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Internet of Things (IoT) – A Technological Analysis and Survey on Vision, Concepts, Challenges, Innovation Directions, Technologies, and Applications (*An Upcoming or Future Generation Computer Communication System Technology*)

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Abstract The Internet of Things (IoT) has been inscription in this review paper. Internet of Things is a keyword to cover various challenges related to internet and the web to the real physical world. We know that, today internet has already taken an important part of everyday life and it has also dramatically changed the lives of human being. The most important factor of this invention is, integration or combination of several technologies with the communication system solutions. The most applicable factors of IoT is the identification and tracking various factors for smart objects. The universal sensing networks is enabled by Wireless Sensing Networks (WSN) and these technologies cuts across many areas of modern day living. The escalation of these devices in a communicating and actuating network will create the Internet of Things (IoT). Here the sensors and actuators combine easily with the environment around us and the information is shared across various platforms in order to develop a common operating picture (COP). Internet of Things predicts the future that, the advance digital world and the physical world will get linked by means of proper information and wireless communication system technologies. In this survey paper we have mentioned the visions, concepts, technologies, various challenges, some innovation directions, and various applications of Internet of Things (IoT).

Keywords: *IoT, internet, identifications and tracking, Wireless Sensing Networks (WSN), sensors, actuators, Common Operating Picture (COP)*

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1. Introduction

A group of two or more than two computers or mobile systems linked together is called as a network. The Internet is a global system of interconnected computer networks that use the standard Internet protocol suite (TCP/IP) to link several devices worldwide. The Internet is basically carrying a high range of data or information and services and applications to support email, and telephony. Internet of things (IoT), it is nothing but the combination of network of various physical objects with electronics, software and network connectivity, which enables these physical objects to collect and exchange data between various souses to destinations. Nowadays, people use the Internet for browsing the Web, sending and receiving e-mails, accessing various multimedia content and services, playing games, using various types of social networking applications and many other tasks. One of the most important thing is that, the Internet will be existing as a base line of classic networks and networked objects.

In [1], the authors have mentioned that, The Internet of Things (IoT) is a novel design which is rapidly gaining the importance in modern wireless communication systems. The basic or fundamental idea behind this concept is the pervasive presence around us of a variety of things or objects – such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile telephones, etc. are able to interact with each other and cooperate with their neighbors to reach common goals. One thing is IoT will have a very high impact on everyday life. From the private user's point of view, one of the most prominent effects of the IoT will be visible in both working and domestic fields. In the United States of America, the National Intelligence Council (NIC) predicts that by 2025 Internet nodes may occupy in everyday things. Many developed countries like United states of America, Europe and some countries of Asia like India, china and japan, they are now a days considering internet of things (IoT) as an area of innovation and growth. So to develop this system, an extensive research is going on in various universities and many research organization across the globe.

In [2], it is mentioned that, the revolution will be empowered by the embedding of electronics into everyday physical objects, making them ‘‘smart’’ and letting them seamlessly integrate within the physical world and this will be giving rise to new opportunities for the Information and Communication Technologies (ICT) sector, paving the way to new services and applications able to leverage the interconnection of physical and virtual realms. In [3,5], it is mentioned that the word or expression “Internet-of-Things’’ (IoT) is broadly used to refer the resulting global network interconnecting smart objects by means of advanced Internet technologies. Devices like Radio Frequency Identification (RFID), sensors, actuators, machines etc. are necessary to support the applications related to IoT and also the whole applications, services to provide such kind of technologies to open new business and market opportunities. In this review paper we are providing a brief interpretation or standpoint on the development and fundamental concept of Internet of Things (IoT), including various kind of research challenges, technologies etc. The IoT is facing many problems like various network challenges and also the “things” formulating the IoT will be specified by low resources in terms of both computations and energy capacities [3]. Several industrial and research bodies are currently working in the activity of research and development of solutions to satisfied the pinnacled technological requirements. This review paper also gives a picture or brief idea of the current state of the creative activity on the Internet of Things (IoT). The further development and potential of Internet of Things has been estimated by using some technologies like cloud computing, Big Data, networking, robotics etc. and these concepts are overlapping in some part of the development process. Many big industries like Cisco, Ericsson, they have identified the development or evolution of internet of things (IoT) embedded with smart environment and smart platforms. In the below section some fundamental concepts and visions have been described.

