It mainly concentrated on Internet protocols and other related technologies of internet. This vision first focuses on the networking aspect of IoT that enable huge number of heterogeneous and constrained objects to be connected together.

Also enable them to communicate with other systems and with each other and to function in low bandwidth and low-power environments[45] .

The third vision is **semantic oriented vision**; the idea behind this vision is that, the number of items involved in the future internet is intended to become extremely high. Thus, issues related to how to represent, interconnect, store, search and organize information generated by IoT will become very challenging. In this regard, semantic technologies could play an important role. Indeed these can exploit appropriate modeling solution for things description, semantic execution environments, reasoning over data generated by IoT, and architectures that accommodate IoT requirements and scalable communication and storing infrastructure[39].

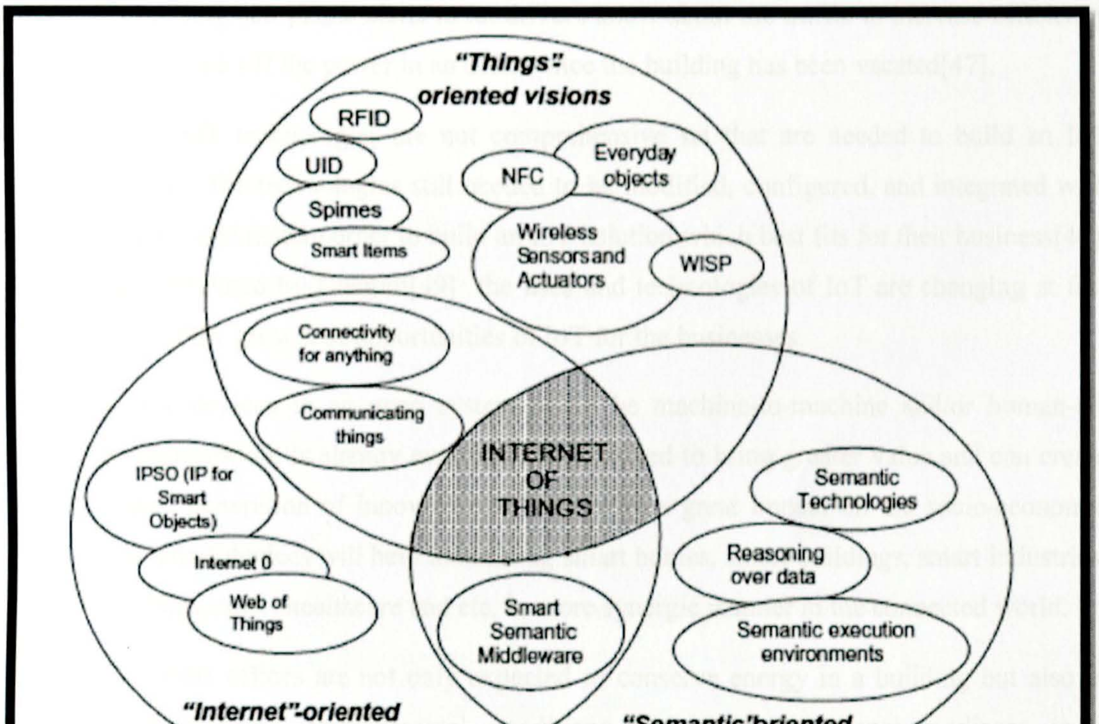

Figure 2 1-Technologies that make up the IoT [39]

2.4. Benefits of IoT

Internet of Things (IoT) represents the future of communication and computing. IoT technologies provides a number of benefits to different business sectors because they cover many areas by enabling functions such as security, payment, tracking and tracing, etc.

Therefore, it is vital for businesses to identify and know which technology or a combination of technologies are best suited for their business to harvest the potential opportunities that IoT provides [4][46]. Common examples of IoT includes devices like wearable's that monitor personal health, tracking devices for stolen cars, security access cards, identity identifier tags for retail goods. Real examples in businesses includes tracking systems for solving or preventing problems by sending cell phone alerts to let drivers know about the traffic to increase efficiency or to remotely switch off the power in an office once the building has been vacated[47].

However, most IoT technologies are not comprehensive set that are needed to build an IoT business solution. The technologies still needed to be modified, configured, and integrated with back end systems and data in order to build an IoT solution which best fits for their business[48]. Likewise, as articulated by Dlamini[49] the uses and technologies of IoT are changing at fast rate as a result of the growth of opportunities of IoT for the businesses.

Connecting IoT devices in an open system could be machine-to-machine and/or human-to-machine communication, is already evolving and expected to bring greater value and can create completely new generation of innovative services with a great impact on the socio-economic aspect. These smart devices will help in building smart homes, smart buildings, smart industries, smart automobiles, smart healthcare and etc. in more synergic manner in the connected world.

For instance, smart offices are not only expected to conserve energy in a building but also to integrate with security, environmental conditions and their operational readiness in a comprehensive way [43].

In the past, telecommunication technology has been focused on enabling human-to-human communication, but these days with the advancements and emergence of new technologies, machine-to-machine communication shall use same communication infrastructure and facilities as the earlier communication does, in a much greater scale. Billions of smart devices or machines shall connect to the network and considerably impacts the way people live and conduct businesses. As the market survey by Cisco predicted, about 50 billion smart devices, which exceeds the world population, will be expected to be connected to the internet, by 2020 [50].

The introduction of IoT technologies in the telecom companies is intended to transform the role of the service providers in enabling better communication between people and devices. So business leaders are required to renovate new IoT enabled services for their customers and applications with the purpose of improving their business processes. Similarly, the advent of IoT in the telecom industries will exhibit its potential to improve business process, procedures and generate more revenue. In order to benefit from the increased revenue opportunity, telecom industries must develop innovative approaches and applications to monetize IoT solutions.

2.5 Challenges of IoT

The emergence of the IoT technology has brought various challenges. Different scholars discussed the potential challenges of IoT. The summary of the challenges is presented in the next section. The security challenges posed by the use of IoT become one major challenge to businesses. The increased use of IoT without doubt increases data attacks on the new IoT devices [51][52]. One example could be businesses which have had compromised security and had customer information conceded includes: Apple, Anthem, Home Depot, Sony, JP Morgan Chase, and Target [52].

In this regard, security is considered as a major challenge which obligates business to overcome the challenge in order to fully utilize the potential uses of the IoT technology. Maintaining the security of IoT technologies is seen as a complex task since there are billions of devices connected to one another and as more devices are getting connected to the internet there will be an increase in the potential attacks of IoT technologies. The attacks primarily affect the communication channels of the communicating devices or objects through physical threats, Denial of Service, identity fabrication and other types of attacks [53].

Weber [54] discussed that businesses feel that for securing the IoT devices from an attack a protection framework is adequate in order to ensure the security of IoT, in contrast individual users feel that more need to done in order to inform privacy and security of IoT, like data confidentiality, availability, and integrity.

If IoT devices security is compromised, the company will be at a high risk of facing different cost implications, since the IoT devices are connected with other devices through the internet. And if the security of one IoT device is breached at a specific point, lots of devices are at risk, they are highly likely to be attacked[52].

Regarding security, Roman et al., [53] discussed that there needs to be ways of achieving universal authentication of IoT technologies. El-Hajj et al., [55] also agreed to this idea in that effective authentication mechanisms will facilitate to have secure links between devices, applications and people. In addition to this, effective authentication mechanism is also considered to guarantee the secure flow of data between IoT devices while also ensuring the integrity of the device.

Furthermore, Jones [56] argues that there is a need for implementing security technologies for the protection of IoT devices and platforms from security threats such as physical tampering and information attacks. The security devices that will be put in place can help in encrypting the communication of IoT devices and address potential security challenges such as mimicking "things" or denial of sleep attacks that will drain batteries.

2.5.1 Challenges of IoT in telecom industry

There are various open challenges that have been found by different researchers including those challenges related to power supply, evolving architecture, enabling a complex sensing environment, complexity of IoT, multiple connectivity options, privacy, security of information exchange between IoT devices [45][57].

Due to the lack of a clear and widely accepted business model, which encourages businesses or investments to deploy of IoT technologies, there is a difficulty in the adoption of IoT paradigm[44].

To some extent, the above mentioned challenges can be met with the help of various wireless and wired connectivity options, such as radio frequency identification, Bluetooth, near-field communication (NFC), and Wi-Fi. These connectivity options are categorized under the three broad types by taking into consideration their geographical area coverage. Such as personal area network (PAN), local area network (LAN), and wide area network (WAN).

The figure 2.2 below shows the categorization of IoT communication technologies. The existing Wi-Fi networks have to be expanded in order to attain wider area coverage and to support mesh networks[58][59]What is more, to understand the information exchange within IoT devices, the confirmation on communication pathway of IoT is very significant.

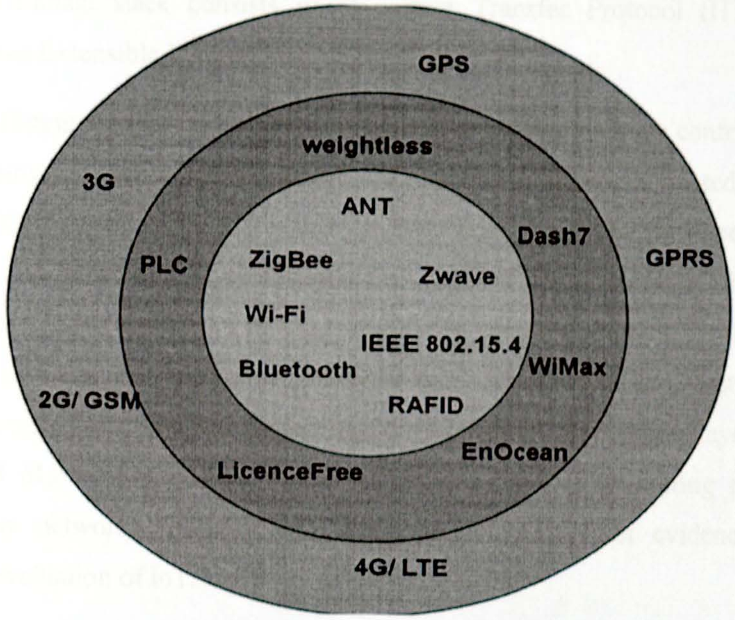

Figure 2 2-IoT communication technologies [60]

It is important to support device-to-device (D2D), device-to-servers(D2S), and server-to-server communications(S2S) in order to enable information sharing between IoT devices[58][60] Various standards (such as 3GPP Standards (LPWAN), LoRaWAN, Sigfox, Weightless, RPMA…) and protocols (such as 6LowPAN, IPV4/IPV6, Wifi, Bluetooth, mDNS…) are involved with IoT communication.

However, some of the protocols and standards take the highest priority, like Internet Protocol Version 4 (IPV4), Internet Protocol Version 6 (IPV6), IPV6 over Low-Power Wireless Personal Area Network (6LoWPAN), User Datagram Protocol (UDP), Transmission Control Protocol (TCP), and Constrained Application Protocol (CoAP).

On the other hand, as per the evaluation of constrained device developers, UDP is considered as cost-effective and advantageous due to its smaller size and performance[61].

Some efforts were made to find a model which will aid in arranging the above mentioned protocols into constrained and unconstrained stacks as per the TCP/IP network layer architecture.

The constrained stack consists of Efficient XML Interchange (EXI), CoAP, and 6LoWPAN which are protocols with similar functionality however their complexity reduced considerably whereas, unconstrained stack consists of Hypertext Transfer Protocol (HTTP), IPv4, and common standards Extensible Markup Language (XML)[44].

In real world, different companies and research centers are making a huge contribution to rapidly develop and deploy IoT technologies. Though, most common standards related to IoT are IEEE 802.11, IEEE 802.15.4, and IEEE 802.3, and the internet engineering task force (IETF)[61][62]. The IETF protocol suite greatly contributes towards IoT in determining the challenges of IoT[63]. Therefore, IoT is getting wider acceptance to be used for practical application scenarios. Different matrices are made available to measure communication speed, cost, and processing speed. Even though, there are few researches conducted on application layer protocols and performances of 6LoWPAN[64][65], IEEE 802.15.4[66] and IPv6 routing protocol for low power and lossy networks (RPL)[66][67] there still doesn't exist evidence which shows comprehensive evaluation of IoT.

The most common major challenges of IoT and its future includes performance, reliability, availability, security and privacy, precision, scalability, interoperability, Big IoT data, compatibility, mobility and investment.

IoT highly depends on the components and performance of evolving technologies. Its performance cannot be weighed up using simple mechanism. In addition, other factors that have an effect on the performance of IoT include network traffic, heavy reliance on the cloud, and huge amounts of data[68]. One of the vital requirements for an IoT environment is the cloud, which facilitates resource sharing.

Users, regardless of their location, are enabled access to IoT services by means of an internet connection with the convergence of cloud and IoT. The convergence follows a cloud-based IoT approach or IoT-centric cloud approach.

While, existing individual challenges of IoT and cloud are being overcome, in both approaches dynamic resource management, orchestration techniques, dynamically offloading from clients or hosts to the cloud are new challenges of cloud and IoT convergence [69].

In some critical applications, reliability is an important feature. Reliability is not just sending reliable information to the receiver, but also being able to adapt to the changing environmental conditions and being resistant to long-term security and usability problems [12][70].

In all aspects of IoT software and hardware components, reliability needs to be guaranteed. An attempt was done to clearly explain with architectural consideration, reliability consideration for link, transport, and application layers together [70]. Furthermore, a probabilistic approach was proposed in order to describe and analyze cost and reliability related properties of the service compositions in IoT [70][71].

