FUTURE INFRASTRUCTURE OF IOT: LARGE SCALE DEPLOYMENTS OF IOT COMPONENTS

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ABSTRACT

Non PC devices and gadgets are increasing day by day, due to this increase and all the time connectivity of the devices to the Internet raised many challenges; such as memory shortage, IP configuration space, energy consumption and security issues. Current infrastructure of internet of things (IoT) is still not mature enough to handle all of these changes. Although, many attempts have been made to address these challenges in the context of IoT, but the proposed solutions either address the specific issue or are very generalized. Thus there is a need to look at the proposed approaches and solutions from a holistic perspective to uncover future benefits and increase applicability and integration of the solutions proposed in literature for IoT. Hence, in this paper and attempt have been made to gather and analyze all the existing and proposed solutions in the literature based on different parameters. Looking at the literature this survey helps in developing the understanding of the existing IoT infrastructures and provide insights about future infrastructure for IoT components and/or devices. The given future directions are based on the focused survey of many research papers.

Keywords:Future Internet; Infrastructure of (IoT); Networks; Smart objects; heterogeneous devices; Cloud computing; Internet of Things.

1. INTRODUCTION

The term Internet of things (IoT) was first used in 1999 by Kevin Ashton [1] in the context of supply chain management. But now it is used in a broader perspective. Hence, the connected devices not only access information from the internet but are following the protocols the internet uses to store information. Due to use of modern technology like Wi-Fi and Bluetooth there has been a very rapid increase in data utilization and exchange. The size of data related to users has become so big that managing it became a challenge. In communication the deices use common grounds to make communication easy between the users. Thus the use of Radio-Frequency Identification (RFID), tags, sensors, mobile phones, etc. is increased. RFID is usually interacting through a unique addressing scheme [2]. Ubiquitous computing became an emerging technology now a day. It uses resources which can be made available anywhere at any time. Cloud computing has become well-known lately because of its provision of making resources on the network available for shared use. Cloud helps users to save their money on processing resources, software and infrastructure and it is easy to use. In cloud the available resources on the network are utilized to perform the assigned task. The data are handled in third party data centers. Cloud is a joint pool of resources which is provided on claim/demand. Cloud computing has

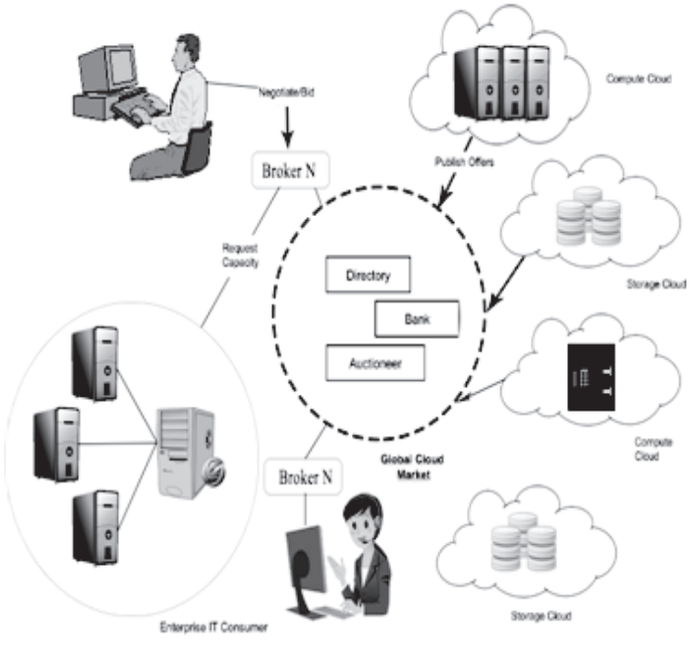


Figure 1. Global Cloud exchange infrastructure for trading services.

become a highly demanded service or convenience due to the advantages of high computing power, low cost of facilities, high performance, scalability, low-priced software, ease of access as well as availability. Cloud dealers are facing progress rates of 60% per year, but as this is a new field in its beginning, cloud computing still has flaws that need proper attention and there is a need to make working on these systems more users friendly.