2. Vision and Fundamental Concept Behind IoT

Internet of Things (IoT) is a concept that considers extensive presence in the environment of a variety of smart objects that through wireless and wired connections. The unique addressing schemes are able to interact with each other and cooperate with other smart objects or we can say smart things to create many new applications or services and also to achieve a common goal.

In [3,5,7,8] the authors have mentioned that, the Internet of Thongs leads to the technological development in the field of ICT. From a conceptual point of view, the IoT has three supports, something related to the capability of a smart object to be notable, to communicate and to interact with each other, and designing of networks of various interconnected objects. IoT will be based on the idea of “smart objects” or “things”, in which a final touch to the existing entities will be given by them in the internet [9]. Smart objects or “Things” should have some physical symbol and physical features like size, shape etc. It should have a proper communication functionalities like- it should be able to accept the incoming messages and reply to them. The entities of smart objects or “Things” should be associated with one name and one address. The most important thing is, the name should be human-readable description of the object. The address should be machine-readable string and it can be used to communicate to various objects. The smart objects should be able to perform some basic fundamental computations.

The Internet-of-Things can be viewed as a highly dynamic network system, which is consisting of a very large number of smart objects or “Things” producing and consuming information from a system-level view or observation and the capacity to interface with the physical area or zone is achieved through the presence of devices able to sense physical phenomena and translate them into a stream of information or data as well as through the presence of devices able to activate actions having an impact or collision on the physical zone or area. In [45], it has been mentioned that, Internet of Things (IoT) is a new revolution of the Internet. Here in this technology various physical smart objects or things make themselves auto recognizable and intelligence has been obtained by themselves only by enabling context related decisions. They can access information that has been aggregated by other things, or they can be components of complex services.

We can say from a service-level point of view, the main issue associate to how to integrate or unite the functionalities and/ or resources provided by smart objects into services [10,11]. The definition of architectures and methods for ‘‘virtualizing’’ objects by creating a standardized or systemized representation of smart objects or “Things” in the digital domain or field and methods for seamlessly combining and composing the resources or services of smart objects or “Things” for end users.

Generally a wide range of opportunities are provided by Internet of Things (IoT) to the manufacturers, companies and various industries. In many productive industries (such as: environmental monitoring, inventory, product management etc.) IoT technology will find much applicability.

IoT will be categorized by a large heterogeneity in terms of devices taking part in the technology system and these are expected to present very different capabilities from the computational and communication viewpoints. In IoT technology scalability level arises in different levels. This includes data communication and networking (or computer networking) - because of very high number of interconnections among a very large number of entities or organizations.

In Internet of Things (IoT), wireless communication technology or systems will play a vital role and they are enabling the smart objects or “Things” to be networked. The universal assumption of wireless communication systems for exchanging data or information will create various issues in terms of availability of frequency spectrum and it will impel towards the assumption of Cognitive radio Systems (smart radio system) [12]. The abilities of wireless communication system can provide and identify the operation of Internet of Things (IoT) and also it will be possible to locate the smart objects or “Things” in the physical area or zone. It is important that the various operations of IoT the energy which will be spent for wireless communication and computing purpose should be very less. The most important thing is techniques or related to energy gathering i.e. the energy should be handled with proper care while dealing with the devices which are used in IoT technology.

The IoT technology is nothing but, it is about the interchanging of information from one device to another device and also analyzing the huge or massive amount of data. So in order to turn them in to very useful information and also to ensure the interoperability between two or more applications, it is most important to provide sufficient data with some specified formats and well defined languages. The security for IoT system or technology should be a key property and also it should be taken in to account while the architectural design.

In Figure 1 (which is mentioned below), the technologies, concepts, and standards of IoT systems are classified and highlighted.

