An Overview: Internet of Things, 5G Communication System and Cloud Computing

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Abstract: This article will provide an overview on internet of things (IoT), 5G communication System and Distributed Clouds. The basic concepts and benefits will be briefly presented, along with current standardization activities. In a nutshell, but the research will focus on relating internet of things, 5G and Distributed Cloud Computing.

Keywords: 5G wireless, Distributed Cloud, Internet of Things

1. Introduction

In order for the upcoming generation of network to emerge there is need for advancement in our contemporary networking field [1], [2], looking at what future hold for us by forming a cluster of network through connecting different things, services, people and everything [3] of different architectures [2], [4] which is refers to internet of things (IoT), (IoS), (IoP) and (IoE) as the core technique of next generation of wireless communication [5]. In order to make this reality [6] there is need for a strong and reliable network with unlimited connections capabilities [4] which is referred to as fifth Generation (5G) of communication System [7] this generation of communication network will provide unlimited data transmission together with massive number of active connections as well as new type of mobile devices, sensors, actuators, robots, vehicles etc. [4] although this so called generation will provide 1000-fold network bandwidth [8] it will not eliminate all the issues that the next generation of technology will come with, such as quick connection with low data rate of internet of things (IoT) sensors and high resolution for game or movie downloads [9], which need will arise that still need to go beyond 5G or Just 6G which is the next focus of researchers [10]. In order for this multiple connection of input and output (MIMO) [11], [12] as well as users to exist using the same time and frequency there is need for non-orthogonal multiple access NOMA[12], [13], this connection will need a massive storage for easy storage and retrieval of incoming and upcoming information generated by this cluster of devices [14].

2. Basic Concept of IoT

Internet of things or internet of everything was coined by Kevin Ashton Executive director of the Auto-ID center in a presentation at Procter & Gamble in 1999, then in a book named ‘When things Start to Think’ published by Neil Gershenfeld from the MIT media Lab [15]. The need for IoT for connecting every object and person [2] is one of the two things that make the development of the next generation of communication system 5G [16], in order to make successful connection of different devices such as smart homes, smart cities and mobile devices in suburban and rural environments[17] as illustrated in figure 1 [6], and this connection will remain regardless of location and time [6] making it easier for humans and machines to communicate [18], for a very long time say 10-15 years without replacement of battery [19] One of the platforms proposed by [18] in order for this technology to work together is the introduction of three layers which are:

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(i) Perception layer, (ii) Transportation layer and (iii) Application layer. Which are the ladder of achieving this, each layer has its role that it plays as discussed below:

- **Perception Layer**: it where the devices sense the physical environments, collect real time data, and reconstruct the general perception of the data in the virtual world. Some of the Technologies for identifying physical objects and sensing of physical parameters are radio frequency identification (RFID) and Sensors. While those for data collection are IEEE 802.15.4 and Bluetooth.
- **Transportation Layer**: Here the transportation of the data collected to the applications and different external servers takes place. In order to access the network through gateways and heterogeneous technologies such as wired, wireless and satellite and also for addressing and/ routing.
- **Application Layer**: Here the processing and analysing of the information flows, sending data to applications and services, providing feedback in order to control applications. Also it is responsible for critical functions such as device discovery, management, data filtering and information utilization/distribution.

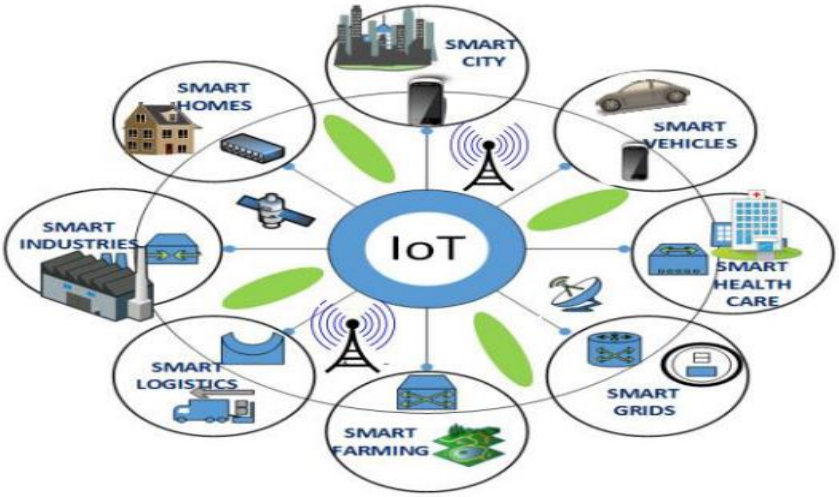

Figure 1 Internet of Thing: Connecting anything anywhere adapted from [5]