The devices connect to the clouds and remain on the network for accessing resources or data are called smart objects, i.e., any hard ware on network is a smart object. An object is considered a smart objects [4] that have the following features:

- It is hardware and have features like ability to process and store data.
- It can be discovered on a network and can communicate back.
- It has a unique ID, physical address and a name.
- It can process physical data with the help of actuators.

From Figure 1. we can easily understand how cloud computing infrastructure works and how data break down and travel into different communication mediums. In cloud computing infrastructure, data are stored into central location and on demand every device can access the data. In future it has to be figured out that how huge amount of data could be managed and how future infrastructure will be able to handle large number of IoT devices requesting connections and data access.

2. PROPOSED SOLUTIONS

In this section we will go through all the solution that are proposed in recent years and we will also see their advantages and limitations. In next section we will discuss some of the practical implementations, after that we will compare all the discussed technologies to see which ones can be practically implemented and which ones are not and what are the possible reasons that make those approaches impractical. In the last section we will discuss some open issues and conclude the paper.

(I) NGSON/SON

IP traffic in the global level is increasing and in near future the challenging situation will arise [9] because most of the IoT objects or devices are non-PC. So for the increase in both IoT devices and IP traffic expect some new requirements from the existing infrastructure, such as support for reliable and scalable content distribution, IP traffic management, privacy, security, trust, mobility etc.
However, the current infrastructure of Internet was never designed for fulfilling those requirements [9]. Some organizations are currently working in these issues and they have introduced new concepts and designs that are to be helpful in above mentioned situations. For example, NGSON (Next Generation Service Overlay Network [6]) Standardized by IEEE that are providing more efficient services like video streaming over a Service Overlay Network(SON) based on custom user context. Besides this a network infrastructure for IoT is proposed in [5]. This infrastructure has following characteristics:

- Infrastructure is context-aware
- It supports edge diversity
- It uses virtual network instance as a service
- It is evolvable network infrastructure

There is a drawback in this infrastructure and that in its context manager or context-aware feature the context support is lacking because there is no support for user-center services

(ii) Daidalos/ SWIFT

As discussed above there is a large increase in IoT devices and mostly these devices are non-PC devices the next problem we will have to face in such a situation is security and privacy issues in communication and end devices. There are many methods available to overcome this problem like pop-ups and warnings about certificate mismatches. The EU projects name Daidalos [10] and SWIFT [11] are addressing the same problem and there are several solutions presented in these projects.

In this context [12] proposed a new infrastructure for IoT. There are two major directions in which this infrastructure can handle security and privacy in near future, one is Identinet, in which identities are at the end point where all the communication takes place these identities may classify all the entities like persons, software and devices. Second direction is digital shadow. Digital shadow takes data as entities using services and nodes in special meaning that help users to interact with the multiple entry points to access the real world data without interrupting the actual view on the data. There are two minor issues with this approach. First, that it is only applicable in SWIFT[11] and the second one is that there arises uncertainty when the environments become dynamic and collaborative.

(iii) IPv6 Mapping Scheme

IoT concept is very vast, every physical device that has some unique id and some memory storage called smart object [13] like QR(Quick Response) or matrix barcodes, Universal Resource Locators (URLs), Radio Frequency Identification (RFID) these all are connected to some network called internet of things and due to increase in there devices there are problems in identification and assigning address or IPs

so a solution provided by the authors in [13] that is based on Internet Protocol (IPv6) mapping. According to authors everything that can be connected to the IoT becomes extendable through this infrastructure or protocol. By the use of IPv6 mapping scheme [14] we can assign and utilized more addresses than before.

(iv) TR(time-reversal)/5G

As we discussed that in future there will be large number of smart objects and IoT devices will connect with each other then the major challenge that we will be facing would be energy issue. According to [16] a new technique or an infrastructure for IoT is introduced for objects named as TR(time-reversal) It is an ideal paradigm for IoT. According to this technique we can reduce the power consumption as well as interface alleviation. through TR system we can support multiple concurrent users that are active and provide better and efficient battery life. This infrastructure reduces the computational power and complexity and also the cost of devices that are connected to the terminal nodes. TR system also supports the various quality of Service QoS options. The system also provides the additional physical-layer that enhance the security and privacy in IoT for customers. The system also accommodates heterogeneous devices that are located in terminal nodes. Recently the researchers are working on new technology called 5G in mobile telecommunications and that will be more efficient and faster that current 4G standards. According to [15] the major idea in this system is non-orthogonal multiple devices access strategy, where massive IoT devices will be connected According to TR infrastructure for IoT these issues are already resolved and mathematically proven [16].