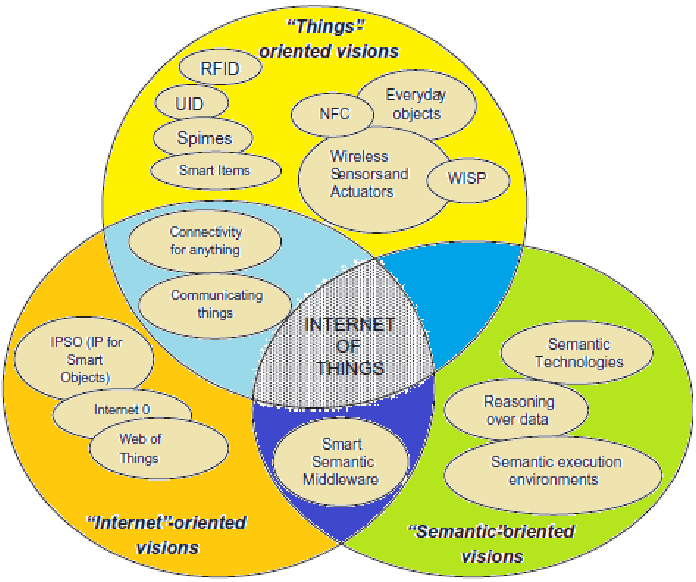

Figure 1. Architectural diagram [3]

In the above diagram the very first definition “Things oriented visions” considers some simple items like Radio Frequency Identifications (RFIDs). In [13], it is mentioned that, the Internet of Things assigns to Auto –ID lab, which is a worldwide network of academic research laboratories in the field of networked RFIDs and some kind of emerging sensing technologies. In this field the prime focus is on the development of Electronic product Code (EPC) to support the spread use of Radio Frequency Identification (RFID) in worldwide trading centers and to improve the object visibility these standards are designed.

In [14], it is mentioned that, in technology field RFID stands in a leading position and also a wide range of portfolio of networks devices and technologies will develop the IoT. In this scenario there are some basic or fundamental components (such as: Near Field Communications known as NFC, Wireless Sensors and Actuator Networks together with RFID) which will link the real world with the modern digital world. The definition of IoT finds some kind of real world implementations is so called smart items or smart objects and also these are the auto sensors not only equipped or furnished with normal wireless communication systems or technologies, memory, and capabilities, but also with new kind of capabilities.

In [17], it is mentioned that, an IoT imagination statement, which goes just out of boundary ‘‘RFID centric” approach and this has been given by the consortium CASAGRAS. The community CASAGRAS consortium proposes a basic imagination of IoT as a global infrastructure or design which makes a connection to both virtual and various physical collective objects and spotlight the importance of including existing or developing Internet and developments of network in this valuable imagination. In this sensation, IoT will become the natural enabling architectural design for the deployment of various integrated services and applications.

There is a statement in [20] is that, a similar approach of reducing the complexity of the IP abundance to achieve a protocol designed to route ‘‘IP over anything” is followed by internet oriented visions and also in some of the meetings this has been mentioned that, the easiest way to move from the Internet of Devices to the Internet of Things. According to Internet oriented vision approach, the IoT will be implemented by means of simplification of Internet Protocol to change it to any object and also make those objects addressable and reachable from any kind of location.

In [21,23], the authors have mentioned that, the basic and fundamental idea behind the “semantic oriented” vision is that the number of items or components in the future internet system will be very high. Some of the important things like how to gather information, interconnection, search and communication by IoT will become a challenging job. So in this case semantic oriented imagination could play a very important role in the Internet of Things systems.

So this all about the vision (or imagination) and fundamental concepts behind Internet of things (IoT).

3. Validating Technologies and Challenges in IoT

In this section we have discussed the most admissible ones. It is not our purpose to provide a survey of each and every technology. Our main goal is to provide a pictorial representation of the role they would play in the IoT. The fundamental research is required to achieve Internet of Things (IoT) and some of the technologies and challenges in the areas like massive scaling, creating knowledge and big data, robustness openness have been mentioned.

3.1. Identification, Sensing and Communication System Technologies

The wireless communication systems as taken an important role today and also today the ratio between radios and human is nearly equal 1 to 1. The reduction in terms of size, weight, energy consumption, and cost of the radio can take us to a new span where the above ratio will increase of orders of magnitude and this will allow us to combine radios in almost all objects and to add the world ''anything" to the above valuable imagination, which leads to the basic and fundamental concepts behind IoT. One thing has been found out that, RFID systems can be used to control various objects in real-time application, without the necessity of line-of-sight and this will allow to map the real world into the virtual world. So, they can be used in an extraordinarily wide range of applications.