3. Benefits of IoT

The emerging of IoT that targets sensory and data collection [20] will bring many benefits to our contemporary life from agro-industrial and environmental fields [21] such as atmospheric conditions to biomass of plants and animals. In a nutshell, it can give the producer/consumer the detail about the product, from origin to properties. It can also be used to produce dense and real time maps of air and water pollution as well as storing environmental records [21] although that is the main need for distributed cloud. Connection of such heterogeneous devices in the IoT [22] is one the promising benefit of IoT that researchers are already doing their job to address such issues, the first known experimental platform on integrating heterogeneous devices was conducted in centre technologic de Telecommnicacions de Catalunya (CTTC) by [23] in order to integrate wireless/optical networks, distributed cloud and IoT and [24] for IoT devices.

The Three characteristics of IoT outlined by [25] agreed upon research published by (liu) are: (i) comprehensive Perception, (ii) Reliable Transmission and (iii) Intelligent Processing.

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- **Comprehensive Perception**: The foundation of identifying and recognition of objects is the overall step in implementing perception. Using radio frequency identification (RFID), sensors and barcode to obtain the information at any time anywhere, this will be new opportunities.
- **Reliable Transmission**: due to the massive connectivity of different available networks, information can be available in any time anywhere, which include wired and wireless transmission technologies, switching, networking and gateway technologies. It further creates interaction among physical world, virtual world, digital world and the society. Such as machine to machine (M2M) communication, human to machine (H2M) and Mobile to machine (Mo2M) communication.
- **Intelligent Processing**: Through distributed cloud computing IoT can be able to process billions of datum instantly, by collecting IoT data into databases, various intelligent computing technologies. Thus, distributed cloud computing Technology will be the promoter of IoT.

Also the applications of IoT as summarised by [25] are:

i) **Location sensing and sharing of location info**: IoT system will collect location information of terminals and end nodes, and then provide service based on the information collected, such as mobile asset tracking, fleet management and traffic information system.
ii) **Environment sensing**: IoT systems can collect any physical or chemical environmental parameters and process information collected using IoT terminals, such information includes environment detection and remote medical monitoring.
iii) **Remote Controlling**: IoT systems can remotely control IoT terminals using information collected and application commands, such services include Appliance Control and Disaster recovery
iv) **Ad Hoc Networking**: IoT systems can self-organized network and can interoperate with network/service layer to provide related services, such as in the vehicle network.
v) **Secure Communication**: IoT systems can establish secure data transmission channel between the application and IoT terminals based on the service requirements.

IoT applications can in practice consist of different types of capabilities and based on the service requirements, as shown in the table below:

		Location sensing and sharing	**Environment sensing**	**Remote Contro-lling**	**Ad Hoc Network**	**Secure Commun-ication**
E-Health	Monitoring	✓	✓		✓	✓
	Home Care	✓	✓			✓
ITS	Smart Fleet	✓	✓			✓
	Automobile	✓	✓	✓	✓	✓
Smart City	Environment Monitoring	✓	✓			✓
	Safety	✓	✓			✓
	Food Traceability	✓				✓
	Smart agriculture		✓			✓
Industry	Process Monitoring		✓	✓		✓

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	Logistic Management	✓				✓

Table 1 Applications of IoT adopted In [22]

