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An extensive review: Internet of things is speeding up the necessity for 5G

Ali Abbas Al-Sabbagh*, Ruaa. A. Saeed.Alsabah**, Ahmed.Yaseen.Mjhool***
(Department of Electrical and Computer Engineering, Florida Institute of Technology, USA)
*(Department of Babylon, SCIS, Ministry of Communication, Iraq)
** (Department of Computer Science, University of Karbala, Iraq)
***(University of Kufa, Najaf, Iraq)

ABSTRACT
The Internet of Things (IoT) is a very large number of objects, with intensive connections and allows these smart objects to be sensed and controlled remotely across efficient network, which is breathing new capability into anything anywhere in the life. This paper presents an overview of about 4G and 5G with their important features and how will drive IoT in future to build smart cities and smart objects. Scientists are concentrates about the advance implementation of these technologies especially the 5G is the term which is not formally used for any current technology and it is still early to provide an exact definition of 5G. We also present an overview of future keys in cellular system to get better IoT such as D2D, M2M, NOMA and Massive MIMO. This work presents the exact steps in 4G and 5G which important towards IoT and the ability to establish the smart cities. Nowadays 4G LTE-A systems are getting maturity and have been installed, the challenge now is how to improve 4G to get a smooth development from 4G to 5G. Among these steps and challenges are considered as the pieces of the 5G using massive MIMO, new access techniques, millimeter wave (mm Wave) and M2M, D2D communication. The future fifth generation (5G) cellular networks have drawn great attention from scientists and companies around the world. 5G cellular networks should accomplish 1,000 times higher mobile data per geographic area. Plus 10-100 times higher number of connecting devices, with low latency and long battery life.
Keywords- IoT, smart city, D2D, M2M , and 5G.

I. INTRODUCTION

In the resent years a huge interest in smart objects that all can connect to the Internet to share and make big new services to world like smart home, mobile health, and for industrial applications, such as smart grid, efficient transportation and logistics.. The resulted combo system is representing to as the Internet of Things (IoT). Fig (1) shows the variety of application that can be provided by the internet of things[1], because of that there must an efficient wireless networking technologies with the development of the world, like Wireless Fidelity (WiFi), Long Term Evolution Advanced (LTE-A),5G 5G, Bluetooth, ZigBee and others. All these network technologies are used to achieve the communication from the devise to devise (D2D) or the devise to Machine (D2M) perspectives. Because of the different type of the network equipment another communication between Machine-to-Machine (M2M) also utilized in many circumstances for example inside homes, commercial buildings, schools, hospitals, and factories.[2]

Figure (1) Internet of Things

Device-to-device (D2D), the term device refers to the user who uses cell phones or other devices. The communications of D2D is the technics that allow devices to communicate with each other without an the need to access points and the involvement of wireless operators or base stations.[3] Machine-to-Machine (M2M) communications describe algorithms, technologies, and mechanisms which enable wireless and/or wired services and networked devices to exchange information or control data easily, without the need of human intervention.

In this case a machine is a device or piece of software. M2M communications will revolute the telecommunication system operators business because of emergence of new networked applications, this will make many new clients and a huge data flowing in networks. Long Term Evolution Advance (LTE-A) Release 10, is a thoughtful technology produced by the Third Generation Partnership Project (3GPP) it is used in hundreds of networks around the world in many regional or national coverage. LTE-A is efficient modulation coding schemes, mandatory multi-antenna operation, and very flexible deployment in UHF frequencies are all take in consideration to characterized also the varies type of cell sizes ranging from several kilometers (macro-cells) to few tens of meters (femto-cells) for in-house base stations, called Evolved Node B (eNB). IoT applications are thought by telecom and service operators to be the opportunity to the new generation of the future because of its bight future and advantages it bring pervasive diffusion [1, 4].

II. SMART CITY

To This section is very related to the future of IoT applications. And a few papers pay attention to give some details about it in internet of things surveys. Smart City is a term going to be hearing frequently in next years. The model most commonly adopted to bring business which grow both software and hardware applications for the Internet of Things. This model can presented by Fig (2) [1,5]. In this section will give some examples about the smart cities first example is Glasgow, UK the government has offered ($37 million) for technology which will make the city "smarter, and more confortable. The new generation information technology and knowledge-based economy, based on the plan of future cellular network 4G and 5G, this combination of the Internet, and other sensors or devices where Internet of Things technology (IoT).