In [25], the authors have mentioned that, Radio Frequency Identification (RFID) is small microchip which will be attached to an antenna (Microstip patch antenna) which is just similar to paste or gum and In this case dimensions would be very low (Hitachi has developed the dimensions of 0.4mm × 0.4mm × 0.15mm). Here signal will generate an alternating current into the tag antenna by induction process and the current will be utilized to supply the microchip which will transmit the tag ID. Usually, the gain of such kind of systems are very low. However, we are very thankful to the highly directive antennas utilized by the readers by which tags ID can be received almost correctly within a radio several frequency bands covering from low frequencies at 124– 135 kHz up to ultra-high frequencies at 860 – 960 MHz that will have the longest range.

Sensor networks will be playing an important role in the IoT technology systems. They can also cooperate with RFID systems to better track the status of things or smart objects (such as: their location, temperature, movements, etc.). Sensor networks basically consist of a certain number of special nodes (or junction points) called sinks and also a very large scientific theory has already been produced on sensor networks in the recent past years. The basic design objectives of the proposed solutions are energy efficient, scalability (i.e. the number of nodes can be very high), reliability (i.e. the network may be used to report some urgent events), and robustness. The main advantage of integrating sensing networks with the RFID tag is that, it will enable a lot of new featured applications to the IoT context. For this several kind of solutions has already been proposed. For example we can say WISP (it stands for wireless identification and sensing platform) ad this project is taken by Intel labs.

3.2. Middleware

Middleware is simply a software layer which is placed between the technology and the application. The middleware is gaining now a days so much of importance in the last years due to its major role play in simplifying or rationalizing the development of new services and the combination of upshot technologies into new the new technologies.

The middleware architectures proposed in the last years for the IoT and it frequently follows the Service Oriented Architecture (SOA) approach. The assumption of the SOA principles allows for decomposing complex systems into applications consisting of simpler and well-defined components. The use of common interfaces and standard protocols gives a view of an enterprise system. SOA enables, the development of business, which is the result of the process of designing workflows of synchronized services and these are associated with objects actions. In [28], it is mentioned that, the hardware and software reusing is allowed by the SOA approach because it does not enforce any kind of scientific approach or technology for the service implementation.

Below in Figure 2 we have drawn the SOA-based architecture for IoT middleware systems. System functionalities to the end user and this layer is not considered to be a part of the middleware but it exploits all the functionalities of the middleware layer.

Service Composition layer is the second layer of the SOA-based architectural design. Various functionalities for the composition of single services offered by networked objects to build specific applications is provided by this layer. The only advantages are services and here there is no any kind of idea of devices on this layer. The fundamental concept or logic behind the creation and the management of complex services could be explained in terms of workflows of business processes by using workflow languages and in [31], it is mentioned that, the business processes that interact with external entities through Web Service operations, defined by using the Web Service Definition Language (WSDL).

The main functions that are expected to be available for each object and that allow for their management in the IoT scenario is basically provided by service management layer. So this layer plays a vital role in this architecture.

Applications Layer
Service Composition Layer
Service Management Layer
Object Abstraction Layer
Objects

Figure 2. SOA-based architecture for IoT middleware systems

Application layer is the top of the architecture. The IoT depends on a large set of objects and each of the objects provide some kind of specific functions. So here there is a need of an abstraction layer, which will be capable of coordinating the access to the different devices with a common language and procedure or protocol. It consist of two sub layers known as interface sub layer and communication sub layer. The interface sub layer provides a web interface introducing the methodologies available in a standard web service interface and also it is responsible for the management of all the incoming or out coming of messages involved in the communication with the external world. The Communication sub-layer implements the basic logic behind the web service methodologies or functions. After that it translates these methods or functions into a set of device-specific commands to communicate with the real-world objects. So this all about the validating technologies that are used for IoT technology.