(v) VM (Virtual Machine)

The concept of smart cities and smart homes are also related to IoT, with the passing time rapid changes are taking place in technology as well as the concept of IoT. In near future when there will be large number of devices and other smart objects connected with each other two major problems can occur. The first one is computational complexity because an ordinary device with limited processing power cannot perform complex calculations and the second is the storage issue or memory limitations in devices so there is a need to design new infrastructures

for these problems. The authors in [17] are addressing the same problems and the solution they proposed is related to "Cloud Computing" and "Cloud storage". Cloud computing is very hot topic in such situations. There are many solutions provided in this paper and the concept of VM (Virtual Machine) is introduced. Cloud is also providing the services all around the world. The proposed system is Market-oriented. According to the proposed system cloud computing will be very helpful in near future for storing and computing complex problems that are impossible for ordinary devices. According to the system virtual machine or device will be assigned to every device that will perform the specific operations according to the needs of that device. The drawback of this system is wastage of energy and security issues may also arise.

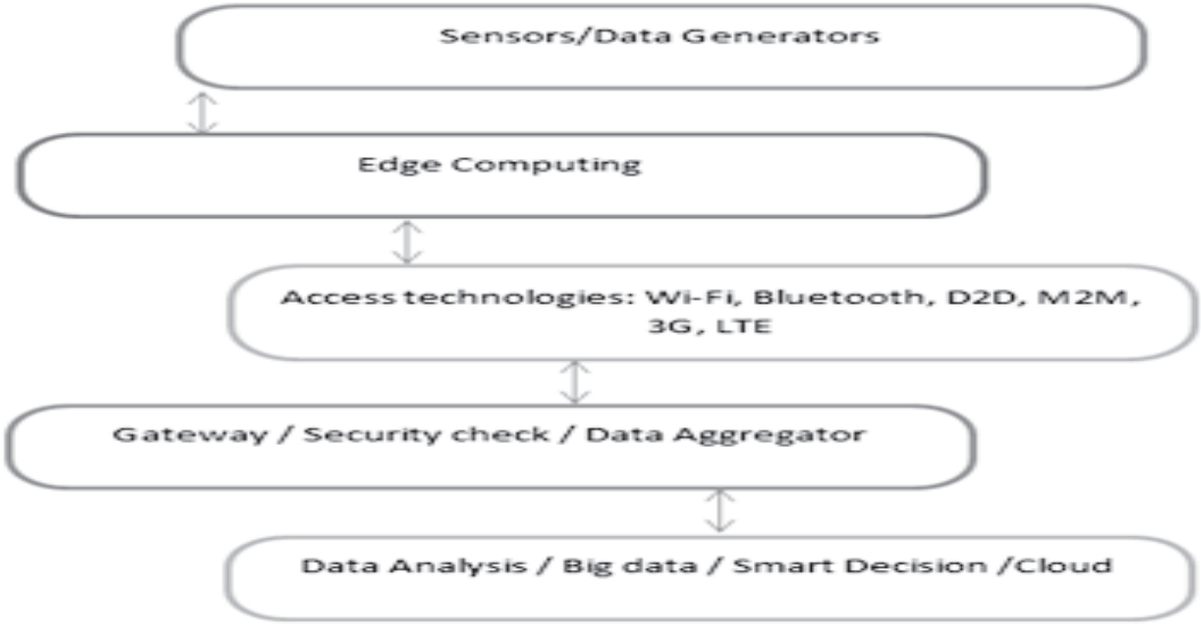


Figure 2. General Hierarchy of Current Technology

(vi). LEONORE

IoT application models work in such a way that IoT devices have some external dependencies and they can only send and receive data at their end terminals nodes. This imply that these models are based on layer architecture whose bottom layer is compatible with IoT objects or devices and the other layers like business and logic layers are involved in some other process. In this way when large scale IoT components and heterogeneous devices are connected at the bottom level then, it becomes very difficult to handle data at this ordinary infrastructure. In the domain of smart cities and large scale developments a new infrastructure has been proposed that is named as LEONORE [19], it is a service oriented infrastructure which provides software package that facilitates the heterogeneous terminal devices. After applying this infrastructure, the devices are able to controls their processors by themselves. The proposed solution is also applicable in pull-based as well as push-based. Pull-based is usually used in configuration management systems so that devices are schedule and provisioning runs to off-peak time, on the other hand push-based solution allow devices to control over the applications that are installed on them also the software updates and security fixes. The proposed system is also tested based on real world scenario and the statistical results prove that this infrastructure is much more efficient and fast in the domain of Smart cities and large scale development of IoT than the ordinary layer architecture. There are some issues at gateway level that still need more research.

General hierarchy of current technology for IoT connectivity and authentication is given in Figure 2.

3. SENSING CHINA (EXPERIMENT)

In the field of IoT many experiments have been carried out. According to [18] smart buildings using IoT can be used to improve efficiency in communication and quality and reduce wastage in terms of time. The "Smart Cities" term has been introduced because those cities use intelligent and efficient technology. According to [18] survey paper, an experiment project was launched named 'Sensing China' in china in June 2010 after the successful completion of the project everything that was involved in this project had identification tags. The benefit of these tags was, that every device can share information and can broadcast the data through some communication medium. People could track information and monitor the data through objects. In near future these projects play the key role in development of IoT. The Authors believe that in future these concepts and designs will become very common.
The main future infrastructure of IoT is shown in Figure 3.