IoT is primarily used to facilitate the exchange of data and information at anytime, anywhere for any person based on the requests made[72]. So in order to realize IoT, availability of physical devices and applications is significantly a critical issue. The IoT network requires high availability which guarantees the presence physical devices as well as IoT application in order to achieve high availability. The most feasible solution for this issue is using redundant maintenance of hardware devices and programs, with the intention that the redundant devices or the program can be used to carry out load balancing when the actual failure exists[73].

There are some situations where simplicity of the infrastructure is disclosed to achieve high availability, despite the fact redundancy increases complexity.

Therefore, to ensure availability the feasible solution is using redundant hardware components. In [73] two redundancy models were proposed: active and passive redundancy models. The passive redundancy model performed better as compared to the active redundancy model. In the passive model spare hardware components will be activated only when the primary hardware component fails and these spare components will be partially loaded or at sleep mode during other times.

Another essential requirement of an IoT application are privacy and security [74]. In IoT, memory cards of a device have limited capacity as a result only small amount of data can be stored on the device memory and the rest of the data will be stored remotely on other sites. The data on the remote storage device are disclosed to other peoples.

Most of the time users do not want to make known their information to others, so these kinds of data need high privacy and security. In the case of privacy, security, governance rules, a new technology is needed to provide users the ability to verify whether the company is satisfying their service level agreement or not, dynamically.

So companies must adapt appropriate mechanism for IoT, in order to meet the desired security level of a user. Privacy, computation, trusted sensing, communication, and digital forging are rarely addressed tasks in terms of security scope. IoT does not conform to common security standards and architecture; though, security has become a very significant issue[72][73]. And the traditional security standards and architectures can't fully satisfy the security requirements of IoT, due to the reason that there are a huge amount of heterogeneous devices which are connected together. As a result of this, there exists a large number of malware entry points which increases the vulnerability of the devices. A scheme had been proposed, by applying a biological immunology approach, based on dynamic defense security mechanisms to improve these security issues in the IoT architecture[75]. As reported by Xu et al., [73], some attempts were done to secure IoT communication by making sure the security of IoT devices is maintained. In the first phase, Computer Aided Design (CAD) techniques were proposed in order to design IoT devices, which are highly optimized in terms of both security and energy. Most importantly, as compared to the proposed costly hardware-securing concepts, CAD techniques can be utilized towards implementing a strong and plenty security with low cost. But it has never been practically used until date.

Literatures presented various approaches for tackling the security issues in the exising IoT paradigm. But, in a dynamic mobility environment the authentication of devices and securing links are still unresolved issues. Accordingly, the authentication of IoT devices in the real world situation still has unresolved issues. And researchers have warned that there is a potential realistic threat to the IoT environment in future industries, which is called "smart home hacking"[76].

Precision is the other important challenge which needs to be addressed in many smart IoT environments such as healthcare, transportation, unmanned aerial vehicular networks, and where devices and systems globally get connected[76].

As reported by Ahmed [76], when dealing with precision, machines could fail if the timing is 1 ms. Also, compliance with rigorous requirements becomes central to the health and safety of the machines, machine operators, and related businesses.

In addition to this, the available bandwidth and network latency are considered as key factors that have an impact on the precision of a distributed IoT mission-critical & delay-sensitive environment. Thus, when deploying IoT in a smart environment, these parameters should be taken into consideration.

For example, in smart transportation environment longer network latencies, potentially, could cause delays in applying car brakes and be dangerous in case of vehicle-to-vehicle communication. So by designing and developing high-precision systems, one can achieve successful IoT deployment in smart environments.

The increasing rate in the number of smart devices and the advancement of embedded technologies have increased the device to person ratio up to 1.84 in 2010[77]. Moreover, the application requirements by a client have been increasing eventually. So the scalability of IoT, which is the ability to add extra devices and services to IoT without affecting the quality of service (QoS), must be taken into consideration. Due to the heterogeneous characteristics of the devices and underlying technologies, scalability becomes an important issue in IoT. For the realization of IoT notion, a distributed and interoperable architecture was proposed for IoT, in order to enable unified addition of new devices to the existing platform via a layered architecture and to address the scalability issue without affecting the quality of service[78].

In addition, the study by Sarkar[78] proposed three layers of IoT infrastructure: Virtual object layer (VOL), composite virtual object layer (CVOL), and service layer (SL). The base structure of the distributed architecture consisted of the basic functionalities of the three layers which are referred to as object virtualization, service creation and management, and service composition and execution. Based on the capability of the processing power and memory, every object hosts its own daemon. Various applications are unified using the three layers of the IoT daemon.

Virtual object layer (VOL) digitally represents the functionalities and properties of each object. On the other hand, multiple objects work in collaboration to perform a certain task. So, at runtime, the composite virtual object will be created as a mash-up of virtual objects corresponding to the task.

So as to create a mash-up potential, virtual objects need be identified. This is done at the composite virtual object layer. With the help of consistent representation of objects or virtual objects, adding new objects to the existing IoT network will not degrade the quality of service (QoS). This is because all the devices are connected in a distributed architecture.

In addition to this, there is also a scalability issue due to the increase of network elements in the internet. The authors Souza et al.,[79], proposed a service-oriented path computation element (S-PCE) to compensate the scalability issue, instead of conventional host-oriented PCE. The performance evaluation result of the proposed model confirmed that, the model do support more network elements than host-oriented PCE by comparing the results obtained and the logs of the DNS servers[80].

Another major concern regarding to IoT is interoperability[81]. In the IoT environment, various types of devices get connected to each other. Therefore, regardless of their type IoT should facilitate services to all these devices, since interoperability is a necessity. By conforming to the standardized protocols, interoperability can be achieved at application and network levels. Achieving interoperability becomes a challenge, as a result of an ambiguous interpretation of the same protocol. Thus, interoperability of IoT would be realized by avoiding such ambiguities. The authors in Ishaq et al.,[82], proposed a solution to address IoT resources using a web protocol through the use of IoT hubs. Due to this the interoperability challenges are reduced to data formats and presenting hub catalogues.

Since most of the devices in IoT environment are mobile devices, this makes the IoT scenario more complex. This necessitates the IoT applications to render services by taking into consideration of the mobility factor as well. There are already available standard management protocols to facilitate mobile issues in IoT. Those are mobile IPV6, at the network layer and TCP migrate, at the transport layer. However, the above mentioned standard management protocols are complex enough to be used in IoT nodes. For constrained devices in IoT environment a CoAP-based mobility protocol was proposed[83]. Likewise, as discussed by Fu et al.,[84] in order to ensure the mobility, a group mobility management (GMM) mechanism shows potential and is shown to be promising.

Kranenburg & Bassi [85] mentioned that another challenge in IoT environment is big data. IoT is one source for generating large amounts of data. As mentioned above, 50 billion devices are expected to be connected with each other in 2020, which can lead to large amount of data production. Most IoT applications performance is determined based on the data management services.

Thus, due to the big data generated by various IoT devices forming a smart IoT environment, managing big data in terms of storage and processing capacity requires highly scalable computing infrastructure that don't affect and compromise the performance of the IoT applications.

The other challenge of IoT based smart environment, where various devices are connected to each other, is compatibility[76]. Due to the unavailability of universal programming language, most devices are unable to connect with each other and creates an incompatibility problem. In order to create compatibility between IoT devices, collaboration among product manufacturers like LG, Philips, Samsung is a must.

If people will not get frustrated if the production companies do not collaborate and they can only use one brand. Therefore, collaboration among these companies is required in order to get hold of infrastructure information of each design and product a universal programming language to be used by developers. To guarantee the success of IoT, compatibility issues must be addressed.

Huge investment in IoT scenario is demanded for the investment decision to deploy an IoT environment. In an IoT environment, there is difficulty for businesses to adopt this technology since things are not interoperable and open in terms of software and hardware. So, open and integrated software and hardware-based IoT solutions are required to be built for the deployment in industries. What is more, the solutions should also be flexible enough to enable industries in evolving and adapting to their change, instead of replacing these deployments with a new system. Investment and expertise are required to generate innovation within the existing software and hardware architectures.

2.6 IoT adoption

Adoption is defined by Milind[86] as "the acceptance and continued use of a product, service or idea". In relation to this, new product adoption behavior is stated as the degree to which consumers adopt a new product earlier than other consumers in their social system[79]. Consumer's passes through the process of getting awareness, show interest, evaluate the product, make trial and then making the decision to adopt or reject the product [82][87]. Conversely, Hall & Khan [88] claim that, consumers do not have a choice for adoption or no adoption, because sooner or later the consumers will adopt it. Their decision will be adopting now or adopting later.

In addition to the evaluation of the consequences, the consumer's primary belief of the consequences of adopting the technology is the driving force for the consumer's attitude towards adopting the technology. So attitude will be made by the strength of the consumer's belief that adopting the technology will lead to a certain consequence [84].

The IoT system is found to be complex, highly variable, rapidly changing, heterogeneous, extremely dynamic, and prone to risks and failure[89]. This indicates that in the mirror of change, the system should have the capability to adapt to the environment in order to carry on offering the desired performance. Particularly, dynamic proactive adaptation is required in order to provide adjustments at runtime[86].

Regardless of the many predictions of the growth in the IoT industry, consumers do not adopt this technology and devices to the extent expected. It is predicted that consumers will lag behind government and businesses in terms of adopting IoT. In contrary to this, the slow pace of consumer adoption of the new technology creates disappointment to the IoT industry.

However, regardless of their slow pace in the adoption, it is estimated that consumers will purchase a huge number of devices and will invest significant amount of money on the IoT ecosystem[90][91].

2.7 Factors affecting the adoption of IoT

There are different factors affecting the adoption of IoT, including organizational, environmental, technology contexts and others.

2.7.1 Organizational context

The organizational context is explained by the executive management support and firm size constructs which are discussed as follows:

2.7.1.1 Executive management support:

The executive management support holds a critical function in IoT adoption since it leads the unification of services, sharing of resources and the processes re-engineering[42] [92]. Without the influence and help of executive management, the company is likely to resist IoT adoption[92]. Executive management support will positively affect IoT adoption.

2.7.1.2 Firm size:

Big companies have more merits than small ones since they have more resources and can take more significant threats linked with innovation adoption[93]. Small firms, although more adaptable, does not have the resources or knowledge to readily adopt newer technologies [93]. The size of a firm is a determinant of IoT adoption. The firm size will positively influence IoT adoption.

2.7.2 Environmental context

The environmental context is explained by the regulatory support factor which is environmental in nature as it is industry and government based.

2.7.2.1 Regulatory support:

The regulations of the government of nations can affect the adoption of IoT by firms. But IoT regulation is still evolving[94]. If and whenever a government enforces IoT policy compliance with a huge amount of money to be paid by firms who do not comply, several companies would want to adopt IoT[95]. This Regulatory support will significantly affect IoT adoption.

2.7.3. Technology context

The technology context explains the technology readiness factor as it is a technology-related determinant.

2.7.3.1 Technology readiness:

The technology context has to do with the organization, knowledge, and skills of the employees. The ability of technological infrastructures to easily integrate with IoT is a part of the organization structure [96]. A firm whose company with technological infrastructure and employees with updated IT knowledge and skills has a higher degree of technological readiness and thus is more likely to adopt IoT. These kinds of firms are in a good position to adopt IoT [97]. Technology readiness positively impacts IoT adoption.

2.7.4. Innovation characteristics

The innovation characteristics are explained by complexity, compatibility and security concerns which are innovation and design related.

2.7.4.1. Complexity:

Complexity explains the level of difficulty in understanding and utilizing innovation [91]. Complexity in IoT adoption is the difficulty level of the perception of IoT adoption and integration. Planning on and Selection from a wide range of IoT gadgets adds a level of complexity [67]. Complexities are not suitable for IoT adoption, especially when there is no skilled employee in many the complex environment [98]. Complexity will affect IoT adoption negatively.

2.7.4.2. Compatibility:

Compatibility explains the level that innovation unifies with present practices or value systems. The rate of adopting a change is proportional to the compatibility level; therefore, the higher the compatibility, the quicker the adoption. Compatibility among technology systems is an important determinant that affects IoT adoption[99]. The compatibility will affect IoT adoption positively.

2.7.4.3. Security concerns:

There are security risks and matters affecting IoT adoption. There are issues like security gaps, privacy and security concerns that affects the adoption of IoT [52] [94] [100].

2.7.5. The Intention for IoT adoption

The intent for IoT adoption is a primary factor in the study of IoT. The IoT has been evolving to grow. There are a lot of benefits to be gained from the evolution of IoT devices by making good use of the data from these devices[101][102] [103];

But the influence on the organizational business strategy, infrastructure, and security architecture must first be taken into consideration by organizations[94] [100]. The intention to adopt IoT has not been fast even though most of the independent constructs has positive impact on IoT [104]. There is a need to address and consider factors such as cost and security concerns to enhance IoT adoption.

2.8. Constructing a guideline for technology adoption

A guideline is a non specific principle or rule that gives direction to some sort of action or behavior. It gives additional support and advice for developing different policies, procedures, or standards. It assist policy makers in explaining the policy to the policy audience in more simpler terms since it is more detailed and specific when compared with framework. On the other hand, **a framework** is general as compared to guideline. It is a general guideline that a certain organization can adopt. It intend to connect inter related core concepts that are appropriate to a variety of contexts [105].

2.8 Strategies for IoT adoption

IoT helps telecom operators to deliver innovative and value-added products and services if it is properly designed and executed in the right way. The consumer need is also different. For instance, some consumers may need connectivity and some others may need complete solutions. Choosing the right strategies depends on several factors[106]. The first factor is the telecom operator's abilities such as available resources and infrastructure. The second is the digital evolution of the country or the region such as a platform strategy. It is unfitting for countries that do not have software evolution[88]. Finally, the existence of digital maturity model (DMM)[107].

There are five telecom strategies for IoT [108]. The figure 2.3 below shows these telecom strategies.