3.3. Massive Scaling

The route of the numbers of smart devices being deployed, it implies that billions and trillions of things will be on the Internet in near future. Since many of the things on the Internet will require their own energy sources, will energy searching and exceptionally low power circuits eliminate the need for batteries? How will the massive amounts of data be used, and stored? What kind of longitudinal studies will be performed? And also how the real-time and reliability aspects will be supported? How will be the mobile devices discovered? It is unlikely that any solution immediately becomes the norm.

3.4. Creating Knowledge and Big Data

In IoT, there will be existing a vast or big amount of raw or fundamental data are continuously collected. Generally it is very necessary to develop any techniques which will convert this raw or fundamental data into usable knowledge. For example, in medical science field, raw streams or data of sensor values should be converted into some meaningful activities performed by a person such as eating, exhibiting signs of depression etc. The main challenges for data interpretation and the formation of knowledge include addressing noisy, physical world data and developing some new inference techniques that do not suffer the limitations of Bayesian schemes.

The amount of collected data will be exceptional. It is also expected that a large number of real-time sensor data streams will exist and it will be common for a given flow of data which will be used in many different ways. Another well-known technique i.e. Data mining techniques. These Data mining techniques are very much expected to provide the creation of most valuable knowledge from all this data. It will enable the data streams to act as primitives for unexpected future inferences which is really an interesting research problem now a days. Apart from this, trust is one of the important aspect of the usefulness of big data and essential elements of trust are security and privacy. However, as a basis for trust it is also necessary to develop something new in-field sensor calibration techniques. So without these basic system-level capabilities, the further inference might be operating with wrong data. One approach is to ensure that, all the information is accompanied by a confidence level in the form of a probability that the information is correct or incorrect.

3.5. Robustness

Internet of Things (IoT) applications are generally based on deploying sensing, actuation as well as communication platform and also in these deployments it is common for the devices to know their respective locations, know their neighbor devices when collaborating, appropriate power levels for communication, and pair-wise security keys. However, over time these conditions can deteriorate and the most common example of this deterioration problem is with clock synchronization. For example, some nodes unexpectedly may be physically moved here and there and it is quite possible that more and more nodes may become out of place and to make again system-wide node locations coherent, node re-localization needs to occur. We can also consider this issue as a form of entropy where a system will decline unless energy in the form of re-running protocols and other self-healing mechanisms is applied.

Another problem hardly addressed is that in some Internet of Things (IoT) applications, especially for safety purpose, run time assurances must be given to authorities. Now let's consider a fire fighting system deployed in a sky scraper office building to detect fires, alert fire station and aid in ejection. Periodically, it is very necessary to demonstrate to various certification authorities and such kind of IoT applications will need services that can support run time certification.

4. Innovation Directions of IoT

The strategic development of enabling new technologies (such as nano-electronics, communication systems, sensors, embedded systems technologies, cloud computing, networking, and software etc.) will be essential to provide capability all the time everywhere. This will lead to support important future IoT product innovations affecting many different industrial sectors. The gap between cyber space and the physical world of real things has been connected by embedded systems.

In [47], the authors have mentioned that, the final report of the Key Enabling Technologies (KET), of the High-Level Expert Group has identified the enabling technologies. It is very critical to many of the existing chains of the European economy such as Micro and Nano electronics, Photonics, Biotechnology, and Advanced Manufacturing Systems. From a technology point of view, the rapid grow in the integration density proposed by Dr. Gordan Moore made possible by a dimensional scaling. The reduction in the critical dimensions while keeping the electrical field constant, and at the same time a user obtained at a higher speed with reduction in power consumption of a digital MOS circuits. So now a days these two parameters became driving or key forces of the microelectronic industry along with the integration density. And also now a days the International Technology Roadmap for Semiconductors has highlighted in its early editions and its associated benefits in terms of performances, the traditional parameters in Moore's Law.