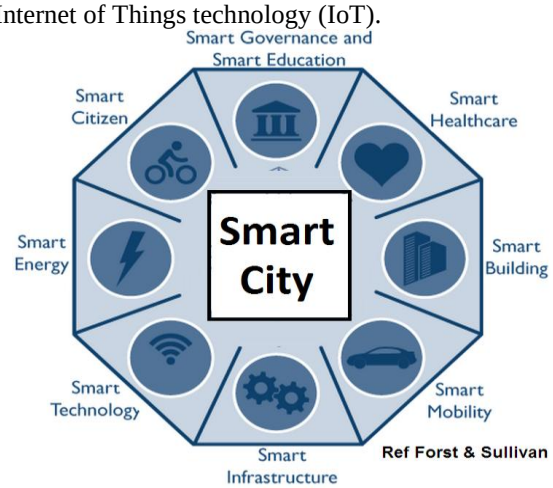

Figure (2) Smart City features

The second one is Copenhagen in Denmark. The third one California because several company make the business there. The main features of a smart city and applications are following below [5,6]:

1- Smart Lighting: the optimization of the street lighting in better way.
2- Smart Parking: this is a big issue in some countries like USA. to monitor the parking availability in the city.
3- Traffic Congestion: especially in big cities with high density. This mission to monitor the vehicles and pedestrian levels. Also Intelligent Highways with warning messages and diversions according to climate conditions.
4- Automation of Public Buildings: Another important application of IoT technologies is the monitoring of the energy consumption (schools, offices, and museums) by many types of sensors and actuators.
5- Structural health: Monitor Buildings, bridges and historical places to evaluate vibration and material conditions.
6- Waste Management: this make detection of the levels in containers to optimize the trash collection.
7- Forest Fire Detection and Air pollution: Monitoring of fire conditions to define alert zones. In addition to monitor the pollution emitted by cars and toxic gases generated in farms.[5,7]

III. INTERNET OF THINGS REQUIREMENTS AND CHALLENGES

There are three important requirements of IoT Senseing data, Processing and connectivity, all these requirements make an obstacles to implement IoT in future by challenging us by several issues related to the huge number of devices and huge data transferred in the world. Internet passed some phases until receiving IoT starting from PC-PC connection [8], then step by step to higher level of cloud to arrive to IoT as shown in figure

below:

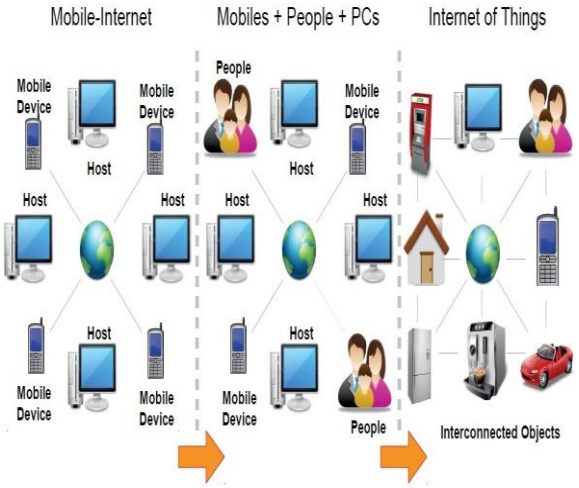

Figure (3) Internet stages to IoT

The challenges of IoT-devices can simply clarify as follow [9,10]:

1- Signaling:
A reliable bidirectional signaling is very important with IoT connected devices to make the routing data easy. Devices may be talking to a server to collect data, or the server may be talking to the devices, or maybe those devices are talking to one another. In other word data needs to send and back from point A to point B in fast way and trusty.

2- Security
Security is a huge umbrella, but it's paramount in Internet of Things connectivity. These can simply as follow an authorization: When sending or receiving a stream of data, it's essential to make sure that the IoT device or server has a correct authorization to send or receive that stream of data.Open ports: An IoT device is dangerously defenseless when it's listening to an open port out to the Internet. Then Encryption needs (end to end encryption) between IoT devices.

3- Presence Detection
By knowing immediately when an IoT device drops off the network and goes offline. Or come back online. Presence detection of IoT devices gives an exact, up to the second state of all devices on a network. This gives the ability to monitor IoT devices and fix any problems that may arise with your network.