Sensing

For operators buying and selling IoT data becomes a new source of revenue. Operators offer data to their customer in enterprises as an option to enable IoT solutions by using the existing infrastructure to deliver environmental data.

This strategy is useful for more efficient asset management of operator networks similarly brings new and reliable opportunities, and it also improves operational expenditure through the exploitation of resources such as environmental analysis data which updated continuously by operators[109].

Connectivity

Connectivity plays an important role in the complete IoT and there are extra business opportunities in connectivity. It serves as the basis of all telecom IoT solutions. In this strategy, telecom strategy provide an economical cellular connectivity package of services and pricing and also provides high-quality & reliable communication by leveraging the potential in the existing customer base, space, and use mechanisms for billing[110].

Generic Platforms

This strategy is a broader solution in which an operator can offer a hosting environment for applications to multiple industrial sectors by providing the necessary capabilities to help developers meet IoT requirements of processing, storage, management, and sharing of data across advanced capabilities in software development with in-depth knowledge of other fields[111].

Vertical-Specific platforms

In this strategy an operator can offer capabilities and building solutions to solve small use cases that are tailored to a specific vertical market, without providing all components of these solutions. An operator should have industry knowledge and experience domain to select the vertical markets that intend to address carefully[112].

End-to-End solutions

An operator can offer all components of a solution including sensors, devices, actuators, middleware, analytics, gateways, user applications and other benefits (e.g. support, connectivity, and billing.

This strategy brings more revenues and gives more control, but it needs careful planning, business partnerships with players, and technology in the industry such as device manufacturers and chip[110].

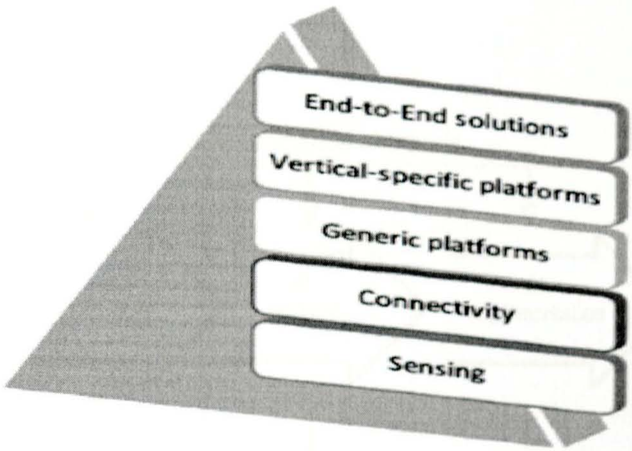

Figure 2 3- IoT strategies for Telecom[10]

2.9 Conceptual model

There are different conceptual models in the literature. Some of the models suitable for the current study are discussed briefly below.

2.9.1 Diffusion of Innovation (DOI)

The diffusion of Innovation theory was developed by Rogers [91], in his book he defined as the process in which an innovation is communicated via certain channels overtime among the members of a social system.

According to Rogers[91], in a social system these individuals do not adopt an innovation at the same time however they can be divided into adopter categories based on their first usage of an innovation. In addition Parasuraman [113] had introduced the expression of 'Technology readiness index' (TRI) at the beginning of the new millennium and it was published in the journal of service research [5]. Parasuraman [113] propose to measure the "people's propensity to embrace and use new technologies for accomplishing goals in home life and at work" [113]. So as to grasp the complexity of users' beliefs about the use of IoT, classification is normally used as a relevant means of interpreting distinguish groups.

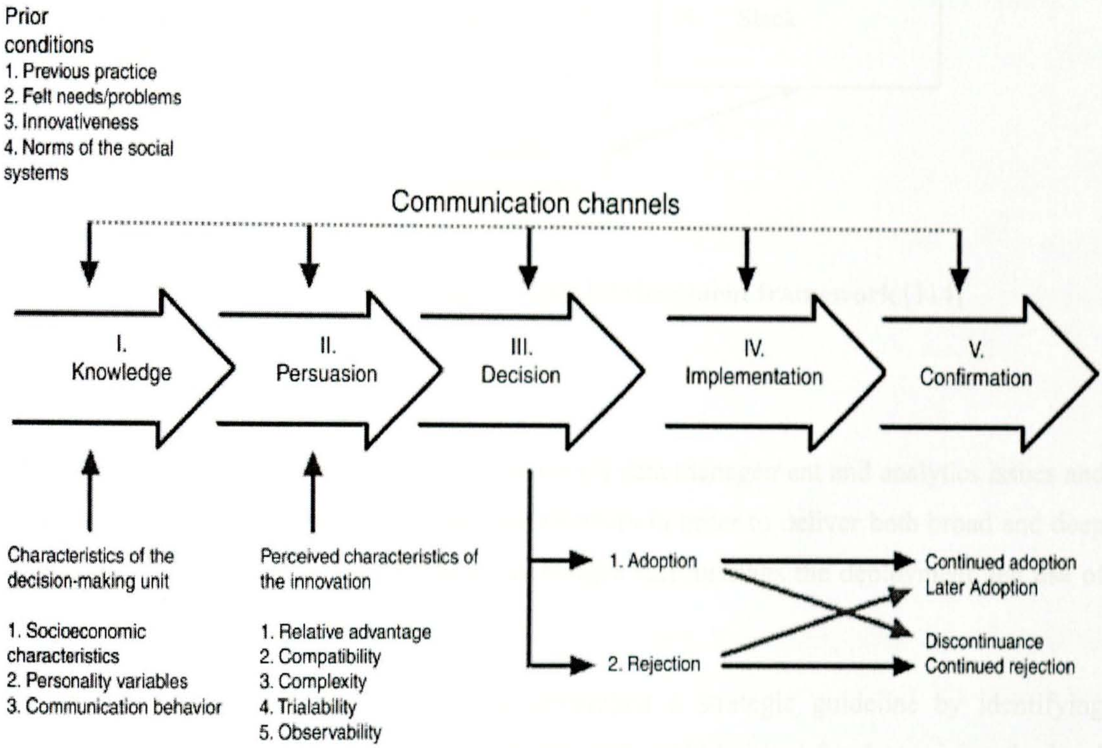

Figure 2 4-Diffusion of Innovation [91]

2.9.2 TOE Framework

Technology, Organization, and Environment (TOE) framework was developed by [114] and they focus on the context in which innovation takes place. This framework consists of three contextual elements or components. Namely: Technological context, Organizational context, and external Environmental context. These contexts together shape the technological innovation of decision making of an organization[114]. The figure 2.5 below illustrates the framework.

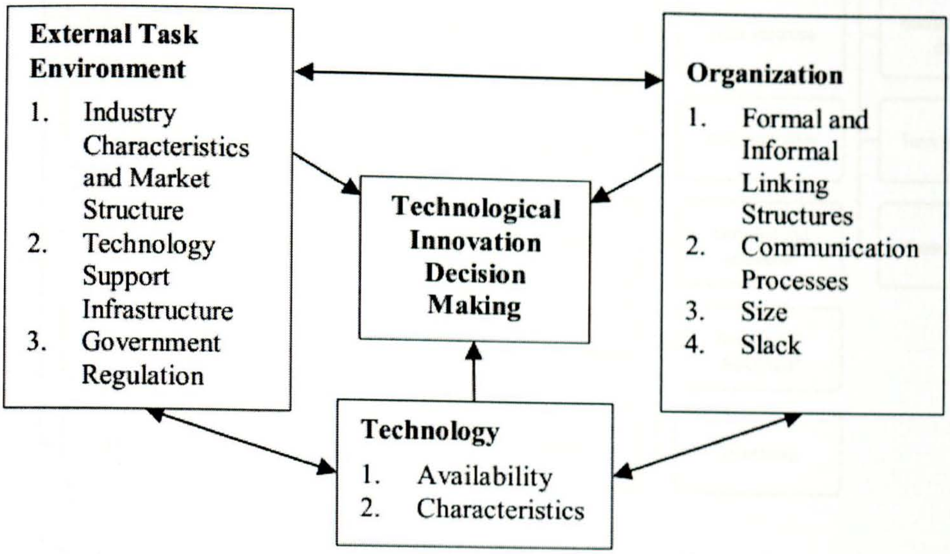

Figure 2 5-Technology-Organization-Environment framework [114]

2.9.3 TDWI

TDWI research conducted by Halper [115] focuses on data management and analytics issues and teams up with industry thought leaders and practitioners in order to deliver both broad and deep understanding of the business and technical challenges surroundings the deployment and use of data management and analytics solution.

Based on the assumptions above, we have developed a strategic guideline by identifying parameters or indicators, from previous researches, that could be used for determining the level of companies' readiness for adopting IoT. This guideline is used to help Ethio telecom understand IoT and the critical factors that affect the successful implementation of IoT [115].

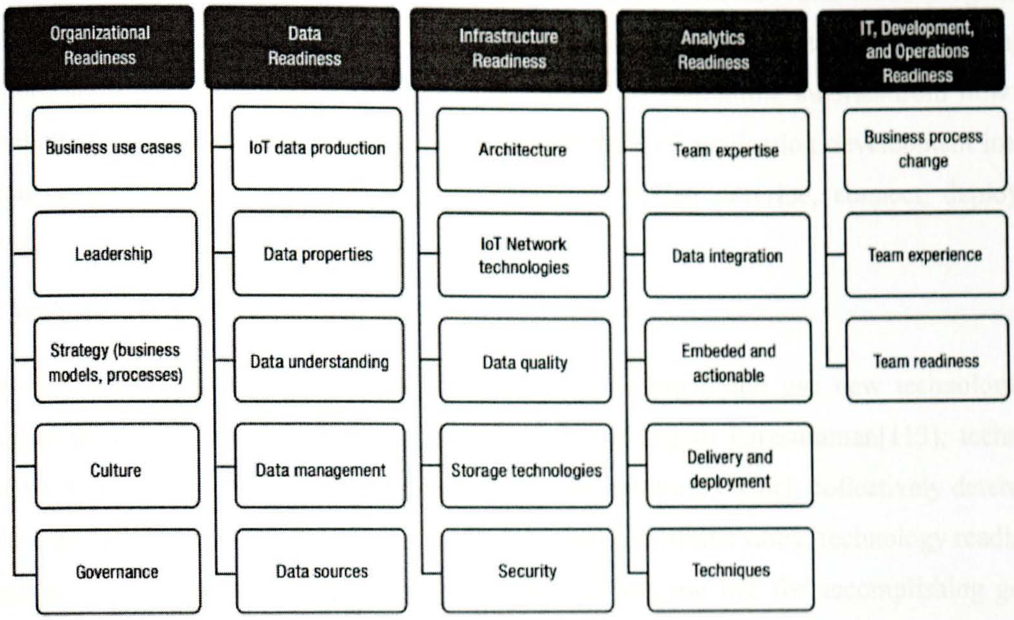

Figure 2 6-the IoT readiness model consisting of dimensions and metrics[115]

Eclipse smart home (ESH) framework is designed to ease of resolution of IoT system and problems encountered by developers who benefits from its interface, persistence mechanism, and automation rules, as well as its SOA implementation[116].

This framework is a connection and integration framework particularly developed for smart home domain and it is independent of connectivity features of the hardware but rather, it makes emphasis on the implementation of a connector to the framework.

This connector is called binding and it is expected to be implemented only once and at least once for a particular communication protocol. This framework, ESH, becomes largely famous since it is open source, and it is being widely implemented as a smart home solution by a large market.

The Calvin framework[117], is a hybrid framework of both the IoT and cloud programming models to explain the complexity of diverse programming languages, distributed computing, and communication protocols. This framework is developed by combining theories from flow based computing and actor model. This framework divided the IoT application development into four separate and sequentially executed aspects which are called describe, connect, deploy, and manage.

2.9.4 Technology Readiness Index (TRI)

Technology readiness refers to people's tendency to embrace and use new technologies for achieving goals in home life and at work[113]. According to Parasuraman[113], technology readiness represents a gestalt of mental motivators and inhibitors which collectively determine a person's tendency to use new technologies. For the purpose of this study, technology readiness is defined as the Ethio telecoms' propensity to embrace and use IoT for accomplishing goals at work, which is measured with the Technology Readiness Index (TRI).

TRI is treated as a different version of Technology Acceptance Model (TAM), which was originally designed for the purpose of explaining user acceptance of new technology, which is an information system [113] . Also, TRI has been integrated with TAM by suggesting that the level of technology readiness particularly does relate to the level of technology acceptance, where both models are significant so as to understand technology adoption [113].

In this study, the focus is on TRI only as the readiness is the prerequisite of technology acceptance. In addition to this, knowing the level of readiness is the very first critical step to understand users' acceptance on new technology [113]. In principle, TRI allows researchers identify a set of motivators and inhibitors to embrace and use new technologies. TRI scale was used in various contexts; for example, online insurance [118], mobile data services [119], human resources [120], bank [121], education [122], and tourism [92]. Though, technologies have been changing after a while and new advancement in technologies has led to the development of technology readiness index 2.0 (TRI 2.0) [113] . When compared to the TRI 1.0 scale, the TRI 2.0 scale is more condensed and consists of four distinct dimensions with each factor including 4 items such as: Optimism, Innovativeness, Discomfort, and Insecurity.

Optimism refers to a positive view in technology, together with a belief of control, convenience, flexibility, and efficiency [113] .

Innovativeness refers to the propensity to become pioneer in technology and thought leader [113]. In previous studies, innovativeness has been most investigated among factors which constitute technology readiness. It is an important factor which is positively related to acceptance of a certain technology [113]. More to this point, studies like Roehrich [123] show that there is a positive relationship between acceptance of new technology and innovativeness, and other studies didn't find empirical evidence that confirm this relationship.