In [50], it is written that, the second trend has been categorized by functional diversification of semiconductor-based devices. The non-digital functionalities contribute to the miniaturization of electronic systems. Consequently, in view of added various functionality, this trend has already been designated as "More-than-Moore". From a technological survey, it has been estimated that, Mobile data traffic is double each year between now and 2015. So mobile operators are facing problem to provide the required bandwidth to the client and customers. In many countries there is no any kind of extra spectrum that can be assigned. So proposed solutions are the seamless integration of existing Wi-Fi networks into the mobile ecosystem and also this will have a very big impact on Internet of Things (IoT) ecosystems. The chips designed to fulfil this integration process are known as “multicom” chips. In a single silicon package, it is expected to cover Wi-Fi and baseband communications. The architecture of mobile devices is likely to change as well as the baseband chip will be taking control of the routing process, so the connectivity components are connected to the baseband or integrated. So as a result of this change in architectural design, an increasing share of the integration work is likely done by baseband manufacturers.

Today many European projects address Internet of Things technologies, knowledge and also it has been mentioned that these topics can be heterogeneous and specialized, also there is a strong need for integration of the individual results. In this context, the integration of knowledge has been conceptualized as the process through which some specialized cognizance situated in multiple projects across Europe is applied and assimilated. The Agenda of Strategic Research and Innovation has been developed with the proper support of a European-led community of interrelated projects and their stakeholders with dedication to the innovation, creation, development and use of the Internet of Things (IoT) technology.

After release of the first edition of Strategic research and Innovation agenda, many active research on several IoT topics have been witnessed. Now a days researches are going on in some specialized areas such as: cloud computing, cyber-physical systems, autonomic computing, and social networks. Because of these advanced research, the scope of IoT convergence have been successfully modified. In [45], [49], and [51] it is mentioned that, the previous versions of this Strategic Research and Innovation Agenda has been incrementally progressed because of the updated release and the main research topics that are incorporated with the development of some IoT infrastructures, key enabling technologies, and applications with an outlook towards 2020 has been highlighted [53].

5. IoT and Related Future Internet Technologies.

5.1. Cloud Computing

The most important feature of the future internet technology and new technology enabler have been encouraged at different levels and allowed the various paradigms known as “Applications as a Service”, “Platforms as a Service”. In [54] it has been noted that, Internet of Things (IoT) applications (Sensor-based services) will be on demand through a cloud based environment only. If we will apply Internet of Things (IoT) systems in large scale then in that case security would be critical barrier and also apart from that it will never be sufficient, if we will apply the extending existing IT security architecture to the IoT. In order to protect these smart objects (or smart things) over a long period of time then in that case cloud based security services with efficient resources is very much essential.

It is observed that, with the rapid growth of Internet of Things (IoT), we are just moving towards a cyber-physical paradigm, where generally we are integrating the computing technology and communication technology with the connected smart objects (or smart things) with the ability to control their basic operations. In below Figure 3, the interchanging of cyber and physical world have been mentioned.

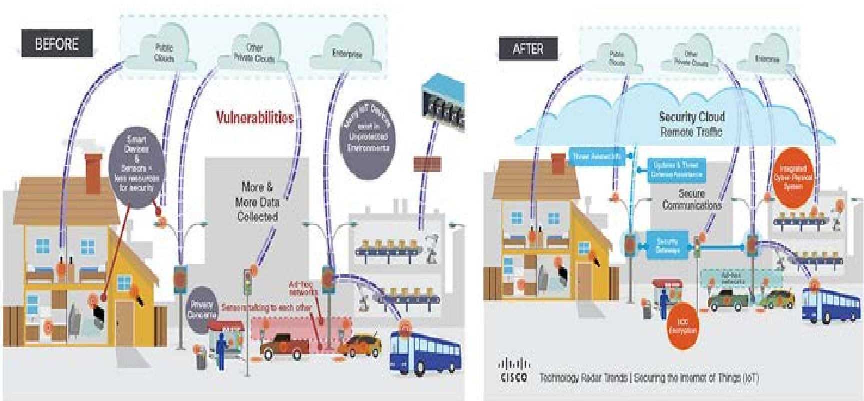

Figure 3. Securely Integrating the Cyber and Physical Worlds [58]

Here in that case many security threats are coming from the interaction between the cyber and physical world. So the improvement in security threat is very much essential. In variations to today’s networks, where assets under protection are typically inside firewalls (a network security systems, that controls the incoming and outgoing n/w traffic based on set of rules) and protected with access control devices, many things in the IoT arena will operate in unprotected or highly vulnerable environments. Protecting such things poses additional challenges beyond enterprise networks [55].