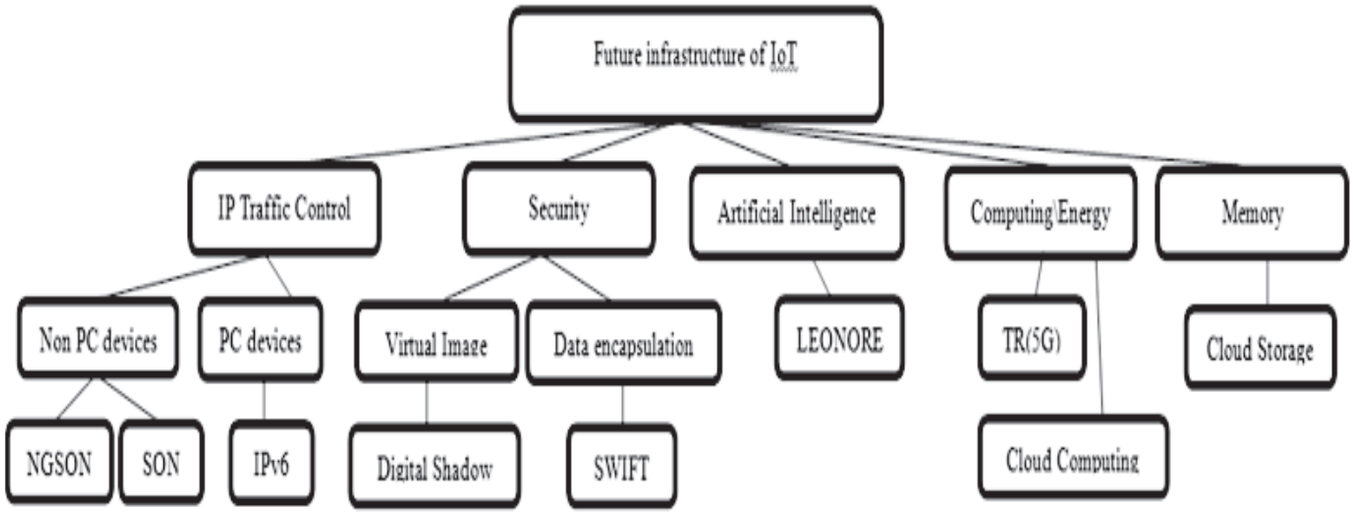


Figure 3. Future IoT Infrastructure