Discomfort is a perceived feeling of being overwhelmed and lack of control by technology. This kind of feeling of being overwhelmed and lack of control by technology can create anxiety with technology.

As Meuter et al., [124] discussed, regardless of the high correlation between anxiety and technology discomfort, these two factors were two different factors. Similarly Dabholkar & Bagozzi [125] argued that anxiety also lead to lack of control and as a result this lack of control can lead to discomfort.

Insecurity is the lack of trust in technology and technology's ability to function properly. It is considered as one of the most significant factors that lead to the rejection and non-use of new technology [113]. Moreover, insecurity also leads to negative perceived benefits [113].

Parasuraman [113] has indicated that optimism and innovativeness are positive drivers of technology readiness while discomfort and insecurity are negative attitudes towards technology.

TRI also enables the respondents on each dimension to be grouped into five useful segments related to technology – skeptics, explorers (early adaptor), avoiders (laggard), pioneers, and hesitators. For instance, the explorers will need minimal help to mastering new technologies, while the skeptics must be provided with concrete reasons for adopting new technologies. As such, TRI will produce very rich information on the level of technology readiness. Due to several revolutionary technologies in the recent years, such as high-speed internet connectivity, mobile commerce, and cloud computing, TRI 2.0 was introduced as to update and streamline the measures from the original [126].

Regardless of more advantages over the original TRI, such as wider applications become more refined, and less burden to respondents, studies that have applied TRI 2.0 are currently very low[16]. However, in the context of the fourth industrial revolution, it is timely relevant to use TRI 2.0 to investigate the IoT readiness of Ethio telecom.

By adopting and deploying new technologies, telecom industries are expected to improve their service quality and customer satisfaction. With respect to the interactions between customers and technologies, previous studies have confirmed that customers with a positive perspective felt that they would be receptive to technology products and services.

On the contrary, customers who have negative perspective felt that they would be resistant to technology products and services. Therefore, technology readiness can positively distress customers' attitude and behavior in technology adoption.

2.10 Related works

Faizal, Zaidi, and Belal (2019), conduct a preliminary study to understand the SMEs' readiness on IoT in malaysia. SMEs need to transform towards IR4.0 sooner or later no matter how they will react to the radical technological change. The transformation has to be done since the accessible source of capabilities will become obsolete and therefore is insufficient to sustain a competitive advantage under new emerging industry standards. Consequently, firms including SMEs worldwide have left without many option, however to prepare and get ready with the change. Therefore, the objective of this study is to focus on the issues on IoT readiness among SMEs in Malaysia. A quantitative method was used. A questionnaire which comprises of two items addressing the respondent background and 16 items to address IoT readiness with a 5-point likert scale adopted from TRI 2.0. All the data were then recorded and descriptively analyzed with SPSS V.20. The results of the study showed that the respondents are pretty optimism with the benefits provided by IoT, but lacking of innovativeness to pioneer the introduction. What is more, though the respondents do not feel discomfort with IoT, they do seem undecided either to trust it or not. In addition top management feels more optimism towards IoT but at the same time feel insecure to it. This study has found the respondents are quite optimism with IoT that will increase their control, flexibility, and efficiency of the works. However, the overall mean of innovativeness is not quite sufficient to suggest that they are ready to be the pioneers and thought leaders of IoT.

Meanwhile, the respondents do not feeling discomfort with IoT, but undecided either it can be trusted or not for doing business. As a way forward the authors recommended the following: to improve the level of IoT readiness, more incentives and support must be provided to SMEs. More training should be provided to SMEs to improve their knowledge on IoT products or services. The respondents should be educated on how to control IoT and make good use of it.

Also, long time planning concerning the use of IoT must be done to avoid becoming too dependent on it. In addition, the directors feeling of distrust on IoT should be managed since their support is crucial to the successful introduction of IoT in SMEs.

Atayero, Oluwatobi and Alege (2016), conducted a study to assess the Internet of Things adoption readiness of sub-Saharan Africa. This study mainly focused on studying how ready developing countries are ready to adopt IoT. This is important because being able to measure the readiness of developing countries in order to adopt IoT will reveal gaps that needs to evolve policy options to bridge gaps identified. Therefore, the objective of this study is to assess IoT adoption readiness of African economies. A thorough literature review was conducted to identify relevant factors to consider so as to examine IoT adoption readiness. From the literature review the authors identified relevant indices that help in capturing vital components of IoT. As a result of the literature review the study identified top ten performing countries in each region for each of the indices. In addition to this, Sub Saharan Africa(SSA) was discovered to be the fastest growing in terms of mobile broadband penetration. This study developed an index that have the ability to effectively capture IoT readiness of developing economies mainly those in SSA. This study tried to assess IoT adoption readiness of SSA using the indices IDI, NRI, GCI, GII and KEI. These represents indices for important IoT components. This was accomplished by identifying the top ten countries in other regions for each of the indices. The countries included are Mauritius, Seychelles, South Africa, Rwanda, Kenya, Cape Verde, Ghana, Namibia, Botswana, and Senegal. Ethiopia was not included. If Ethiopia was included we could have used the study finding as a baseline and we could take the assessment result and proceed from that on the way forward. Generally, SSA region are found to be lagging behind all the indices except the GII. This indicate the region demands a strong institution which can drive the increase in human capital, Innovation that facilitate the delivery of affordable services, installation of adequate ICT infrastructure and a market which promotes competitiveness.

As a way forward the authors recommended to extend the findings of this research, an index which better captures the readiness of SSA countries on IoT by considering other relevant factors should be developed.

Ali Alenezi (2019) conducted a study to assess internet of things & cybersecurity readiness in smart-government and organizations. Sometimes, it is challenging for organizations to map the digital environments that they operate. Since connecting new devices adds complexity to the infrastructure and sometimes organizations cannot manage it. The rising use and expansion of the internet increases the opportunity for its malicious use that threatens privacy and security. Even though the benefit of IoT is realized, the development of security requirement has been lacking and it becomes barriers when deploying IoT.

This research focused on identifying the challenges of IoT on new-generation-smart-government and to dig out the main challenges facing the country in terms of developing an IoT framework for smart government. This study used both quantitative and qualitative methods for validating the finding. A survey was used for extracting information about the development of IoT, its absorption in the present day, companies and level of staffing, and performance these companies are operating in the present scenario. The findings of this study shows that investment, in compliance with standard, and risk assessment have a significant effect on organization cyber security readiness. Also, the result showed that compliance to policies and standards, risk assessment and investment strongly influence the cyber security readiness. Without knowledge compliance will never exist. Training courses, conferences, talks, workshops and emails significantly help to build awareness leading to better compliance with cyber security standards. In addition, risk assessment and investment findings imply that the management has a responsibility to secure funding for their department upgrades and employee training and advancement to face the ever-growing cyber treats. Moreover, the other finding of the study is a model that investigates the relationship between employee awareness, expertise, organizational investment, risk assessment, and compliance with standard. This study explained the challenges involved in the implementation of smart government, particularly the integration of GOV 2.0 and smart cities and provides a framework for smart government to illustrate the challenges and phases of smart government.

As a way forward the authors of this study recommended in order to extend the result of this study, an additional systematic research is required so as to determine how ready corporate and government security organizations are across the country and to better estimate contributing factors. Moreover, the survey instrument has to be enhanced to incorporate ISO audit and ICT security readiness checklists. To promote the establishment of a secure base for IoT in smart cities and smart government it is worthy to investigate the potential of an IoT framework according to NIST cyber security framework pillars design implement and verify.

Hugo Gerritsen (2018) conducted a study on adoption of internet of things in business. IoT popularity is growing however the popularity surpassed by the high failure rate of IoT initiatives. A research gap was identified since there was barely any literature on the influencing factors in the adoption process of IoT. Most enterprises struggle with the effective adoption of IoT. As stated on Cisco's survey 74% of the IoT initiatives were a partial failure.

This is totally understandable as IoT is still a complex and immature technology, with not many people who have the expertise to make IoT projects successful. But, there are others factors which influence the success of IoT projects and enterprises have some difficulties recognizing and facing those factors. The purpose of this research aims to provide overview. The research method used was first a thorough literature review on existing IT adoption models, then another review was conducted on the challenges which occur when adopting IoT in business. Lastly, a case study was conducted in the form of expert interview. The findings of this research include a synthesis of the three research approaches into an integrated Internet of Things adoption framework. A framework consisting of eighteen relevant factors which influence the adoption of IoT in business was developed. Generally, to achieve the goal of the research a thorough literature review and case study was conducted. Though, the current literature is incomplete in this area this particular research tries hard to be as complete as possible on the subject. The outcome of the three research approaches were synthesized into and integrated IoT adoption framework. As a way forward the author of this research recommended the following: further research to extend the result of the case study on IoT adoption in business should be conducted. In addition to this, future research must consider that IT adoption model to see if any relevant factors raise that wasn't raised in this particular research. Moreover, it could be used to further strengthen the finding of this study by confirming some overlapping factors.

Katole et al.,[127] proposed an IoT framework that will take care of standardization and interoperability aspect with the help of which many domain specific applications can be built. The proposed IoT g has three components. Application service layer is an independent layer and interoperates with the IoT framework to provide application oriented and domain specific services. The second layer is the IoT framework consisted of utility layer and IoT service layer. The utility layer consisted of utilities that can be used by different applications in the application layer. Examples of utilities for application include navigation, location services, and tracking; and IoT service layer, which provides various services for interoperability among different entities in a targeted IoT environment.

An example of services includes device management service, device communication service, mediator service, location service, security service, interface service, and data service. The third layer is the IoT environment layer, which represents the network of physical entities or things in the Internet of Things.

The AVIoT[128], is an IoT framework developed for visualizing and managing IoT objects that are present in a specific environment; for instance a smart home. This framework aims to allow users to apply its visual authoring tools to abstract and program the behavior of IoT things. Therefore, end users can monitor easily and define the behavior of things IoT ecosystem without prior internal knowledge of the connection system of the sensors or the architecture. This framework is proposed in order to allow visual configuration and management of things within an IoT environment with ease. The AVIoT framework allows a principled process of the abstraction of sensors and actuators, interactive IoT visualization, and interactive IoT authoring.

Research gap

Many studies focused on developing framework for managing IoT objects, which can be applied on a specific smart domain. But from our thorough literature review we have found a gap on the development of a guideline to help companies guide in their IoT adoption decision. Therefore, this study attempts to fill the gap by developing a guideline that will give support for companies in assessing their readiness for adopting IoT.

From the literatures reviewed so far a research gap was identified. In that it was hardly to find a literature on IoT readiness to guide adoption of IoT. Therefore, this study strives to develop a strategic guideline to guide the adoption of IoT in Ethio telecom.

CHAPTER THREE

METHODOLOGY

3.1 Overview

According to oxford dictionary [129], a research methodology is defined as the systematic way of investigating and studying material and sources so as to establish facts and reach new conclusions. This chapter explains details of the research methodology followed in this study. This chapter also explains the different approaches and views in which the methodology is used as well why the specific methodology has been chosen to carry out the research.

3.2 Study area

The study was conducted at Ethio telecom, the sole telecom service provider in Ethiopia. It is the major internet and telephone service provider company. Among the various departments in the company, information system is the department that is concerned with new innovations and product development. The researcher work closely related with information system department/division throughout the research. The focus of this study is being designing a strategic guideline for assessing the readiness of Ethio telecom to adopt IoT. The target population of this research is individuals who work in Ethio telecom in information system department and directly participate in the new project of creating IoT ecosystem. Ethio telecom is the only company who is about to start an IoT company, and we need to minimize the scope also. It is not possible to take the whole company employees as a population. The target population were identified prior to the data collection and identify the department that is concerned with such kind of new technology adoption and implementation.

3.3 Research design

Two research paradigms characterize majority of researches conducted in the information systems discipline; Behavioral and design science research[130]. Behavioral research is one methodological approach primarily used to develop and test theories that can explain, predict human and organizational behavior.

Despite the fact that, design science is a problem solving approach which tries to create new and innovative artifacts that extend the boundaries of human problem and organizational capabilities[130]. Design science was selected as a methodology because the outcome of this research is readiness assessment guideline, an artifact.

This study followed the design science research (DSR) as a main research methodology in order to address complex problems by investigating and developing the utility of the proposed solution artifact. Because the outcome of this study requires a design and design science is suitable for this.

A guideline is a model artifact or a statement that shows a course of action to follow in doing something. In our context, it is a statement that shows the procedures to be followed before IoT implementation.

In this study, Peffers et al.[131] design science process model was used, as shown in figure 3.1. The main activities are: problem identification and motivation, defining objective of solution, design and development, demonstration, evaluation, and communication.

Design science research involves two primary activities to improve and understand the behavior of aspects of Information systems. The first one is the creation of new knowledge through the design of innovative or novel artifacts and the other is the analysis of the artifacts performance with reflection. The artifacts created in design science research includes but not limited to constructs, models, methods, and instantiation [81].