4. Basic Concept of 5G Communication Network

From the first generation of communication system called 1G that emerge in 1980s [13] that gives voice as a service [26] and uses analog radio signal with frequency of 150 MHz, and the technique called frequency division multiple access (FDMA), with low capacity, unreliable handoff, poor voice links and no security [14]. Then the second generation of communication system, called 2G that emerges in late 1992 [27], that combines voice and text message as a service [26] and uses time division multiple access (TDMA) technique [13]. Then third generation 3G of communication system that comes around 1999 [25], integrate mobile and internet, it increases the bandwidth and reduces cost of resources [28], then 3.5G of communication system that was introduced in 2001 [25], it gives voice, text and broadband data [29] as a service and uses code division multiple access CDMA technique [13]. Then fourth generation 4G of communication system that was introduced in 2010 [25], that gives high capacity multimedia [26] as a service and faster broadband internet with low latency [29] and uses orthogonal frequency division multiple access OFDMA technique [13]. And the fifth generation of mobile communication system that gives wireless world wide web [26] although there is no specific multiplexing technique that 5G will use it still combine the OFDMA the technique used in 4G and the later called non-orthogonal multiple access NOMA techniques [10] for a good multiplexing techniques. Nevertheless, the implementation of this communication system is expected around 2020 [6], [7],[30] that will unify mobile operators and consumer communications within a single technology [17], as well as supporting three generic services as illustrated in figure 2 [31], [4], [10], [12], which are: (i) Enhanced mobile broadband (eMBB), (ii) Massive machine-type communication (mMTC) and (iii) ultra-reliable and low-latency communication (URLLC), as elaborated by [32]:

- **Enhanced Mobile Broadband (eMBB)**: will provide operating modes with higher data rates and extended coverage area.
- **Massive Machine-Type Communication (mMTC)**: will control data flow to or from massive number of wireless devices with guaranteed performance level.
- **Ultra-Reliable and Low-Latency Communication (URLLC)**: will provide authenticated services for critical applications such as autonomous driving and health monitoring devices.

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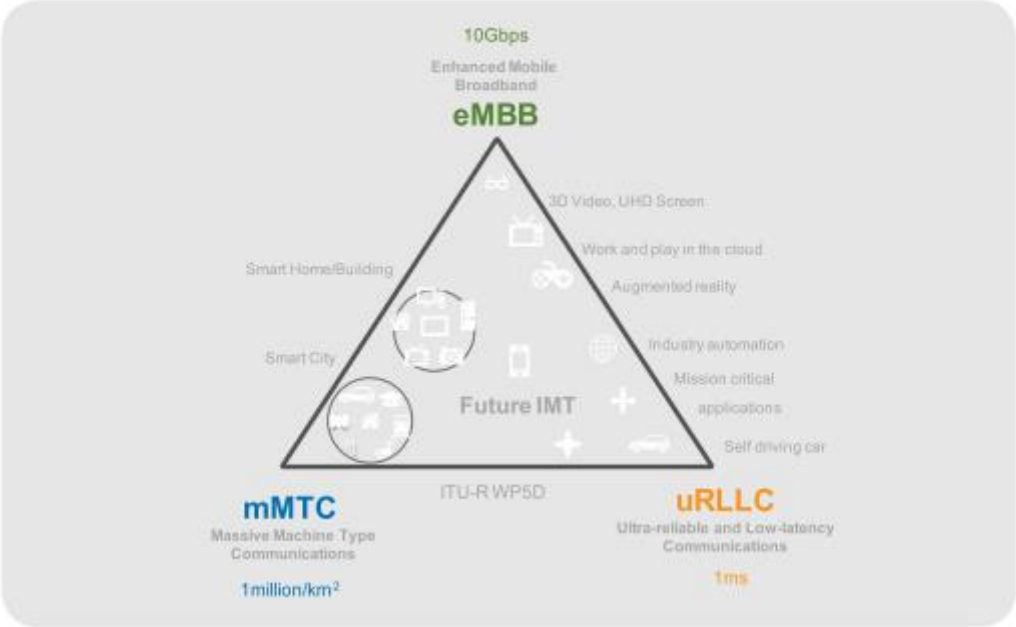

Figure 2 adapted from [29]

5. Benefits of 5G Communication Network

The need that make development of new way of communicating are, increase in efficiency, rarely out of touch, greater flexibility for users and reduced cost [30]. Some of the benefits that 5G of communication system will bring as summarized and illustrated in figure 3 by [16] are: (i) Mobile Broadband, (ii) Internet of Things

- **Mobile Broad Band**: Allowing users to experience high speed data and low latency in order to support 3D and ultra HD video applications.
- **Internet of Things**: By connecting different devices together to form a cluster of network, two important applications of IoT with different characteristics where Identified: Massive machine-type communication and mission critical applications
    - **Massive machine-type communication**: there will be massive connection of devices such as, sensor networks, connected home, smart metering and so on.
    - **Mission critical applications**: It will allow computers to perform mission critical actions, such as driving using connected cars, industrial automation and many applications in health such as remote surgery.