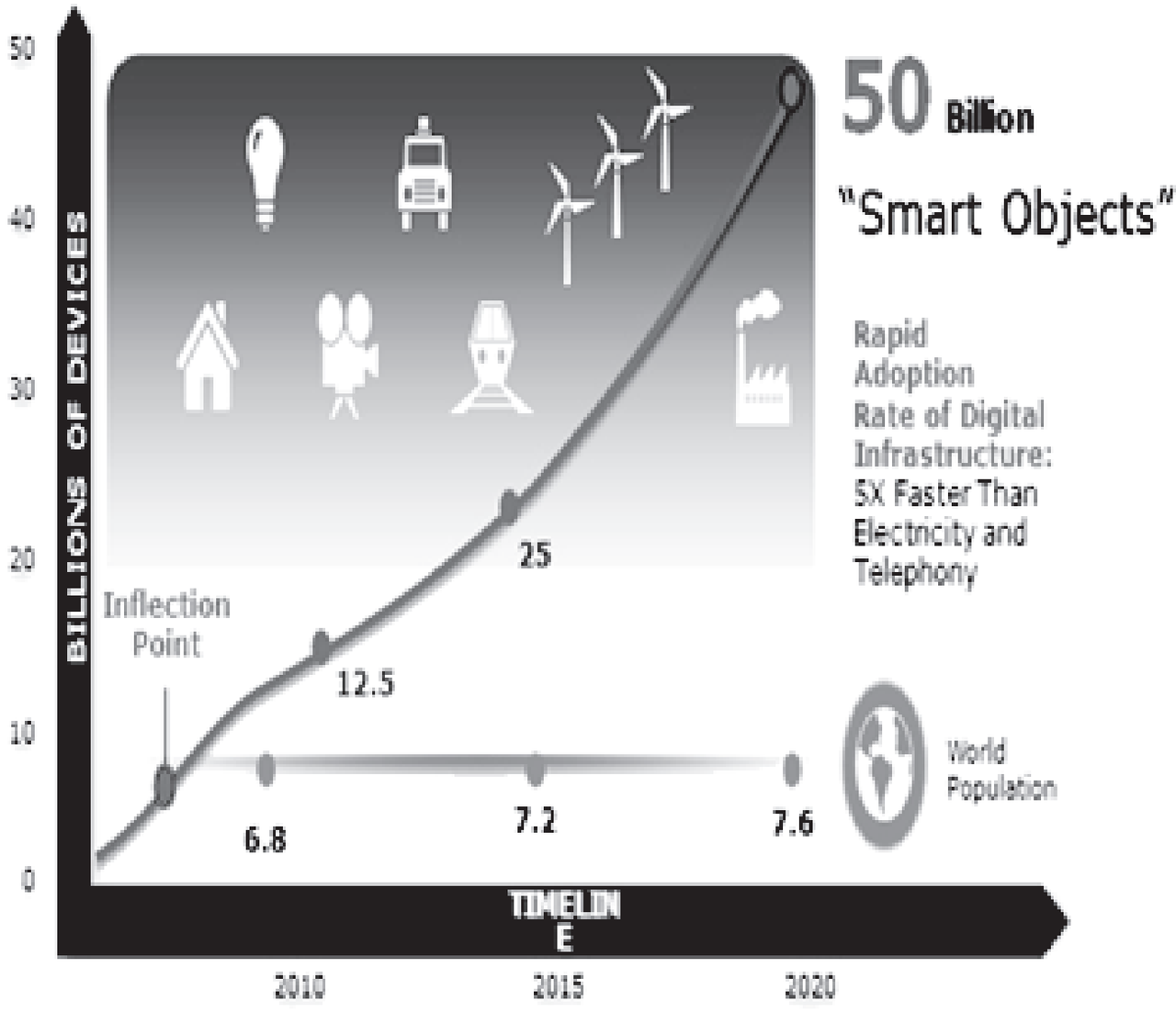
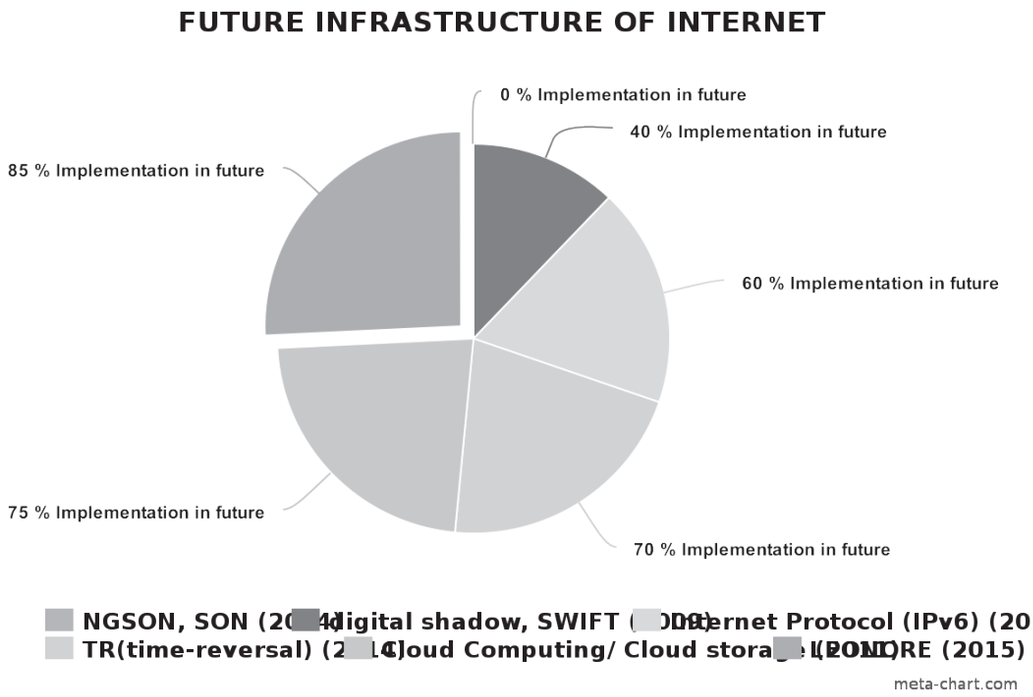