4- Power consumption
Sending data between one another (IoT Devices) takes a toll on power and CPU consumption. With all this communication need an efficient cellular system using HetNet 4G or 5G as a long battery life, also a smart sensor built in IoT device and figure below shown the relation between recive power verses the distance by HetNet.

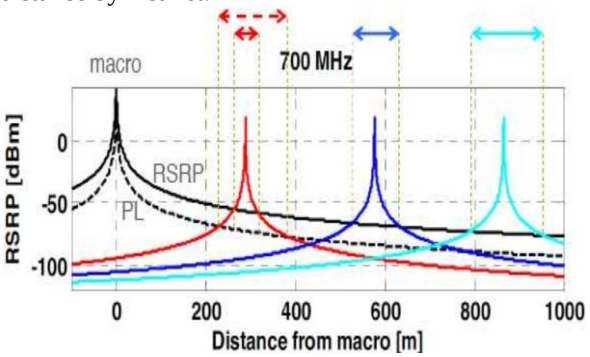

Figure (4) Receive signal VS distance in HetNet

5- Bandwidth
As expected in future thousands of IoTdevices are connected to the network, so the bandwidth consumption is another challenge for IoT connectivity. Bandwidth on a cellular network is expensive that why we have discussed a LSA in 5G section. [1,9, 10]

IV. INTERNET OF THINGS PREDICTIONS

In next five years IoT and the Cloud more than 90% of all IoT data will be hosted on service provider platforms as cloud computing reduces the difficulty of assisting IoT "Data Blending". Also Within three years network capacity, 50% of IT networks will transition from having excess capacity to handle the extra IoT devices to being network constrained with closely 10% of sites being overwhelmed. IoT at the end By 2018, 40% of IoT-created data will be stored, processed, and acted upon close to, or at the edge, of the network. Today, over 50% of IoT activity is centered in manufacturing, transportation, smart city, and consumer applications. IoT and the Smart City. Challenging to build innovative and sustainable smart cities, local government will represent more than 25% of all government external spending to organize, commercial value of the IoT by 2018. Within five years, 40% of wearables will have evolved into a viable consumer mass market. By 2018, 16% of the population will be Millennials and will be accelerating IoT adoption due to their reality of living. IoT will become open-sourced allowing a rush of vertical-driven IoT markets to form. Also IoT and embedded systems.
By 2018, 60% of IT solutions originally developed as branded, closed-industry solutions. This section we have discussed some statistical information to get an idea about the future and challenges and some these numbers and facts are shown in Fig (5): [11,12]

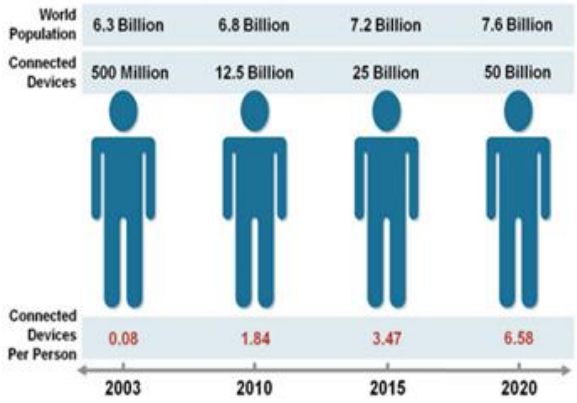

Figure (5) expected IoT devices -Year 2020

V. D2D COMMUNICATION

One of the achievements of 3GPP Release 12 is the development of of LTE (D2D) discovery and device communication with the device. Release 12 is just the beginning but over time D2D will create a number of new service opportunities, in the same time achieving the performance and efficiency of important advantages in LTE networks. To do this, allowing mobile devices to detect the presence of other devices in the vicinity and communicate directly with them, with minimal involvement of the network. LTE D2D is complex development but a great opportunity for mobile network operators; it can have serious consequences for the design of the mobile network. D2D set a precedent for networks relinquish some of their control over mobile devices and traffic and that will impact on existing services and future planning of the network. During these years, an important area of interest for the especially social networks and Internet industry which can achieved by the proximity-based information and applications The most important application can be made to a user at a given time in a particular place at a particular time situation, the more valuable it becomes, and the more likely that the user will act on it. A secure, dynamic, flexible, efficient a decentralized approach to proximity discovery and device-to-device communication, is provided by enabling proximity-based services to flourish LTE D2D. [13,14]

VI. M2M COMMUNICATION

The communication of the machine to machine can enrolled in many brunches in our life such as, safety and protection, smart home technology, e-health, sensor networks in factories, education is an incomplete list of areas in which machine-to-machine communications could be achieved, as shown in Fig (6). M2M is a generalized growth of mobile communications with a host of applications, in the future, the 3rd Generation Partnership Project (3GPP) will standardized the principle of M2M application operation in 3GPP networks. Because M2M communicate between different machines (sensors usually) and the core network. We will have about 300 billion devices M2M trend.

