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Comprehensive survey study on fifth-generation wireless network and the Internet of Things

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Abstract

Internet of Things is the interconnection of different components so that it should be able to communicate to each other to achieve a common goal. Therefore, for these components to communicate there will be a need of the communication Technologies. With the coming in of 5G wireless Network which provide more ability over the 2G,3G, 4G and other communication technologies. In this survey paper focuses much on what have been done before with 5G wireless Network in relation to Internet of Things, Application of 5G IoT, it also describes the various challenges which may arise when implementing it and the research questions. The next-generation protocol that will help to alleviate the current challenges which have been encountered. This paper will analyze the comprehensive survey on fifth-generation wireless network and Internet of Things from different papers and this will help to map the way forward on what best can apply 5G and other protocols in Internet of things.

Keywords: Internet of Things (IoT), 5G, Next-generation protocol, communication Technologies

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1. Introduction

The Internet of Things is an exciting and innovative technology that has the potential to transform the world by connecting physical objects which is called Things together in a network. It is concerned much with devices that use low power to communicate with one another over the Internet[1]. For these devices to be able to communicate to each other, they need to be connected to each other. The interconnection of the devices is possible using the communication technologies, therefore this makes the communication technology the main component and most of them are wireless technologies[2]. There are many wireless communication technologies which can be used in Internet of Things for instance Bluetooth, Zigbee, Z-wave, Wi-Fi, 4G, 3G, 2G, 5G and other [3] and Cellular technology is classified into short-range and wide-area technologies. Short-range cellular technologies use unlicensed spectrum like Wi-Fi and Bluetooth whereas wide-area cellular technologies use licensed spectrum like GSM, LTE, and 5G [4]. IoT relies heavily on the new 5G communication technology that has recently been created. This is so, because the future IoT devices will need to meet new performance standards, such as vast connectivity, security and dependability, as well as wireless communication coverage and coverage of ultra-low latency and throughput, as well as ultra-reliable operation, among other things [5].

There will be even more than 500 billion Internet-enabled gadgets worldwide by 2030 as it is predicted by Cisco, Therefore IoT modules will be built into these devices, allowing them to communicate with each other and build IoT networks[6]. The Internet of Things (IoT) will be used in nearly every aspect of human life, especially smart cities, smart homes, smart agriculture and smart transportation[7]. This paper will provide the comprehensive survey of different works which put too much attention on combination of fifth-generation and Internet of Things. This survey paper contribution can be

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summarized as follows: The overview of Internet of things and the challenges that are being faced when implementing the 5G wireless Network in the IoT environment, the main applications of 5G IoT, it also describes the How the Next Generation protocol will help to solve the current challenges faced in the 5G IoT main applications, and then it also explains what is the way forward when it becomes to 5G and IoT. It is structured in this way; Section II: It highlights the research questions, section III: the overview of the 5G and IoT (The communication generations and 5G features, The IoT overview), Section IV: the challenges which are being faced when implementing the 5G IoT, section V: The main Application of 5G IoT, Section VI: The Next generation protocols, The proposed way forward. Then there will be conclusion at the end of the paper to summarizes all the sections of the paper.

2. Research Questions

In this survey paper, the following questions have been identified after going through different papers which tackles the fifth-generation and Internet of Things.

- Discuss already available communication technologies used for IoT
- How can fifth-Generation wireless Network contribute to different IoT Application
- How future IoT will benefit from Next generation protocol

3. The Overview of the 5G and IoT

3.1. The Internet of Things overview

Since its inception in 1985, the Internet of Things which is best known by the word the IoT. An early IoT concept was to integrate people, processes, and equipment with communication technologies so they could communicate data remotely for information processing and administration[8]. Since 1999, the Internet of Things (IoT) has been widely discussed. Because of the rapid growth of communication, device, sensor, and internet technologies, it has been predicted that all items, including mobile devices, that surround us in the world would be connected to one another through communication infrastructure in the near future. The Internet of Things (IoT) has the potential to link anything to the internet, including mobile phones, PDAs, smart devices, actuators, and sensors. Afterwards, these devices can communicate in an intelligent manner with other devices or people using a unique addressing method in order to achieve specific goals in a variety of domains.