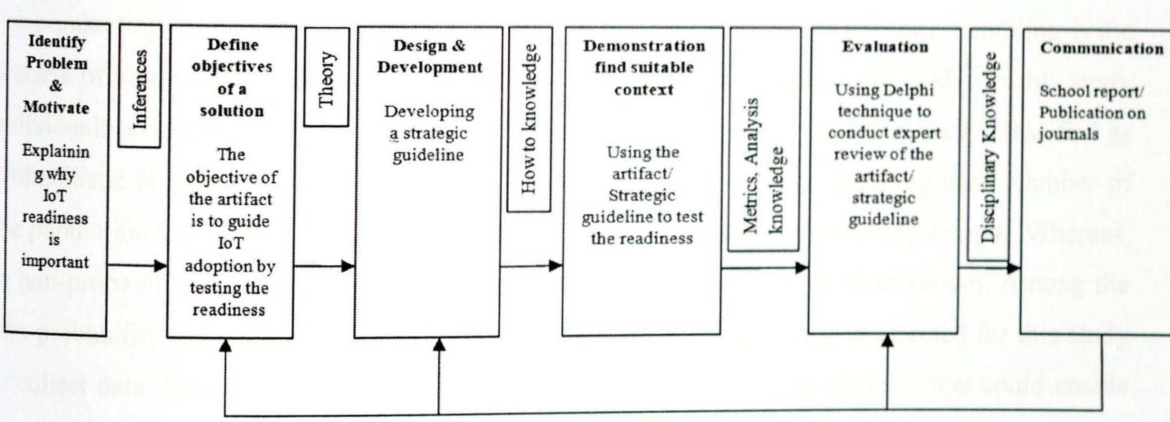

Figure 3 1-Design science research methodology process models [132]

3.4. Problem Identification and Motivation

3.4.1 Motivation

The main motivation for doing this research was that adoption of IoT is unexploited technology in Ethiopia. The IoT adoption has been left alone in Ethiopia for some time now while other countries have been trying to include and use it. The way the world is going in the communication roam shows that the need to shift or use Internet of Thing (IoT) partially is inevitable.

In addition to this, Ethio telecom is in the process of building an IoT ecosystem. Furthermore, local researches conducted on the adoption of IoT in the telecom industry are very few. Only one study conducted by Melak [133] was found at Addis Ababa university digital library. The above reasons show that the area is wide open and there are lots of problems that need to be addressed.

3.4.2 Problem Identification

The initial step in design science is problem identification. Here is where the problem or in this case challenges are identified and presented. In this phase the specific research problem is defined and the value of the solution is justified. During this phase the researcher conducted thorough literature review from journals, conference proceedings and the internet to understand the specific problems and to get deeper understanding towards the complexity of the problem nature. The main problem found from the reviewed literatures was that, for implementing IoT a huge investment is made and it requires a lot of resources. Therefore, for successful implementation of IoT studying the Ethio telecom readiness is very critical.

For conducting the survey, sample individuals are selected from Ethio telecom. Sampling is the process of selecting units from a population which can be included in the study. In this study individuals are sample units. According to Acharya [132], sampling can be broadly classified as probabilistic and non-probabilistic. Hence, in the case of probability sampling each member of the population has an equal chance of being selected and included in the study sample. Whereas, in non-probability sampling the probability of a subject being selected is unknown. Among the non-probability sampling techniques purposive or judgmental sampling is selected for this study to collect data. This technique was selected to use judgment to select samples that could enable to answer questions and to meet the objectives. It was necessary to take sample because it enable us to select individuals/employees who have a direct relation with the topic we are studying.

This sampling technique was selected because it enables the researcher to collect targeted data or data collection from experts who are in direct relation with the topic being studied. Purposive sampling enables a researcher to use judgment to select samples that could enable to answer questions and to meet the objectives. In this study the case company is Ethio telecom. The company is on the start of implementing IoT so it is good opportunity to obtain the required information from employees who participated in the implementation. In addition to this, the company is the sole and state-owned telecom service provider in Ethiopia.

For this research, detailed and focused literature review was done to understand more about Internet of Things concepts and IoT readiness assessment framework with a central issue of identifying critical factors. Various researches conducted on IoT are reviewed from journal articles and conference proceedings.

In addition, we conducted survey to extract the view of multiple stakeholders that participate on IoT readiness adoption. The stakeholders are the company employees. Because the stakeholders must be aware of the IoT concepts and pre requisites before the actual implementation. A questionnaire with Close and open ended questions (see annex II) were distributed for selected respondents and the response is collected accordingly for analysis. A questionnaire was used because it allows us to capture objective type of answers from pre defined options. And also questionnaire is the best instrument for conducting assessment. The questionnaire items were extracted from TRI 2.0.

3.4.3 Pilot testing

For the purpose of testing the reliability and validity of the questionnaire, a pilot test was conducted. This was done by taking 10 sample respondents. These respondents also participated in the evaluation as well. In addition to this, doing this helped us to make sure the data collection instrument was free from ambiguity and irrelevant items. Pilot testing is important to minimize bias during data interpretation. The prepared data collection instrument, the questionnaires were distributed to willing respondents and they filled and return with constructive feedback. Based on the feedback, the researcher made some modification to the instrument so as to minimize bias.

Since the study use quantitative data only, it is necessary to check validity and reliability of the measurement techniques.

Reliability checks the quality of the measurement. The measurement to be used for analyzing the data collected must give the same result if we run the test again and again. Without any reliable measurement the result will always stay invalid. Thus, reliability of the measurement is a prerequisite for obtaining valid research finding. And validity in quantitative method refers to the acceptability of the research finding[83]. Therefore, in order to ensure the validity of the findings we perform a reliability test using a method of Cronbach's alpha reliability test. Doing this helped us to show whether the questionnaire items response are consistence across the study. After taking respondents from the company a Cronbach's alpha result of 0.817 was obtained. This number is greater than 0.7, which shows that the researcher considers that the questionnaire was reliable to conduct a full scale of data collection.

3.4.4 Reliability Analysis Test

Reliability test is critical when we interpret study effects and test results. This test is one of the requirements that need to be performed in quantitative research. It is one form of ensuring internal consistency of the question in the questionnaire.

Cronbach alpha coefficient is used more often and is incorporated in various statistical package programs such as SPSS. The bigger the value of Cronbach's alpha test is, the more the items in a questionnaire are inter-correlated [134]. Table 3.1 below shows the result of reliability test. The overall Cronbach's alpha value of the questionnaires item is 0.854. This number show there is a high level of internal consistency among the questionnaire item and the items are inter-correlated.

In addition, table 3.1 presents the internal consistency between each of the four major categories, such as optimism, innovativeness, discomfort, and insecurity.

Major categories	Cronbach's Alpha	N of Items
Optimism	0.757	5
Innovativeness	0.812	5
Discomfort	0.709	5
Insecurity	0.806	5

Table 3 1-Reliability test result for each categories of the questionnaires' item

3.4.5 Data Analysis

Research results interpreted from quantitative data can generate effective output. After collecting quantitative data using the questionnaire, the collected data was entered and analyzed using SPSS 20. SPPS software package was chosen as the analysis tool to help in simplifying the analysis process as well as the presentations of the result. Because the data collected is quantitative data and SPSS is well known data analysis software for such kinds of data. The use of descriptive statistics also depends on the nature of the data collected, it allows data to be presented in understandable and meaningful way

Descriptive statistics methods such as frequency distribution, mean calculation, and cross tabulation are used to summarize the collected data.

3.5 Objectives of the Solution

This is the second step in the design science research process model. At this step, the study aims to identify the design requirements for designing the proposed readiness assessment guideline for IoT. The objective of the solution, strategic guideline, was to facilitate IoT readiness assessment and to bring success.

It aims to provide answer for the questions "what guideline needs to be designed for testing the readiness of Ethio telecom to adopt IoT?" after identifying a problem and once the relevance was evaluated, a solution was developed in the form of a strategic guideline. The main aim is to design a strategic guideline for assessing the readiness of Ethio telecom to adopt IoT.

Quantitative data was gathered to assess the readiness level, awareness, familiarity of the employees of IoT. As a data collection tool questionnaire was used to show how the proposed guideline is expected to support solutions to the challenges that were not previously addressed or considered in other researches.

The purpose of the guideline was to identify potential gaps prior to IoT adoption and provide the organization with the ability to fill the gaps before beginning IoT implementation. Defining the objective of the solution is dependent on the problem identified and requirement set which are the bases for deciding details of the guideline.

3.6. Design and Development

Design science research should produce a feasible artifact in the form of models, methods, constructs and instantiations[135]. In this phase the actual artifact, which is a guideline, was designed and developed. A guideline is a model artifact or a statement that shows a course of action to follow in doing something. In our context, it is a statement that shows the procedures to be followed before IoT implementation. The survey is used to identify currently existing gaps regarding the preparedness of the company to adopt IoT. A theme is identified from the survey result. Two frameworks TOE and DOI are used to identify components that get in line with the identified problems. The guideline is designed by taking components from both frameworks to adapt the current challenges. The designed guideline shows prior issues to consider before initiating IoT adoption with a description.

Each of the components of the guideline is discussed in detail in the next chapters. The developed readiness assessment guideline is designed to Ethio telecom but can be used for big organizations with massive network infrastructure.

3.7 Demonstration

Demonstration is the application of the artifact developed to a real life situation. In this phase the researcher demonstrates the artifact developed, the strategic guideline, to the end users for the purpose of collecting feedback to improve the proposed artifact. The end users are those who uses the artifact at the end, in our case the employees.

Since the guideline is designed in statement form, the technique we used to demonstrate it to the participant is a graphical representation of the guideline components. In addition, a description of how they are related to one another and what each represents was provided.

A session with some of the respondents was held and the guideline is demonstrated by explaining the purpose of each components of the guideline. We start by selecting participants and the resources required for the demonstration includes effective knowledge of how to use the artifact to solve the problem.

3.8 Evaluation

As explained by Peffers et al.[136] without evaluation, we only have an unproven design theory or a hypothesis in which the developed artifact is useful for solving some problem or making improvement. Also, the guideline developed needs to be evaluated for the purpose of evaluating its quality so that it can be valuable to solve real world problem[112] In this phase the study tries to measure and evaluate how well the guideline helps in assessing the readiness of the company in implementing IoT. Evaluation proves how the proposed guideline is effective and efficient in identifying the missing factors or components for saying the company is ready enough to implement IoT. This is performed by comparing the objectives of the solution to the observed results after demonstrating the guideline. The respondents of the research used to verify the completeness of the guideline and the capability of the guideline for guiding the adoption of IoT.

This study attempts to construct a guideline; in order to evaluate the design artifact of the proposed guideline; we followed Peffers et al.[136] evaluation methods. The evaluation methods are expert evaluation, logical argument, technical experiment, action research, subject based experiment, case study, and illustrative scenario. By considering the above evaluation method, in this study we used expert evaluation to evaluate the proposed guideline. By taking into account the applicability of the guideline, experts who gained adequate knowledge and experience in the area were used for the evaluation. With the aim that the researcher will obtain fruitful feedback from these experts and modify the proposed guideline in a way to achieve the objectives set along to solve the existing problem.

3.9 Communication

After the completion of this research work, the report is submitted to the School of Information Science as a partial fulfillment of MSc. Degree in Information Systems. And an attempt will be made to distribute the results of this research to a well-known academic conference and journal. The final artifact of this study, the guideline, will be communicated to Ethio telecom to serve as a reference during the implementation of IoT.

CHAPTER FOUR

ANALYSIS AND DISCUSSION

4.1 Overview

The purpose of this chapter is to report the findings by giving a brief description of the results. In this study, Parasuraman and Colby [126] technology readiness scale was used. The instrument to measure and evaluate customers' technology readiness is the TRI scale with 36-items that was invented by Parasuraman[113]. This measurement scale consists of four constructs: optimism, innovativeness, insecurity and discomfort. Each of the constructs consists of five items. The level of IoT readiness was measured by five items which were borrowed from Lin & Hsieh [137] and Makanyeza & Mumiriki [138] and adopted to fit this research objective.

A questionnaire comprising of five items to address the respondents background and twenty items to address the IoT readiness of Ethio telecom with a 5 point Likert scale ranging from 1 for 'Strongly disagree' to 5 for 'strongly agree' was adapted from TRI 2.0. In order to ensure the respondents understanding of the survey, on all questionnaire forms a page of basic information on IoT was attached. Due to cost and time limitations, the researcher has personally distributed the questionnaire to the respondents.

This study focused on Ethio telecom employees. During the data collection, the questionnaire was directly distributed to the employees at different position by using personal communication. Of the total questionnaires, 72 were returned, of which 65 were appropriate for subsequent statistical analyses. The rest of the data was incomplete. The time for data collection was from March 2020 to July 2020. After completing the data collection, all the data were recorded and descriptively analyzed using SPSS v.20 statistical package.

4.2. Respondents Background

Summary of respondent's position in the organization and their ICT usage is presented in table 4.1. The survey has received 9.2% responses from directors, and 29.2% responses from executives. And this study has obtained 29.2% from engineers and 32.3% from consultant.

In terms of ICT usage, 85.1% of the respondents are using email services, 76.9% of the respondents are using social media, and 58.4% of the respondents are using mobile messages, and have computer and software at work. Generally, this statistics have indicates that although the respondents are familiar with some ICT tools, some are not still using any internet web pages in order to socialize and communicate with customers, while more than half are yet about to adopt the current trends of doing business with online platforms.

Items	Frequency	Percentage
Respondent Position		
Directors	6	9.23%
Executives	19	29.23%
Engineers	19	29.23%
Consultant	21	32.3%
ICT utilization		
Email services	56	85.15%
Social media	51	76.9%
Mobile messages	38	58.4%

Table 4 1-Demographic characteristics of respondents

4.3. Motivator

Motivators are the positive aspects of technology readiness which comprises of two traits: optimism and innovativeness [113]. These traits are the enablers or drivers that improve an individual's technology readiness. A 5-point likert scale, ranging from strongly disagree to strongly agree, was used to capture the respondents opinion. While a mean score from 0.01 to 1.00 represents "Strongly Disagree", a mean score of 2.00 represents "Disagree", a mean score from 2.01 to 3.00 represents "Neutral", a mean score from 3.01 to 4.00 represents "Agree", and a mean score from 4.01 to 5.00 represents "Strongly Agree". The results listed here are from the likert scale range. Each of the traits were considered different, an average was not calculated. Because each represent a different meaning.

4.3.1. Optimism

Optimism is one of the traits of motivator which refers to a positive view of technology and a belief that it provides increased flexibility, control, and efficiency in people's lives[113]. Therefore, in general an optimist respondent feels favorably towards using technology. They tend to see more benefits in specific technology and worry less about the drawbacks or negative side of technology[139].