Mobility (or potency) support and geo-distribution are required by many Internet of Things applications in addition to the awareness of location and low latency (the amount of time a message takes to traverse a system.), while the data is to be processed in “real-time” in micro clouds or fog. Many new applications are enabled by Micro cloud and Fog computing and services applies a different data management system, which extends the Cloud Computing paradigm (a certain pattern)/ model to the boundary of the network. Similar to Cloud, Micro Cloud/Fog provides data, compute, storage, and application services to end-users. In below Figure 4, the Fog computing paradigm have been shown.

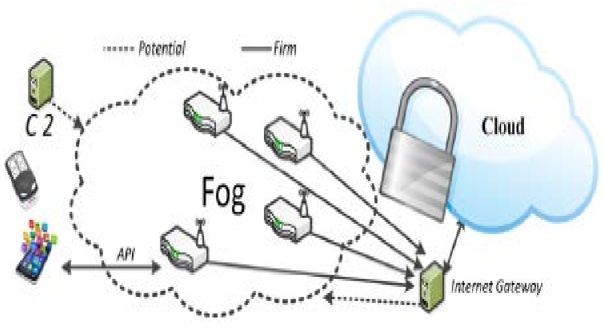

Figure 4. Fog Computing Paradigm [59]

The Micro cloud or Fog needs to have some features (such as: Low latency and location awareness, Wide-spread geographical distribution, Mobility/ potency, huge number of nodes, Predominant role of wireless access, Strong presence of streaming and real time applications, Heterogeneity) in order to efficiently implement the required IoT applications. Moreover, if we generalize the serving scope of an Internet-connected object or things beyond the "sensing service", it is not hard to imagine virtual objects (or things) that will be integrated into the fabric of future IoT services and reused in many different contexts.

5.2. IoT and Semantic Technologies

The IERC SRIAs have identified the importance of semantic technologies towards discovering devices, as well as towards a goal to achieve semantic interoperability. Upcoming research on IoT is likely to embrace the concept of Linked Open Data. This could build on the earlier integration of sensor technologies into IoT infrastructures and applications.

Semantic technologies will be playing a vital role also in enabling (or validating) sharing and re-use of virtual objects as a service through the cloud. The semantic enrichment of virtual object descriptions will realise for Internet of Things, what semantic interpretation of web pages has enabled in the Semantic Web. Internet of Things (IoT) users will be assisted by the associated semantic-based reasoning to find more independently the relevant proven virtual objects to improve the performance.

5.3. Networking Technology

Today Mobile traffic has been driven by a predictable activities such as making calls, receiving email, and watching videos. Over the next 5 to 10 years, billions of Internet of Things (IoT) devices with less traffic patterns will join the network, including vehicles, machine-to-machine (M2M) modules, that requires all the time bandwidth, or different types of sensors that send out tiny bits of data each day. It has been observed that, the rise of cloud computing requires new network strategies for the evolution of fifth generation mobile cellular networks (or 5G), and a good convergence of network access technologies has been represented very clearly. The architecture of such network has to integrate the needs for IoT applications. Fast, and high-capacity network is needed to make the IoT and M2M communication possible.

5G networks will be providing 1,000 to 5,000 times more capacity than 3rd Generation (3G) and 4th Generation (4G) networks and will be made up of cells that provides peak rates of between 10 and 100Gbps. It will be taking data 1–10 milliseconds to get from one designated point to another. Another focus is to separate communications infrastructure and the mobile users will be allowed to move very smoothly between 5G, 4G, and Wi-Fi, which will be fully integrated with the cellular network. Networks will be programmable, and the operators will be allowed to make any kind of changes to the network without touching the physical infrastructure/ model. These features are very much important for IoT applications. The evolution of present communication technologies has the potential to grow to extraordinary levels in the near future by including the developing Internet of Things.

6. Applications of IoT

Internet of Things has many applications in various fields. So we have categorized the applications in to four different fields and they are such as: Home, Enterprise, Utilities, and Mobile telephone systems. Figure 5 which is mentioned below represents the applications of IoT in these four fields.