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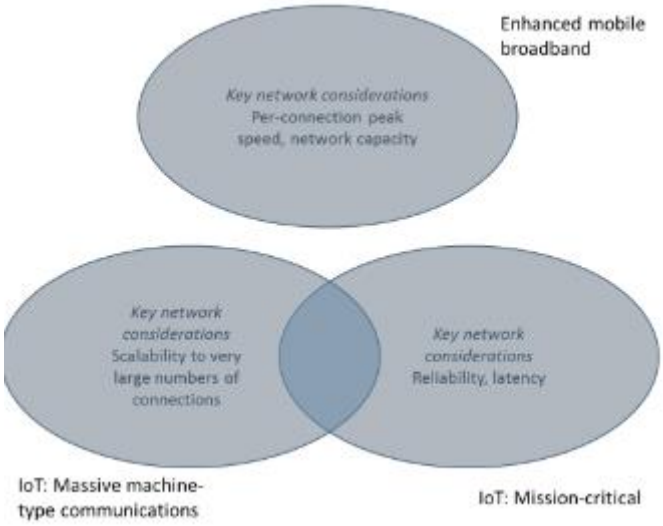

Figure 3 Classification of 5G applications adopted from [15]

some of the benefits that 5G communication system will provide as mentioned by [33] and [7] are:

- **Virtual Presence:** This generation of communication will provide user services at all times.
- **Tele-Medicine:** User can get help from the doctor from his home, by using remote health monitoring system anytime anywhere.
- **Tele-Geoprocessing Applications:** User can get location by Querying using global positioning system (GPS) and geographical information system (GIS).
- **Crisis Management:** This generation of Communication system is expected to restore system break down in some hours.
- **Education:** furthering education through online platforms using affordable means even free.
- **Artificial Intelligence:** By developing intelligent systems that will communicate with humans and machines in order to ease human life.
- **Travelling:** Sharing information live as one travelled due to the high bandwidth of this generations network.
- **Economic Growth:** Due to the High quality network and massive development of new systems that will allow consumers and businesses to benefit.
- **Security:** It will perform the functions such as authentication, authorization, encryption, establishment and implementation of service policy agreement between the various vendors.

6. Basic Concept of Cloud Computing

The root of cloud computing dated back to 1960s [34] when the idea was first introduced in 1969 by J.C.R. Linklinder of ARPANET which he called " Intergalactic Computer Network" and in 1961 by John McCarthy which he called " Utility Computing", but the world "Cloud Computing" was probably introduced in 2006 by Eric Schmidt when talking about Search Engine Strategies conference [35], but National Institute of Standards and Technology (NIST) define cloud computing based on the three services [36], this cloud provide: (i) Infrastructure as a service (IaaS), (ii)

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Software as a service (PaaS) and (iii) Platform as a service (PaaS) and elaborated by [3]

(i) **Software as a service (PaaS):** It is where applications that are running in cloud can be rented with limited interaction to a customer. Other services were introduced under SaaS such as Human as a service (HuaaS) and reasoning as a service (RaaS).

(ii) **Platform as a service (PaaS):** It is where customer has right to alter their applications that are running in the cloud. Usually for coding to developers.

(iii) **Infrastructure as a service (IaaS):** also called hardware as a service (HaaS), It can further be divided into Computing as a service (CaaS), data as a service (DaaS) and network as a service (NaaS).

As well as four deployment point of view [36], which include private, public, hybrid and community cloud, we can view it as provider, consumer, auditor, broker and carrier or in a way they function as service deployment, service orchestration, service management, security and privacy as illustrated in figure 4.