Summary of the respondent's suggestion concerning optimism motivator is shown in table 4.2 below. The mean was taken from the analysis result of the data from SPSS. It was calculated by taking the average of each item in each of the four dimensions.

Issues	Percentage					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
IoT will contribute to a better quality of working life				46.8	53.2	4.53
IoT will give more freedom of mobility at work				44.2	55.8	4.56
IoT will give more control over daily activities at work				67.5	32.5	4.32
IoT will make working life more productive			22.1	55.8	22.1	4.0
Respondents prefer to use advanced technology available				44.2	55.8	4.56
Average Mean						**4.39**

Table 4 2-Summary of survey result on Optimism

The result on optimism show that, the issue of "respondents' prefer to use most advanced technology available" and also the issue of "IoT will give them more freedom of mobility at work," registers mean of 4.56. Also, IoT will contribute to a better quality of working life score mean of 4.53. On the other hand, IoT will give more control over daily activities at work achieves on the average 4.32. Finally, IoT will create more productive working life with mean of 4.0.

Therefore, with average mean of 4.39, respondents 'Agree' with optimism in using IoT. From the result, it can be concluded that the respondents have sufficiently positive view on IoT and believe that it will give them better control, flexibility, and efficiency over their day to day working activities.

With this level of optimism, it appears that the respondents are more motivated and ready to accept IoT with its potentials.

4.3.2. Innovativeness

Innovativeness is another trait of motivators which refer to the tendency to be a technology pioneer and thought leader[113]. Consumer innovativeness research has found that these essential individual characteristics highly correlate with consumer's creativity behaviors and novelty-seeking behavior such as adoption of new technology product[140]. Therefore, this parameter is used because individuals with a high degree of innovativeness, show intrinsic interest in trying new technologies and will become early adopters or innovators.

The respondent's suggestion concerning **Innovativeness** motivator is shown in table 4.3 below based on the five issues.

Issues	Percentage					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
At work, others will come to the respondents for advice on IoT	10.4	20.8	35.1	23.4	10.4	3.03
The respondent will be among the first of the circle to acquire IoT when it appears		20.8	45.5	22.1	11.7	3.25
The respondent can figure out IoT products/services without help from others		11.7	20.8	55.8	11.7	3.25
The respondent can keep up with latest IoT developments in their areas of interest		11.7	32.5	55.8		3.44
The respondent enjoy the challenges of figuring out IoT gadgets	10.4		33.8	45.5	10.4	3.45
Average Mean						**3.37**

Table 4 3-Summary of survey result on Innovativeness

The result on innovativeness shows that, the issue of, "respondents can figure out IoT products/services without the help from others" scores a mean of 3.68. Also, whether respondents enjoy the challenge of figuring out IoT gadgets registers a mean of 3.45. In addition, respondents can keep up with the latest IoT developments in their areas of interest registers a mean of 3.44. On the other hand, the issue that, "respondents will be among the first to acquire IoT when it appears" score a mean of 3.25. Finally, the respondents somehow 'agree' that others will come to them for advice on IoT at work with a mean of 3.03. Therefore, with the average mean of 3.37 (between 'Neutral' and 'Agree'), it can be concluded that the respondents motivation still need to be improved so as to become more innovative as their tendency to be the IoT pioneers and thought leaders are just slightly better than average ('Neutral').

4.4. Inhibitor

Inhibitors are negative aspects of technology readiness which have two traits: insecurity and discomfort. These are the detractors which decreases individual's technology readiness [113].

4.4.1. Discomfort

It is one of the traits of the inhibitor which refers to the perceived lack of control over technology and a feeling of being overwhelmed by it. We expect a negative relationship between this trait and technology usage. In addition to this, consumers control beliefs positively affect their adoption of technologies[141].

Summary of the respondent's suggestion concerning **discomfort** inhibitor is depicted in table 4.4 below.

Issues	Percentage					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
If the respondent get technical support from a provider of IoT, he/she will feel as they are being taken advantage of someone who knows more than they do	10.4	11.7	33.8	44.2		3.12
Technical support line will not be helpful to explain IoT in terms that the respondent understand		45.5	32.5	22.1		2.77
The respondent think that IoT systems are not designed for use by ordinary people like him/her	10.4	23.4	33.8	32.5		2.88
There is no such thing as a manual for IoT product/service that is written in plain language	10.4	57.1	10.4	22.1		2.44

It is embarrassing when the respondent has trouble with an IoT gadget while people are watching		32.5	57.1	10.4		2.78
Average Mean						**2.79**

Table 4 4-Summary of survey result on Discomfort

The result on discomfort shows that, respondents are somehow "agree" in that they will take advantage of someone who knows more than them with a mean of 3.12. On the other hand, the respondents "disagree" to the statement that, IoT systems are not designed for use by ordinary people like them with a mean of 2.88. Moreover, the respondents seem "Disagree" about the statement, "it is embarrassing when I have trouble with an IoT gadget while people are watching me" with a score mean of 2.78.

Also, the respondents seem to disagree to the statement which state, the technical support will not be helpful to explain and make them understand the IoT better with a mean of 2.77.

Furthermore, the respondents inclined more towards "disagree", with a mean of 2.44, on the statement that ask, there is no manual for IoT product/services that is easy to read. Therefore, with the average mean of 2.79 (between "Disagree" and "Neutral"), it can be concluded that respondents do not necessarily perceived lacking of control over IoT and feeling being overwhelmed by it, which indicates that they do not seem to discomfort with IoT. However, there is no guarantee that their readiness to adopt IoT will be inhibited by this feeling.

4.4.2. Insecurity

This is the second traits of inhibitor which refer to a distrust of technology, stemming from skepticism about its ability to work properly and concerns about potential harmful consequences [92]. This trait combines general safety concerns, need for assurance, and worries about negative outcomes. Here, individuals who are distrustful of and skeptical about technology, tend to expect risks rather than benefits in any new technology and therefore avoid it.

The respondent's suggestion concerning insecurity inhibitor is shown in table 4.5 below.

Issues	Percentage					Mean
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
The respondent will be too dependent on IoT to do things at work		23.4		55.8	20.8	3.74
Too much IoT will distract the respondent to a point that is harmful	10.4	10.4	11.7	67.5		3.36
IoT will lower the quality of relationships by reducing personal interaction	10.4		22.1	33.8	33.8	3.81
The respondent will not feel confident doing business that is reached only by IoT	10.4	33.8	44.2	11.7		2.57
The respondent is worried that information sent over the internet will be seen by other people		32.5	20.8	46.8		3.14
Average Mean						**3.324**

Table 4 5-Summary of survey result on Insecurity

The result on insecurity shows that the respondents are somehow "Agree" to all statements mentioned in table 4.5, IoT will lower the quality of relationships by reducing personal interaction, they will become too dependent on IoT to do things at work and feel worried that information they sent over the internet will be seen by other people as well as too much IoT distracts to a point that is harmful with a mean score of 3.81, 3.74, 3.74 and 3.36, respectively.

The respondents are not sure either to feel confident or not to do businesses that can only be reached by IoT with a mean of 2.57.

Therefore, with the average mean of 3.324 (between " neutral " and " agree"), it can be concluded that the respondents seem to be more dependent on IoT to do their day to day activities, and believes that too much IoT will cause distraction at some point. And in addition the respondents believe that IoT will lower their personal interaction.

The above results indicate that respondents feel some sort of insecurity about IoT. However, there is no guarantee that their readiness to adopt IoT will be inhibited by this feeling.

4.5 Discussion

It seems that they are somehow not innovative enough to be IoT pioneers and thought leaders. Moreover, the respondents believe that they can figure out IoT products and services without help from others. This implies that, their technical knowledge on IoT products and services are good. Their motivation to become more innovative and become IoT pioneer and thought leaders still needs some improvement.

On the other hand, the respondents are generally not feeling discomfort with IoT as they are somewhat 'disagree' that they will lack control over IoT and feeling of being overwhelmed by it. In terms of insecurity, they feel somehow insecure about IoT.

But it is difficult to tell that IoT is perceived as harmful and distrust by the respondents. Despite the fact that, when looking at the individual items of the factor insecurity, the respondents do concern on being too dependent of IoT to do things at work. Also they have worries that, it will lower the quality of their relationship with their colleagues by reducing interpersonal interaction.

4.6. Design requirement

The strategic guideline to be followed must incorporate the following requirement to fill the gaps identified during the assessment.

- The employees must be motivated to be IoT pioneers and thought leaders.
- Ensure the employees have control over IoT and do not feel overwhelmed by it.
- Implement security policies to reduce employees feeling of insecurity.
- Reduce employees feeling of being too dependent on IoT.
- Ensure employees do not feel too dependent on IoT.

- Understand the consumer's expectation and readiness since they have a belief that it will reduce their interpersonal relationship.

4.7. Objective of the solution

The purpose of designing the guideline is to serve as a baseline for preparing a strategy for the effective implementation and successful adoption of the IoT in the company. The following are the objective of constructing the guideline for implementing IoT in Ethio telecom.

- To have consistent implementation of IoT.
- To avoid any redundancy and optimize resources
- To optimize costly operation
- To attract stakeholders of the organization towards using the IoT.

CHAPTER FIVE

DESIGN OF THE STRATEGIC GUIDELINE

In the previous chapter, we have come up with some insights of the findings. This chapter deals with the proposed strategic guideline for assessing Ethio telecom readiness to adopt IoT. This chapter brings the components of the strategic guideline and the description of each of the components.

5.1 Guideline development procedure

As noted by Lin & Chang [142], knowing the level of readiness is the first critical step to understand user's acceptance on new technology. Based on the literature review made, we identify the key activities in technology readiness and what needs to be considered when adopting a new technology. According to the findings, we revealed that the respondents were not innovative enough to be IoT pioneers and thought leader.

Therefore, it is very important for the management to create more awareness to its employees and to motivate them to be pioneers and innovative enough. Additionally, a lot of respondents feel insecure about IoT. Therefore, the readiness assessment guide must give attention to clear out employee's insecurity and frustration and to boost their confidence. The proposed guideline must incorporate such kind of issues to consider it carefully before the adoption and during the readiness. The proposed strategic guideline was obtained by combining components from TOE and DOI adoption models and the gap identified from the data analysis result (design requirement) (see section 4.5).

To fulfill the gaps identified the strategic guideline should include the following components

- Top management support to motivate and support the employees towards using IoT,
- To let the company employees have more control over IoT, the guideline must have a component to assess the complexity of IoT, as having control will depend on how complex the technology is.
- In order to reduce employees feeling of insecurity, the strategic guideline should have a component to address implementation of security, governance and policy.

5.2 Components of the Strategic Guideline

The proposed guideline for Ethio telecom was based on the preliminary study and detailed literature review. The proposed guideline was constructed to fill the gaps identified from the data collection by integrating components from DOI and TOE framework. It includes elements from these frameworks that have the ability to fill the identified gap and succeed in fulfilling the design requirement. The 17-guideline components were extracted from literature. Thorough literature review was conducted on technology readiness assessment articles and requirements for IoT adoption. As mentioned above, the guideline components were extracted from previous studies and customized to our context and were tested by the respondents. All the guideline components are presented below.

1. Defining business goal & the expected outcome

It is very important to clearly identify and define the problem statement that introducing IoT will solve. Despite the fact that, for any initiative, the success of IoT is extremely dependent on the clarity of a problem statement.

The organization stakeholders, employees, must identify the expected outcome together with the key success metrics. And the organization should know how the IoT solutions will impact the efficiency, productivity, and customer satisfaction in the long run. It is also very crucial to define the key performance indicators that will be measured and improved through IoT solutions.

2. IoT objective & IoT use cases suitable for the business

IoT implementation starts with identification of key objectives, without focusing at all on the market hype. Whether a company wants to start a new line of business, simplify its existing operation, compete with competitive companies, or just want to explore about it: figuring out the key objective is crucial. Accordingly it would be best if Ethio telecom determine what the company wants to achieve by implementing the IoT technology. As each organization has different needs, for instance some may aspire to improve customer experience while others aim to decrease operational costs. It may be a bit hard to identify business use cases that suit the company business need. The first and foremost thing Ethio telecom should do is to create key objectives based on the overall mission and vision and create a roadmap to achieve the business goals.

3. *Understanding the Industry pressure*

Large companies have advantageous competitive position in the market by targeting specific customer preference. Recently, the disruptive potentials and technological innovations of IoT have changed not only the market segmentation but also the customer's expectation.

For this change the major output are purchasing personalized and customized products and services that are delivered faster. This is the most important aspect to increase competitive advantage or pressure, particularly since the changes happening over business models, and companies are facing a challenge in sustaining continuous innovativeness so as to keep their competitive advantage.

Even though, Ethio telecom is the sole telecom service provider in the country, they must plan in advance by taking into consideration key factors to satisfy customer needs and to stay in the market as other competitors are joining the industry.

4. *Understanding the organization size*

In recent years, IoT as a technological innovation is a valuable resource that is also facing up bigger shifts. The changes have a huge impact over quality standards, business development costs, and in terms of legal aspects such as individual, social, and environmental factors. There are various challenges that a company will face on the way of adopting IoT, especially if this bring forward a new way of strategic thinking for achieving sustainability. Thus, IoT tools and applications will require higher rate of adaptation and better management of the operational systems of the company business models. Simultaneously, the need to transform the infrastructure of organizations will appear together with the increase in generated number of innovations. The size of an organization has a direct relationship with the resources provided, particularly in terms of taking the initiatives to adapt to the innovative changes related to IoT. Therefore, the company must take into consideration the resources available at hand, employee's competences, position in the market, and the size of the company before adopting IoT.