Figure 5. Applications of IoT based on data [6]

5.4. Home

The sensor information is used only by those individuals who directly own the network and basically Wi-Fi is used as the backbone which, enables the higher bandwidth data transfer as well as higher sampling rates. In home also a Smartphone can be used for communication along with several interfaces like Bluetooth for interfacing sensors measuring physiological parameters, and there are several applications available for Apple iOS, Google Android and Windows Phone operating systems that measure various parameters. In [32,33], the authors have mentioned that, for elderly care the expansion of computer networks is creating a home monitoring systems, which will help the doctors to help their patients and aged people thereby reducing hospitalization cost.

5.5. Enterprize

Sensors have always been a most important part of any kind of industry setup for security, automation, and control etc. This can be replaced by a wireless communication system which will be giving the flexibility to make any kind of changes to the setup whenever it will be required and this is nothing but called an IoT subnet dedicated to factory or industry maintenance. Basically we are referring to the 'Network of Things' within a work environment as an enterprise based application and here the Information that has been collected from such kind of networks are generally used by the owners or users and the data may be released selectively. Here in this case Environmental monitoring is the prime application which is generally implemented to keep track of the number of participants and manage the utilities within the building.

5.6. Utilities

Another critical application that is being addressed using IoT is water network monitoring and quality assurance of drinking water. Here in this case sensors are measuring critical water parameters and these parameters are installed at important locations in order to ensure very high supply quality. So that, this will avoid accidental contamination or pollution among storm water drains, drinking water, and sewage disposal. So the same network can be extended or expanded to control the irrigation in various agricultural land and the network can also be extended for controlling soil parameters which will allow informed decision making concerning agriculture.

5.7. Mobile Telephones

Due to the nature of data sharing and backbone implementation smart transportation and smart logistics are placed in a separate domain. The main contributor to traffic noise pollution is urban traffic and it is also a major contributor to urban air quality degradation and greenhouse gas emissions. The popularity of Bluetooth technology (BT) devices reflects the current entry of IoT in a number of digital products such as mobile phones, car hands-free sets, navigation systems, etc. Basically Bluetooth devices emit signals with a unique Media Access Identification (MAC-ID) number that can be read by any kind of Bluetooth sensors within the coverage area and also the readers placed at different locations can be used to identify the movement of the Bluetooth devices. So these are the applications of Internet of Things (IoT) in various fields.

7. Conclusion

The Internet has changed drastically the way we are maintaining our lifestyle. For example such as moving interactions between people at a virtual level in several surrounds covers from the professional life to the social relationship and also the IoT has the potential to add a new dimension to this process by enabling the wireless communication systems with and among smart objects or "Things". One of the most interesting model or pattern which appears in the Internet of the future or upcoming generation is the so called "Web Squared". The most important thing behind this concept that, it will be obtained by taking into account the information about the user background collected by the sensors.

The Internet of Things will grow to 26 billion units and it will be installed in 2020 representing an almost 30- fold increase from 0.9 billion in 2009. The revenue will be incremented up to $300 billion by the IoT product and service suppliers in 2020. It is expected that "ghost" devices with unused connectivity will be common due to the low cost of adding the capability of IoT to the consumer products and there will be a combination of products that have the built in capability but require software to "activate" it. Various enterprises will make a very large-scale use of IoT technology, and there will be a wide range of products (such as: advanced medical devices, factory automation sensors and applications in industrial robotics) sold into various markets.

By the year 2020, the cost of all the component will have come down to a certain point/ level that, the connectivity will become a standard feature, even for processors costing less than $1. This leads to the possibility of connecting almost anything, from the very simple to the very complex to offer remote control access, monitoring and sensing. The IoT incorporates/ comprises of sensors, actuators, electronic processors, microcontrollers, and information services associated with the things. The IoT applications are still implemented by the different industries with a very high importance in manufacturing, healthcare sciences and home/ buildings.

So in this review paper we have surveyed the most basic, important and fundamental aspects of Internet of Things technology which will be done in near future and also some the aspects has already been done and now also still extensive research is going on this IoT technology. So we conclude that, the great invention of this IoT technology will lead the computer communication systems to a different level in near future.

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