Figure 4. Increase in IoT devices in future.



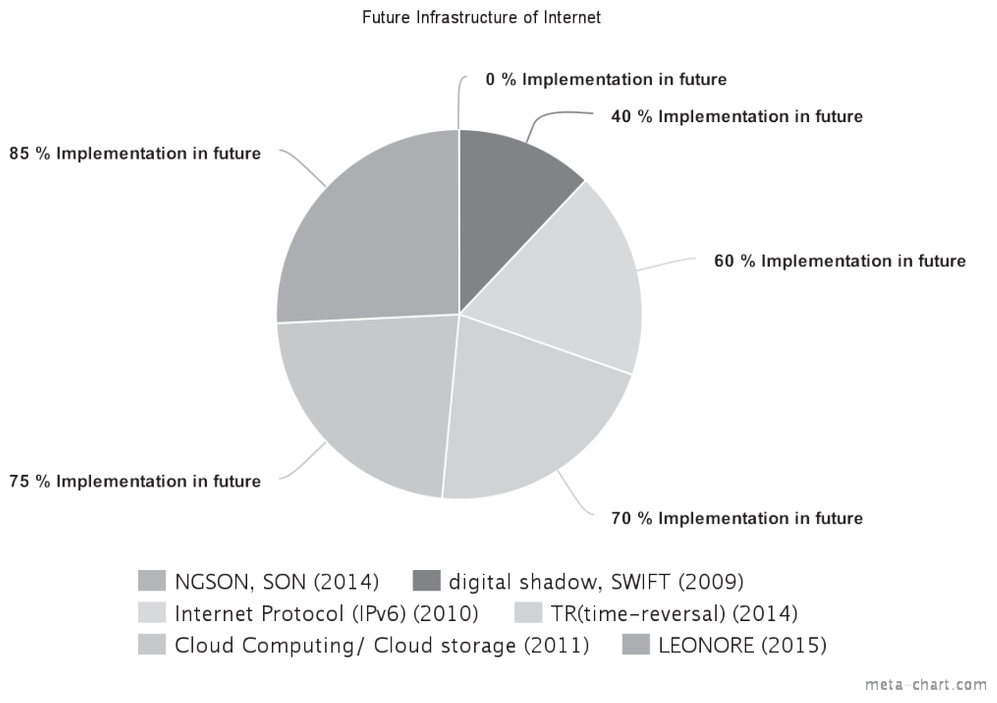


Figure 5 (a)(b) Future infrastructure and technology applicability in IoT

Table 1: Performance Evaluation of IoT Solutions

Infrastructure / Technology	Year of Propose	Practical Implementation	Statistical Result	Details
NGSON , SON [9]	2014	Test phase	nil	To control IP traffic for non PC devices
Digital shadow SWIFT [12]	2009	nil	40%(paper based)	The concept of virtual image or data encapsulation
Internet Protocol (IPv6)[13]	2010	Implemented	60% (current Internet)	A mapping scheme to control IP traffic
TR(time-reversal) [16]	2014	Test phase	70 Expected	The concept of 5G / Efficient computation / Energy Efficient
Cloud Computing/ Cloud storage	2011	Implemented	75%	The concept VM (Virtual Machine)/Storage
LEONORE [19]	2015	Test phase	85% (proven through Experiment results)	AI (Artificial Intelligence) at terminal devices /Software base Solution

(VI) PERFORMANCE EVELUATION & COMPARISON

There are so many IoT devices that are rapidly increasing and connecting to the network, according to the recent study [9]; that 80% devices are non PC devices and in near future it is very difficult to handle the entire infrastructure. We have already discussed different infrastructure and the techniques that are proposed recently. Figure 4. shows state that how much increase in these devices in near future.

In the Figure 4. we can see that as the time passing we should have need to a new infrastructure that will be capable to handle the huge increase.

So according to the given statistical results that are gather form different research papers we can draw a pie chat that is given in Figure 5(a) and (b).

There are many things to be compare like IP traffic control, storage in IoT devices, security, artificial intelligence , data backups , computational complexity etc in all these aspects many infrastructures have been proposed but as compared to all the infrastructure LEONORE[19]is giving the best results according to the researchers this infrastructure is tested in real ground and the experiments prove that in near future this infrastructure can be implemented because according to it when the device has ability to learn and respond accordingly, at that time it will be very easy to manage everything. Moreover, in near future devices will need large memory for that Cloud Computing/ Cloud Storage [17]gives