5. *Conducting Basic & applied research*

A research should be conducted so as to create a knowledgebase which will later be used as an input for the planning and design of the IoT innovation.

A basic research which investigates the advancement of scientific knowledge which do not have the specific objective of applying this knowledge to practical problems and applied research which is a scientific investigation that intend to solve practical problems. Therefore the company must start with a basic research which then leads to applied research. The result of these researches will end on start of the development stage.

6. *Understanding the Complexity/ compatibility nature of IoT*

Regarding structure, there are various factors which influence the path for innovation activities. The more big, complex, and differentiated product and services are provided by the organization, it is easier to cross boundaries and higher number of sources to be used so as to explicit high possibilities for generating new ideas. As the size of the market get increased and fragmented, it will be more difficult to achieve a reliable and efficient integration of its applications.

There are various technologies, platforms and businesses that interconnect and try to build a standard for its broad application in the industry. All the approaches have the same goal, to become a standard and used in the market by companies. The increase in the number of hardware and software used during the adoption will constraint the adoption of IoT in a more open way. Some of the devices and technologies used for the adoption of IoT and its standardization will become useless or unnecessary in the next few years, thus it is important to define a proper strategy for the company so as to keep up with the transformation flow. It is important to understand the short life performance of IoT appliances in comparison with the generic computing technologies, which can then be utilized for much longer period of time. The purpose and functionality of the product is what will shape the approach of the user or customer to the service or product provided.

7. *Choosing the right platform, tools and solutions provider that fits Ethio telecom needs*

Before the implementation of the IoT technology choosing the right platform, tools, and solutions that can contribute and go in line with the key objectives identified in the problem statement is significant to the successful implementation of IoT. Of course the cost involved in integrating different available solutions with IoT is massive. It is very significant that Ethio telecom chooses its platform wisely. There are many companies that ranges from big to mid size and has the potential in providing IoT solutions. While choosing an IoT solution, Ethio telecom should focus more on agility and core offerings and make an informed decision.

This also includes the language used to program and key APIs since not all language are supported by all platforms.

8. Identify the hardware & device and participating in the connected solution

Ethio telecom has to carefully identify the hardware, machinery and equipment from an existing inventory of devices. As per organization goals and the expected outcome, Ethio telecom may have to collaborate with suppliers which provide sensors, actuators, bridges, adapters and other hardware's. The combination of existing devices and the identified components from the devices layer, which becomes the source of the comprehensive data acquired by the platform.

The organization should identify everything that it takes to onboard physical devices to the connected platform.

9. Define device connectivity & data format

An enterprise IoT solutions deal with the various protocols and mechanisms needed for device connectivity. It includes how sensors and actuators communicate with legacy devices, how devices talk to the edge layer, the raw format of datasets which are generated by the devices, the protocol translation that takes place between devices and gateway. Sensors communicate to gateway and edge layer through Bluetooth low energy, Zig Bee, Z-wave, Ethernet, Wifi, Serial Port etc. the data format can be XML to CSV to JSON. The edge layer will have to translate the wire format protocols and transport protocol before sending the data to the IoT platform. Therefore, the organization has to clearly define the right combination of data format and transport protocols across the stack to go a long way.

10. Prepare data points & metrics aligned with the outcome

Sensors attached to IoT devices generate multiple data points which translate to massive datasets. While the data is the root of an enterprise IoT solution, it is important to cautiously choose the right data points that contribute to the metrics. Every device that is connected to various sensors generate dozens of data points. Some of the data need to be analyzed in batch while other data points need to be analyzed in real time. Thus, the organization should prepare data points and metrics that support in achieving the company objectives.

11. Development-Develop new product & service & business model

Regularly, the organization needs to create new product and services on top of existing products by connecting them to the internet. It is critical in improving customer experience and increasing competitive advantage.

In addition to this, while creating a new IoT product and services the organization should focus on outcome based solutions. Before implementing any ideas, outcome must be decided. New IoT solutions must have a focus on specific outcomes more than thoughts. An IoT solution could deliver a lot of insights into consumer buying behavior, psychology and product usability however that data is not an outcome. Also the insights that are gathered from the data are not an outcome/ the real outcome that Ethio telecom must focus on is how the company go about using the data to increase revenue and consumer satisfaction.

The ultimate goal should be to collect key analytics and analyze those to improve decision making. Therefore, each of the new ideas and solutions must be outcome oriented. The last focus should be given to gather key analytics and analyze those to improve decision making.

12. Prototyping implementation

Before initiating the IoT project, a team/ all stakeholders/ must be gathered from different departments to think it thoroughly. By its nature, IoT involves various systems to interact with each other. This means Ethio telecom need employees with different expertise throughout the projects inception, design, prototyping, implementation, and incrementation. Depending on the need and the IoT product/ services to be introduced some of the experts that the organization must include in the pre-implementation team includes: Software engineers, Computer engineers, Mechanical engineer, Electronic engineer, IT expert, Automation Engineer, Telecom Specialist…

Implementing IoT technology in a company is like implementing any other project; commitment is unavoidable; it is a key. In order to understand the complexity of building IoT products and services Ethio telecom must decide on the outcomes, carefully design the implementation, acquire the required knowledge, and then test with a prototype.

Prototyping consisted of using already available and less robust systems which can easily be attached and removed as required so as to understand what works and what doesn't. These may consist of hardware's designed with IoT in mind, or even with an adapted Rasberry Pi or Arduino products.

If the team input, initial results, and cost estimates on the full IoT implementation are the reason for maximizing optimism, then Ethio telecom must commit to it by implementing better platform and hardware with better quality that is more responsive and faster.

13. Implement security, governing, and policy across each layer

Just like any other enterprise solutions, security is very critical for all IoT products and services. Datasets should be carefully encrypted, anonymized, and compressed before performing any processing. So a complete and inclusive governance model is important to restrict access to sensitive data and report by unauthorized users. Developing policies that define which roles and personas are allowed to control the devices and accessing the business intelligence dashboards. IoT security must be tightly integrated with the existing business policies and security best practices. This planning must also include identifying and implementing complex business rules which define several policies for interconnecting devices and accessing the data. Data privacy and security are primary concerns while implementing IoT. Therefore, the organization needs to make sure that data governance best practices are integrated into the IoT implementation. In addition to this, applying communication protocols, endpoint security, access control, fraud management, and encryption could be taken as measures to enhance data privacy and security. And if necessary, general data protection regulation (GDPR) compliance could be considered to minimize security breaches.

14. Integrate IoT system with other advanced technology(connect, adapt & integrate)

What it takes to set up an IoT technology stack, that are suitable for IoT connection includes: sensors, communication networks, devices, cloud infrastructure, IoT platforms and applications. After the sensors are set in place for collecting and storing data, business can introduce new technologies for using the data for analytics, edge computing, and machine learning to IoT infrastructure. Furthermore, data from multiple sources should ultimately speak the same language to be processed either in the cloud or on an edge device.

This is because before the IoT applications can provide the desired insight, data must be collected from several 'things', then communicated thru a network for further processing.

Therefore, these new IoT technologies need to be needed to be connected and integrated physically and logically with legacy systems and must be updated accordingly. At the end of this phase, the result is a fully functional system by including data transmission, storage, and processing. Therefore, Ethio telecom must plan carefully to integrate IoT system with existing and other advanced technology without disrupting the existing legacy system.

15. Commerciallizaiton (DOI)

Once the new system are integrated and adapted with the legacy systems, the next stage includes production, manufacturing, packaging, marketing, and distribution of IoT products and services that embodies and innovation. This is the stage where the innovation is fully developed passed thru several tests and ready to be used by the potential users and fulfill its purpose.

16. Top management support(TOE)

In the adoption of any innovation top management support is very important. Their attitude depends on the level of openness for adopting new and innovative solutions have high impact over the rate of successful adoption. Of course, switching to such new technology requires a change in the company culture and posture. There is always a difference depending on the size of the company. The smaller the company is the easier to get feedback. However, as the company is larger in terms of size the management should find a way to get feedback from all the system users and affected employees.

The top management must be able to clearly identify allocation of IoT in the company's core strategy. Ethio telecom should decide to adopt products of IoT and training must be provided to all employees regarding required and relevant topics. One strategy could be properly dividing the entrepreneurial units which should be segmented into independent small units for keeping up with the dynamism of the target market and its dimensions.

17. Diffusion and adoption(DOI)

Once all the technology product and services has been developed, a decision has to be made to begin diffusing the innovation as the different actors and stakeholders need to be in simultaneous ways so as to make the diffusion process as effective as possible.

Various stakeholders can be the entity producing the innovation or the IoT product and services, entity(es) funding it and others while various actors could be change agents, diffusion agencies or systems, governmental agencies, regulating agencies, and other actors which has the ability to communicate and disseminate the innovation to potential adopters. In this stage the company must create organizational relationship with other companies to facilitate the successful diffusion and adoption of the IoT technology.

5.3 Demonstration

Demonstration of the artifact developed, the strategic guideline was made to the respondents. In this phase the researcher demonstrated the strategic guideline to the respondents for the purpose of collecting constructive feedback so as to improve the artifact. Since the strategic guideline is in statement format, the technique used by the researcher was to create a graphical representation of the guideline main components and demonstrate the graph constructed. After this, a brief description of how we come up with the guideline was made. In addition to this, a description on how the components are interrelated to each other and what each of the component represented was clarified to the respondents so that they could have a clear picture of the strategic guideline.

The demonstration was made by using a laptop and a projector, a printed copy of the strategic guide was also shared with 10 respondents so they will be able to see the components and their description by themselves.

5.4. Evaluation of the strategic guideline

As an artifact, the developed guideline need to be evaluated so as to evaluate its quality and fit for purpose which in a way be valuable to solve the identified real world problem[143]. Moreover, when evaluating an artifact it can be from multiple perspectives such as usability, completeness, functionality, and we may use any evaluation method such as expert validation, experimental testing, and descriptive method [143].

This study used expert evaluation to validate the proposed strategic guideline by using Delphi method. As Hsu [144] explained, the Delphi technique is a widely used method for collecting feedback from respondents in their domain of expertise. The reason for choosing the expert validation is since the Delphi technique is suitable to extract experts' opinion in certain aspect and in their own area of expertise. Therefore, 10 experts from information system division were chosen to evaluate the proposed strategic guideline. They were selected based on their relation with the IoT ecosystem and they also participate in the survey.

After the selection of the evaluators from the information system department, we prepared a printed format of the guideline and prepare a session to discuss with the participants.

The evaluation questionnaire was adopted from [145]. The questions were customized to our context. The printed guideline along with the evaluation questionnaire was provided to the respondents prior to the presentation. The researcher explained the component of the evaluation criteria's so that they have that in mind while the presentation was made. Next to that a brief presentation of the proposed strategic guideline was made to the respondents. After that, all of the experts were asked to evaluate the guideline (goal, environment, structure, activity, and evolution) by filling up the questionnaire.

Proposed strategic guideline evaluation result

A reliability test was made in order to test the questionnaire internal consistency using cronbach's alpha method before the actual evaluation. The result of the test is indicated in the below table as presented in the table, the cronbach's alpha test result is 0.861 this means the questionnaire response are reliable since it is greater than 0.7.

Based on the result, the survey achieved a value of approximately 0.86, meaning the question items have high interrelation, collinearity, and redundancy to measure same concept or construct.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
0.861	0.866	23

Table 5. 1-Reliability statistics result for the empirical data

A total of 23 question items were used to evaluate the proposed guideline through a Likert scale data measurement technique and then those interval scale items are grouped into five basic categories.

The evaluation questionnaire (see annex III) was analyzed using a descriptive statistical analysis such as mean and standard deviation methods. We used the mean to know the central tendency of the guideline. As shown in the table below the summary of the criterion is presented and the highest mean is 4.45 and the lowest 3.91.The evaluation result average mean is 4.14, which implies, the evaluators or the respondents have agreed that the guideline fulfilled the requirements of goal, environment, structure, activity and evolution. What is more, to achieve the maximum benefit of the guideline improvement areas and some feedback was provided from the survey evaluation using an informal interview at the end of the evaluation.

Descriptive Statistics					
Evaluation Criteria	N	Min	Max	Mean	Std. Deviation
Goal	10	2	5	4.45	.635
Environment	10	2	5	4.16	.846
Structure	10	2	5	4.04	.970
Activity	10	2	5	3.91	1.09
Evolution	10	2	5	4.16	.846
Average score of the guideline	10	2	5	4.14	.877

Table 5. 2-Descriptive statistics result of guideline evaluation survey

5.5. Discussion of result

A previous study conducted by Faizal et al., [146] assessed SMEs readiness on IoT and found that the respondents were quite optimism with IoT that will increase their control, flexibility, and efficiency of the works. However, the overall mean of innovativeness was not quite sufficient to suggest that they are ready to be the pioneers and thought leaders of IoT. Meanwhile, the respondents do not feel discomfort with IoT, but undecided either it can be trusted or not for doing business.

A study by Faizal et al., [146] only studied the SMEs readiness in Malaysia. In addition to assessing Ethio telecom employees readiness, this study, have developed a strategic guideline to support in the adoption of IoT. As a design science research, any artifact must be evaluated before actually put in place. The evaluation result of this study showed that the respondents have agreed with the strategic guideline fulfilling goal, environment, structure, activity and evolution with a total mean of 4.14 out of 5.

After the demonstration and evaluation an informal discussion was held with the respondents, and the following are the feedbacks provided

- The guideline should be utilized in the real life situation.
- There could be some unforeseen changes and requirements, which may arise as the implementation begun. Therefore, the guideline must be open and allow to incorporate all new circumstances.
- Detailed and step-by-step instruction on how each of the guideline component works is essential.
- An agreed framework by scaling up the strategic guideline, to guide the company on its IoT readiness implementation and further refinement may be required depending on the things available on the ground.