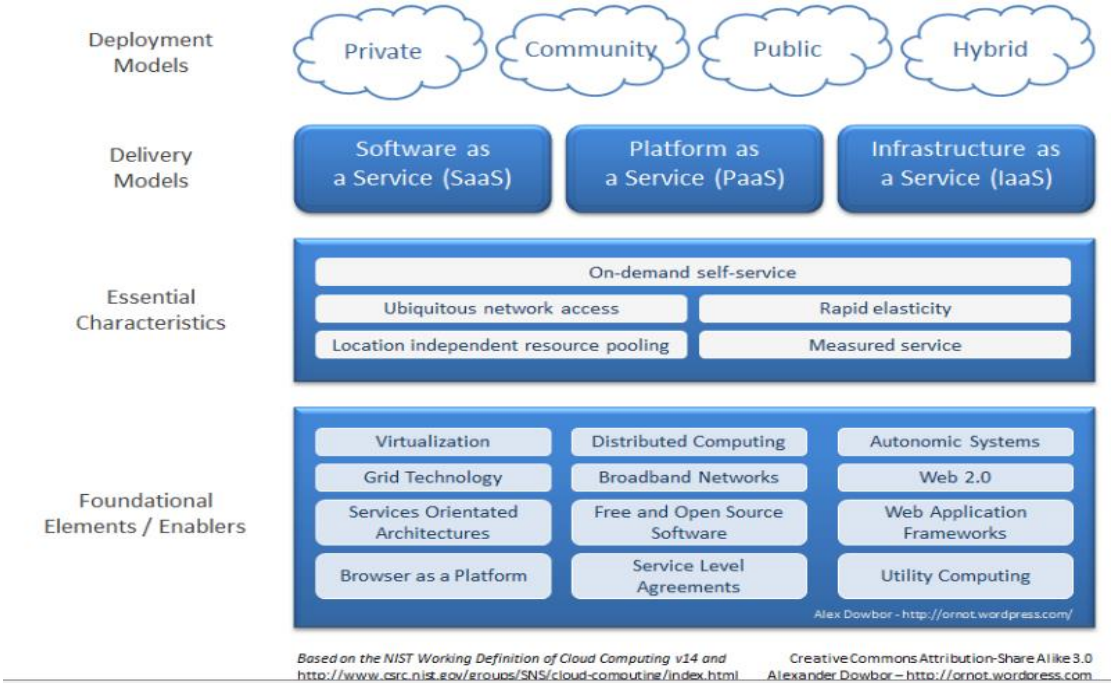

Figure 4 Cloud computing, characteristics, deployment models, service pool, and types of services and users Adapted from [34]

By looking at the four development models, also refer to the four types of cloud computing as elaborated by [37]

- **Private Cloud**: it where the cloud infrastructure is used and maintained within a single firm for their own used, this gives the optimum security since the access is only within the firm.
- **Public Cloud**: it is where the cloud infrastructure is owned by individuals were the services are being rented by individuals by using pay as you use service.
- **Community Cloud**: It is where the cloud infrastructure is shared within individuals with common goal working on same problem, it can be owned by one or all of the individuals.

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- **Hybrid Cloud**: it where two or more cloud infrastructures are linked together for the purpose of public and community cloud.

7. Benefits of Cloud Computing

Cloud computing provide user with easy access to resources that were expected 5G era will integrate [4], Some of the benefits of Cloud computing include Storage availability, reliability and accessibility [38], [39]:

- **Availability**: cloud computing resources will be available to the users at all-time everywhere anywhere.
- **Reliability**: Cloud computing resources are reliable, in the sense that there is no fear of data loss due to standby servers in case of failure.
- **Accessibility**: easy access to data stored on cloud computing resources at all time.
- **No Maintenance Cost**: All cloud computing resources are maintained by the providers.
- **Ease of Scaling**: The user can easily increase the storage capacity he pays for, from small to large or vice versa.
- **Saving in Up-front Costs**: Cloud computing services follow for as you use model, the user can only pay for the service he used.

8. Conclusion

Due to the emerging of next generation of communication system 5G and the relationship of this generations networking system with Internet of things IoT and the cloud computing. This research gives and overview of the mentioned technologies limiting to the basic concepts and benefits of each.

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