M2M is used in navigation, security systems, communication between different objects, as a rule, in itself, health systems, etc. These devices should be in certain requirements based on the operating conditions. [15, 16]

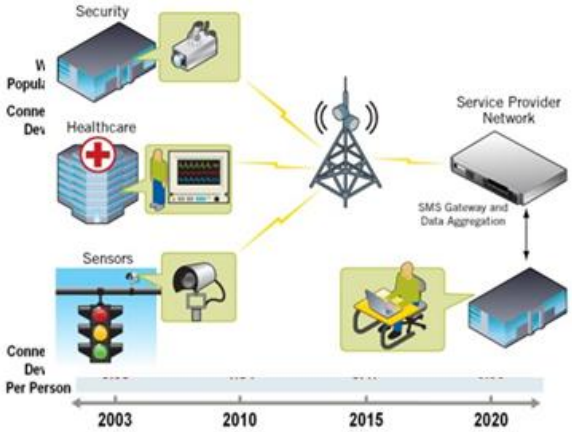

Figure (6) M2M different applications

VII. FIFTH GENERATION (5G) TECHNOLOGY

5G is the next generation for mobile system proposed to be commercially 2020 this technology has amazing data capabilities and high data broadcast within the latest mobile operating system. 5G provides high connectivity and universal coverage by using the same multitier network in 4G. Some of its features are following: [17]

1) 5G Cellular system provides a high resolution for bi-directional large bandwidth with effective billing system.
2) 5G Cellular system offers subscriber supervision tool.
3) High quality service by using special policy to avoid error.
4) 5G Cellular system provides large data in terms of gigabit. And will become more accurate.
5) 5G provides up to 25Mbps connectivity speed. And uploading, downloading speed is touching peak.[18]

This will come by using the splitting techniques from 4G with new access scenarios by Macro, Micro, Pico, relay and Femto to get more users in small coverage areas as shown in the fig(7):

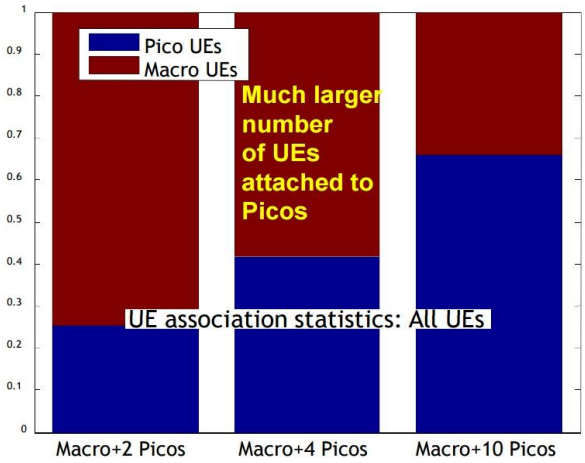

Figure (7) (Macro + Pico) attached users.

VIII. MASSIVE MIMO

Massive MIMO is the solution to access thousands of arrays to be configured at the base station. For more accurate beam control and greater spectral efficiency than legacy MIMO, in legacy base station has an eight antenna arrays. But massive MIMO also involves the use of spatial multiplexing and interference mitigation to increase system capacity. Some research work to get more than 64 antenna arrays. This required a new antenna design, and reference signal design still needs additional effort. This called CoMP which is mean Coordinated multi-point transmission. Massive MIMO is an extension of CoMP. this is clearly shown in the figure [16,17]:

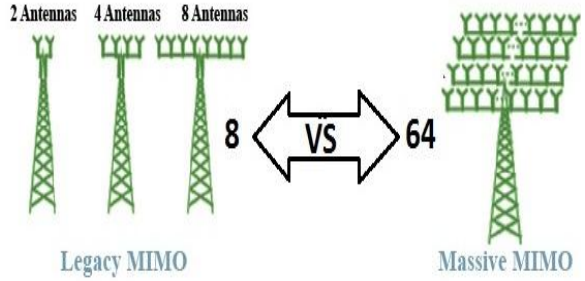

Figure (8) 5G-Massive MIMO

IX. NEW MULTIPLE ACCESS (NOMA)

NOMA is non-orthogonal multiple access which is a new proposed solution instead of OFDM using non orthogonal signal as shown in figure below. The information at the transmitter side is superposed in the power domain or code domain and is demodulated at the receiver side. NOMA also can be used in NFC near-far between users and obtain the maximum sum rate.

NOMA can be considered as power-domain or code-domain. The first one NOMA power domain is an extension of the spatial, time or frequency domains and enables more users to access in the limited case. The second one NOMA Code-domain contains low-density CDMA and interleave division multiple access (IDMA) this is a combination idea. NOMA is mostly used high dense area, or access cannot be easily synchronized like D2D Discovery phase. Or can be used in different case which is the base station has a comparatively small number of antennas not Massive MIMO. Such an ultra-dense networks, D2D communication or M2M communication.[17]

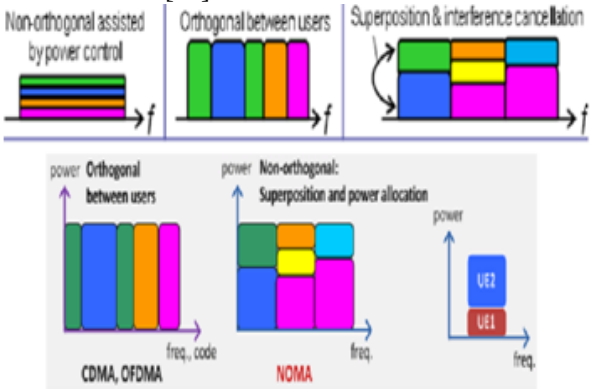

Figure (9) Non-Orthogonal multiple access.

X. SHARED SPECTRUM

CR: Cognitive radio was often pushed as a solution to the problem of frequency spectrum shortage; it is rarely adopted as there are always concerns about the impact on the primary user or license holder of the spectrum. Nowadays there is a vision for alternative solution proposed which can seriously solve this issue is (ASA): Authorized Spectrum Access or some time called (LSA): Licensed Spectrum Access. Simply the idea of LSA is to permit approved users to access licensed spectrum based on conditions set by the licensee of the spectrum. This allows the spectrum to be more efficiently used and solve the problem of QoS: quality of service for the users. [17, 18]

XI. MILLIMETER WAVE (MMWAVE)

Bandwidth is an important issue for high throughput, by using a millimeter wave length will go higher and higher in frequency not like the current one in 4G up to 6 GHz. That why there is effort to look beyond 6 GHz up to 60 GHz and also at the millimeter wave frequencies to evaluate their feasibility for use in future networks. But we have a challenge for outdoor cases because broken waves in buildings, at the same time in future have to use a new channel modeling in different scenarios. This will be required before transmission technologies can be designed for them. Millimeter wave frequencies hold the most promise, and there are already on-going efforts to make this a possibility. This is very usefull for indoor applications with high dense devices with small area. [17, 18]

XII. 5G IMPROVEMENTS FOR IOT

As shown in Fig(10) IoT expected devices is very huge by attached smart sensors to all the objects in our life. A cellular 5G mobile systems will require a combination of new system ideas to boost the spectral and energy in efficient way. This work present the main requirements for 5G wireless systems to fit IoT are outlined below: [12, 18, 19]