Chapter six

Conclusion and Recommendation

6.1 Overview

This chapter presents an overall summary of the research undertaken. It focuses on showing how the result of the study is related to the research questions and objectives set in the thesis. This chapter also provides recommendations for future researchers and extension of this thesis finding.

6.2 Conclusion

As a new technology, Internet of Things is at the initial stage of development in Ethiopia. IoT is one important enabler of IR 4.0 that will redefine the domain different industries. IoT will affect the competitive advantage of companies worldwide including Ethiopia. Due to its novelty, the IoT readiness of Ethio telecom is yet to be understood. The findings of this study confirmed that the respondents are quite optimism with IoT that will increase their control of the work and efficiency. Though, the overall mean of innovativeness is not quite sufficient to suggest that the employees are ready to be the pioneers and thought leaders of IoT.

So as to improve the level of Ethio telecom IoT readiness, additional incentives and support should be provided to the respondents as a payback for their optimism on IoT. What is more, more training should be provided to the employees in order to improve their knowledge on IoT products and services. Meanwhile, even though the respondents do not feel discomfort with IoT, more awareness should be created on how to control IoT and make good use of it. Moreover, long time planning is a must regarding the use of IoT to avoid becoming too dependent on it, also to maintain existing human interactions and relationships. Lastly, the respondents' awareness and knowledge should be increased with relevant programs. This research is an initial study to understand IoT readiness basic components to contribute to future studies. For next investigation and researchers, this research can be extended by evaluating the strategic guideline to assess the readiness of Ethio telecom for IoT.

In order to achieve the objectives of this research an attempt was made to answer the following research questions:

Challenges to adopt IoT by Ethio telecom

In response to this question, through literature review an attempt was made to identify the challenges to adopt IoT by Ethio telecom by conducting a thorough literature review. The literature review result revealed that the most common challenges faced while adopting IoT includes performance, reliability, availability, security and privacy, scalability, precision, interoperability, big IoT data, compatibility mobility and investment.

Requirements to design the strategic guideline

In oder to identify the requirements needed to design the strategic guideline, a primary data was collected using survey questionnaire to identify the readiness level of the respondents in order to adopt IoT. the analysis result indicated that the respondents were not as such motivated therefore they required more motivation from the top management, it seems that the respondents do not have control over IoT and worried that IoT will create dependence on the technology. What is more, the respondents also feel insecure about IoT. Based on the identified gaps from the data analysis the researcher tried to define the design requirement for the strategic guideline and set the following:

- Top management support to motivate and support the employees towards using IoT,
- To let the company employees have more control over IoT, the guideline must have a component to assess the complexity of IoT, as having control will depend on how complex the technology is.
- In order to reduce employees feeling of insecurity, the strategic guideline should have a component to address implementation of security, governance and policy.

What suitable guideline can be designed to guide the adoption of IoT by Ethio telecom?

The proposed guideline incorporates the findings that are identified using the survey questionnaire. In addition, the findings of the research indicated the area of improvement which needs to be included, in relation to technology readiness of the employees, and are addressed in the guideline. Therefore, to fill the gaps identified from the survey requirement, the proposed guideline was designed by incorporating some components from TOE and DOI frameworks.

The proposed guideline is believed to improve the readiness of Ethio telecom to achieve a successful adoption of IoT and be prepared in advance for the upcoming changes to save a huge amount of investment. This study doesn't perform the workability analysis of the strategic guideline by applying it a real life situation. Therefore, another research need to extend the finding of this research by testing the guideline in Ethio telecom context.

6.2 Recommendation

Based on the findings of the study, the following recommendations are suggested as a way forward.

- This research study focuses on IT professionals from Ethio telecom information system division for collecting data and designing the guideline. Further research needs to be done to assess IoT adoption from users and customers perspective.
- The respondents' optimism on IoT is a good indicator to transform Ethio telecom towards IR 4.0. *With this level of optimism, the respondents should be given more encouragement, incentives, opportunities, and supports from the company to equip themselves with IoT technologies.*
- The respondents' do possess some elements of innovativeness that will help them to increase their motivation to adopt IoT. Nevertheless, as the score falls between 'neutral' and 'agree', the respondents are more likely to be technology followers than the innovators. *Since IoT is still very new in our country and for Ethio telecom, the respondent's knowledge needs to be enhanced in order to be the pioneers and thought leaders of IoT. This can be done by exposing them with more training on IoT.*
- The respondents' are not feeling discomfort with IoT. This is a good sign to introduce IoT as the respondents are not thinking that they will be losing control and being overwhelmed by IoT. *Even though the results didn't show that discomfort with inhibit respondent's readiness for IoT, training on how to achieve better control of IoT and make good use of it must be provided.*
- The respondents are a bit skeptical that IoT will work properly and will not bring harmful consequences to the company. *Therefore, to increase IoT readiness of Ethio telecom and to get full support from the top management, the respondents' skeptical feeling on IoT should be reduced.*

- Since IoT is a new technology, top management initiation to introduce IoT in Ethio telecom is very important. In addition to this, top management optimism on IoT will increase the confidence level of employees and provide support to implement the new change.
- IoT security issues should be given priority where the facilities and infrastructures to improve them have to be designed and developed.
- Other researchers can extend the result this research by testing the workability of the strategic guideline developed in this research.

The evaluation survey confirmed that the guideline components can fulfill those five criterias and the guideline is ready to be used for assessing the readiness.

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Annex I: Information Sheet

Dear Sir/Madam,

In partial fulfillment of the requirements for the Degree of Masters of Science in Information systems, currently I am conducting a research on "Designing a readiness assessment guideline towards adopting IoT: The case of Ethio telecom" at Addis Ababa University. The aim of this study is to design a framework for guiding the adoption IoT by Ethio telecom. This questionnaire is prepared with the aim to collect data about the readiness of the company. Your answer is extremely valuable for the success of this study and it is highly appreciated. The questionnaire survey will take approximately 30 minutes to complete and the results of the survey will be used for the purpose of academic research only. Hence, all responses will be kept in strict confidentiality and individual participants will not be identified in any reports or publications and also shall not be used for other purposes other than the intended aim of this research. I kindly ask you to read all the questions carefully and give your genuine answers based on your awareness of the current condition at your company. Your dedication is most valued and appreciated and I would like to take this opportunity to thank you in advance for your kind participation, genuine and on time response to the questionnaire.

If you have any inquiry, please feel free and contact me @ amanuelzewdu3@gmail.com or +251932514406

Thank you Again!

Amanuel Zewdu

Annex II: Data collection instrument

Demographic Characteristics:

Please indicate your response to each question by circling the appropriate answer.

1. Age

A. 10 - 15 years old
B. 15 - 30 years old
C. 30 - 45 years old
D. 45+

2. Education

A. High School
B. Bachelor's Degree
C. Master's Degree
D. Ph.D. or higher

3. Work Experience

A. 1-2 years
B. 3-4 years
C. 5-10 years
D. More than 10 years

4. Current Position

A. Directors

B. Managers
C. Executives
D. Engineers
E. Consultant
F. Trainer

4. ICT Utilization Percentage

A. Email
B. Mobile Massagers
C. Computer & Software
D. Social Media
E. Online Business
F. Others

No	Questions	Survey Scale: Strongly Disagree=1; Disagree=2; Neutral=3; Agree=4; Strongly Agree=5;				
	Optimism					
1	IoT will contribute to a better quality of working environment.	**1**	**2**	**3**	**4**	**5**
2	IoT will give me more freedom of mobility at work.	**1**	**2**	**3**	**4**	**5**
3	IoT will give me more control over my daily activities at work.	**1**	**2**	**3**	**4**	**5**
4	IoT will make me more productive in my working environment.	**1**	**2**	**3**	**4**	**5**
5	I prefer to use the most advanced technology available.	**1**	**2**	**3**	**4**	**5**
	Innovativeness					
6	Other people will come to me for advice on IoT at work	**1**	**2**	**3**	**4**	**5**
7	I will be among the first in my circle of friends to acquire IoT when it appears	**1**	**2**	**3**	**4**	**5**
8	I can figure out IoT products and services without help from others	**1**	**2**	**3**	**4**	**5**
9	I can keep up with the latest IoT developments in	**1**	**2**	**3**	**4**	**5**

	my areas of interest					
10	I enjoy the challenges of figuring out IoT gadgets.	1	2	3	4	5
	Discomfort					
11	If I get technical support from a provider of an IoT product or service, I will sometimes feel as if I am being taken advantage of by someone who knows more than I do	1	2	3	4	5
12	In my opinion, technical support lines will not be helpful to explain IoT in terms that I understand	1	2	3	4	5
13	Sometimes, I think that IoT systems are not designed for use by ordinary people like me	1	2	3	4	5
14	There is no manual for IoT product or service that's written in plain language	1	2	3	4	5
15	It is embarrassing when I have trouble with an IoT gadget cwhile people are watching me.	1	2	3	4	5
	Insecurity					
16	I will be too dependent on IoT to do my work	1	2	3	4	5
17	Too much IoT will distract me to a point that is harmful	1	2	3	4	5
18	IoT will lower the quality of relationships by reducing personal interaction	1	2	3	4	5
19	I will not feel confident doing business with a place that can only be reached by IoT.	1	2	3	4	5
20	I am worried that information I sent over the internet will be seen by other people.	1	2	3	4	5

Annex III: Evaluation Survey

Dear respondent,

I am conducting a research entitled "**Designing Readiness Assessment Guideline towards Adopting IoT: The case of Ethio telecom**" as part of the partial fulfillment of the requirements for the Degree of Master of Science in Information Systems, at Addis Ababa University. Throughout the data collection process, you have provided valuable inputs especially during the guideline demonstration and evaluation phases. In this sense, the proposed guideline is improved rigorously based on your previous comments and suggestions.

This evaluation survey as the extension to the previous interview evaluation is developed based on five categories and these are goal, environment, structure, activity, and evolution. The first section will evaluate the goal of the proposed guideline in terms of goal attainment, utility, feasibility, and generality. The second section will evaluate the environmental perspective of the proposed guideline in terms of people, technology, and organization. The third section will evaluate the structure of the proposed guideline in terms of completeness, simplicity, understandability, consistency, and homomorphism. The fourth section will evaluate the activity of the proposed guideline in terms of completeness, simplicity, consistency, functionality, trustworthiness, and performance. The last section will evaluate the evolution of the proposed guideline in terms of robustness, scalability, adaptability, modifiability, and learning capability.

The evaluation survey will take approximately 25 minutes to complete and the results of the survey will be used for academic research only. Hence, all your responses will be kept in strict confidentiality and would not affect anyone in any case. If you faced any unclear points or need support, please do not hesitate to contact me through the below address.

The evaluation survey is conducted by employing a five-point Likert scale technique. The scales are; strongly agree, agree, neutral or neither agree nor disagree, disagree and strongly disagree and their assigned weights are 5, 4, 3, 2, 1 respectively.

Thank you in advance for your active participation and generous contribution to the evaluation of the proposed guideline.

Amanuel Zewdu
amanuelzewdu3@gmail.com

No	Evaluation Criteria	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	Goal					
1	The proposed guideline will allow achieving its objective or can facilitate the successful adoption of IoT.					
2	The proposed guideline will be useful to achieve the desired goal.					
3	The proposed guideline is feasible in terms of technical, operation, and economic perspective					
4	The proposed guideline is broader in scope to address the problem					
	Environment					
5	The proposed guideline is consistent with people in terms of usefulness, ease of use, ethicality, and absence of side effects.					
6	The proposed guideline is consistent with the organization in terms of business alignment, and absence of side effects.					
7	The proposed guideline is consistent with technological fitness, and the absence of side effects.					
	Structure					
8	In terms of the structure of the proposed guideline, it is complete and contains all the necessary elements					
9	The proposed guideline contains a minimal number of elements.					
10	The proposed guideline is uniform, standardize, and free from contradiction among the elements.					
11	The proposed guideline can be comprehended, both at a global level and the detailed level of the elements inside the guideline					

12	The proposed guideline is in harmony with another model and the modeled phenomenon					
	Activity					
13	The activity of the proposed guideline contains all necessary elements and relationships between elements					
14	The capability of the proposed guideline to provide functions which meet stated and implied needs when it is used under specified conditions					
15	The activity of the proposed guideline contains the minimal number of elements and relationships between elements.					
16	The activities in the proposed guideline maintain their uniformity, standardization, and freedom from contradiction among the elements.					
17	The proposed guideline is trustworthy in terms of expected outputs delivery and performing correctly.					
18	The degree to which the proposed guideline accomplishes its functions within given constraints of resources.					
	Evolution					
19	The proposed guideline can handle invalid inputs or stressful environmental conditions.					
20	The proposed guideline either to handle growing amounts of work gracefully or to be readily enlarged.					
21	The ease with which the proposed guideline can work in contexts other than those for which it was specifically designed					
22	The ease with which the proposed guideline can be changed without introducing defects					
23	The ability of the proposed guideline to learn from experience					

Declaration

I, the undersigned, declare that this thesis research is my original work and has not been presented for a degree in any other university, and that all source of materials used for the project have been properly acknowledged.

Declared by:

Name: Amanuel Zewdu

Signature:__________ **Date:** July /20/22

This thesis research has been submitted for examination with my approval as university advisor.

	Name	**Date**	**Signature**
Advisor :	Million Meshesha(PhD)	July 20/22	

Addis Ababa University

College of Natural and computational Sciences

School of Information Science

Title:- Designing Readiness Assessment Guideline towards Adopting IoT: The case of Ethio telecom

Candidate: Amanuel Zewdu Signature_____________ Date_________________

Advisor: Million Meshesha(PhD) Signature_million_ Date_July 20/2022_