the best results and in near future it is highly likely that everything will be on cloud. In the context of TR(time-reversal) [16] or 5Gthe research shows this infrastructure could be implemented in near future because energy is the main issue increasing day by day so it could be the best solution but in terms of computational resource to cloud computing technology is matchless. According to [14] IPv6 solution could not be helpful in near future due to enormous increase in IoT devices. So in near future we need an infrastructure that will provide all the aspect at the same time like energy, machine learning, security, complex computation solution, high storage capacity etc.

5. OPEN ISSUES

Increase in ubiquitous computing, smart devices, architectures and IoT technology many things are going to face rapid change in near future and there are many emerging technologies and infrastructure that could cope with the emerging challenges. In order to meet the future, challenges these infrastructures need to be designed carefully. Research shows that machine learning and artificial intelligence(AI) based contextual and self-configurable solutions will replace the existing technology. Literatures points out that in future there will be large number of non PC devices hence focus remains on the connectivity, security, data intensive devices and cloud based solutions. Besides, intelligent technology and increased connectivity bring new challenges. Moreover, memory issues and energy issues, are always challenging and lot of work is required there in these field.

6. CONCLUSION

In this paper a survey of the various infrastructures available in literature is presented with the focus on the challenges of the Internet of Things technology. We reviewed the focused literature on various infrastructures recently proposed for IoT in terms of memory needs, processing needs, connectivity. It turned out that various proposed architectures for future IoT technologies have their benefits and limitations and those frameworks suggest diverse approaches and solutions. Thus, this survey provides the initial insights in the rapidly growing field of IoT. Based on the facts in existing literature the emerging trends are highlighted in this paper. In future we aim to explore the real world cases for such technology with the experimental data and results.

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