1- Data rate and latency: in 5G networks are intended to enable an practiced data rate of 300 Mbps and 60 Mbps in downlink and uplink. The end-to- end latencies are estimated to be in the order of 2 to 5 milliseconds.
2- Base station (BS): BS densification is an effective methodology to meet the requirements of 5G , according to the large number of low power nodes, relays, and device-to-device (D2D) communication links with much higher density in small area. This is a smooth development of 4G as shown in figure () displays a multi-tier network with a macrocell , relays, picocells, femtocells, and D2D links.
3- Machine-type Communication (MTC) devices: This step after M2M and D2D as discussed in previous section, which is number of traditional human-centric wireless devices with Internet connectivity such as vehicles, home appliances.
4- Multiple RATs: this is important key and the main difference than 4G inside the architecture of 5G which is not about changing the existing technologies, but to enhance and support them with new technologies. The desire 5G systems will continue to evolve to provide a superior system performance. In 4G- RATs, including GSM,HSPA and LTE.
5- Energy-efficient communication: One of the main challenges in 5G wireless networks is to improve the energy efficiency of the battery wireless devices And the combination of different energy harvesting technologies may be essential for macrocell communication, by using (e.g., solar and wind energy). Practical circuits for harvesting energy are not yet available since the conventional receiver architecture is designed for information transfer only.
6- Millimeter-wave communication: To satisfy the exponential growth in network traffic and number of devices with their future variety beyond the current 4G standard. and there are already on-going efforts to make this a possibility. This is useful for indoor applications with high dense devices with small area. To be precise the use of millimeter-wave frequency bands (e.g., 28 GHz, 38 GHz or 60 GHz bands) instead of the conventional 20 MHz channels for 4G.
7- Prioritized spectrum access: The ideas of both traffic based and tier-based priorities will exist in 5G networks, e.g., reliability and latency requirements, energy constraints.

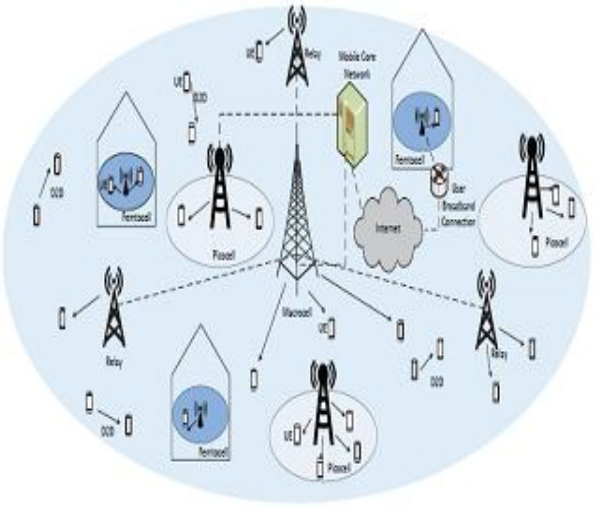

Figure (10) 5G network with muli-tier.

Basically the macro and femto users play the role of high-Low priority users. In the uplink route, macrocell users at the cell edge typically transmit with high powers which cause a high uplink interference to close femtocells. D2D transmission where different devices may opportunistically access the spectrum to form a communication link between them. Figure (10) A multi-tier network gives an idea about macro cells, Pico cells, Femto cells, relays, and D2D links. Arrows indicate wireless links, whereas the dashed lines denote the backhaul connections. This is an important feature will extend in 5G networks to allow other nodes, rather than the macrocell BS, to have the control. For example, consider a D2D link at the cell edge and the direct link between the D2D transmitters UE to the macrocell is in deep fade, then the solution by using the relay node to control the signaling of the specific link this happen by seven different layers for proposed 5G network as shown in the table below: [12, 14, 19].

Table (1) Layer structure of 5G

Application layer	Application (services)
Presentation layer	
Session layer	Open transport protocol
Transport layer	
Network layer	Upper network layer
	Lower network layer
Data link layer	Open wireless architecture
Physical layer	

XIII. CONCLUSION

The IoT has gained significant attention over the last few years. This idea comes by attached smart sensors to all the objects in our life. Also 5G is the next step after 4G in the evolution of mobile communication after using D2D and M2M and these will be a keys component of IoT to enable connectivity for a wide range of applications beyond those of previous generations by using the same heterogeneous networks of current LTE-A. 4G opens the doors through D2D communication to get smooth change towards 5G because new requirements for 5G are already unleashing a flurry of creative thinking and a sense of urgency in bringing innovative new technologies into reality. To implement an IoT, this requires a massive MIMO system with a new access technique such as NOMA and Licensed Shared Access. Also a mm-Wave cellular system 60GHz was considered something strange but now it is practically considered an predictability.

In Future 5G networks will be primarily designed to expand system performance and provide new services by the expected large number of connected device. This technology will increase the capacity and single user data rate, also reducing the delay by increasing the number of terminal connections. , it is a long road ahead to truly IoT and smart cities using 4G then 5G networks. Many technical Challenges remain under research to help pave the road to IoT and 5G.

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