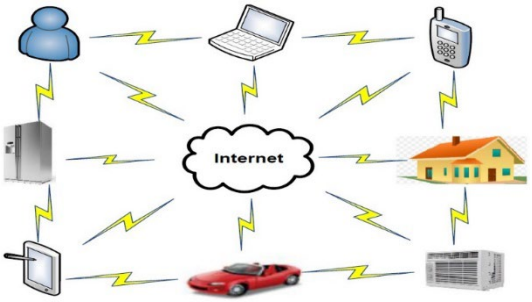

Figure 1. Shows how IoT works[3]

3.2. Fifth Generation overview

There will be billions of devices connected via wireless communication in the heterogeneous Internet of Things, which makes use of a variety of wireless technologies like 2G/3G/4G, Wi-Fi, Bluetooth, and so on as it been shown in [1]. By utilizing OFDM (Orthogonal frequency division multiplexing), Segan claims that 5G is built on the principle that digital signals may be modulated to lessen interference. OFDM and a new radio (NR) air interface are at the heart of 5G's technology. Wider bandwidth technologies including sub-6 GHz and millimeter waves (mm) are also used in 5G. With millimeter waves, 5G will be able to transmit data at speeds up to 1 Gbps. The use of spectrum resources will extend from the sub-3 GHz employed in 4G to 100 GHz and beyond in 5G, allowing for greater bandwidths. 5G is capable of operating in both lower and millimeter waves (more than 24 GHz).

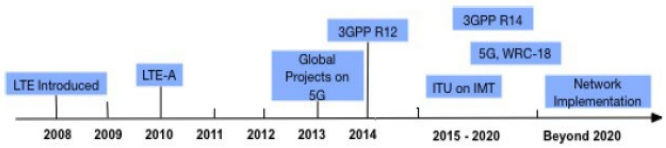

Figure 2. Shows the progression of cellular networks from 3G to the 5G-enabled Internet of Things

3.3. Reasons why 5G Wireless Network

The following are some of the reasons why need to adopt 5G Wireless Network:

- 5G is much fast than the previous networks (4G).This is so because it is possible for 5G to deliver peak data rates of up to 20 Gbps and average data rates of over 100 Mbps, making it significantly faster than 4G.
- Compared to 4G, the capacity of 5G is much greater. According to [9], It is intended to handle a 100-fold increase in traffic capacity while also improving network efficiency.

- The latency of 5G networks is significantly reduced. As a result of a 10 times reduction in end-to-end latency, the 5G network can deliver instantaneous, real-time access (10 times less latency than 4G).
- Unlike other networks, 5G is a single, unified platform that is more powerful. When it comes to mobile broadband speeds, 4G LTE was all about giving quicker connections than 3G, but 5G is intended to be a more robust platform that can handle new applications like mission-critical communications and the enormous Internet of Things. As an added benefit, it is capable of supporting all spectrum types and band sizes (low, mid, high), as well as a broad variety of network configurations (from standard macro-cells to Wi-Fi Hot Spots), as well as innovative methods of interconnection
- 5G makes better use of available spectrum than 4G. In order to maximize the use of available spectrum, it is designed to take advantage of a diverse range of spectrum regulatory paradigms and bands, ranging from low bands below 1 GHz to mid bands (1 GHz to 6 GHz) to high bands known as millimeter waves.

4. Research Challenges on 5G-IoT

The 5G has capabilities that can meet the needs of the future IoT, but it also presents new research challenges on the 5G-IoT architecture, security issues, trusted communications between devices. IoT applications are being transformed by the 5G-IoT, which incorporates a variety of technologies. We have categories these challenges into three main categories, Namely: Technical challenges, Standards issues, and the security and privacy challenges.

4.1. Technical challenges

- 5G-IoT architecture where we have the other most challenging issues of Network management and Scalability: Due to the huge number of IoT devices, network scalability is a big concern in the 5G-IoT. Another difficulty to take into account is how to keep track of the current status of a large number of IoT devices[10]. Heterogeneity and interoperability: Interconnecting heterogeneous networks is difficult. Thousands of IoT devices will be connected via a communication technology to share and collect data with other smart networks or apps[11].
- IoT applications deployment: Weak resources and a varied environment make IoT application deployment a difficult task. Overlay deployments of IoT devices networks prevent devices and applications from communicating and sharing information[12].
- There are more technical challenges such as Device to Device communication, Wireless software defined network, dense heterogeneous networks deployment in IoT, full-duplex transmission at the same time

4.2. Standardization challenges

The 5G-IoT will see a lot of IoT solutions being proposed. The standardization of 5G-IoT will make it easier to implement and build applications. In 5G-IoT, there is a lack of consistency and standardization for both IoT systems and applications because of the heterogeneous nature of networks and devices. Many obstacles and challenges remain before these solutions may be put into practice[13].

4.3. Security and Privacy Issues

Device and network levels of security will need to be upgraded in the next 5G-IoT for sophisticated applications such as smart cities, smart networks, etc. The complexity of 5G-IoT security makes it difficult to use. In addition to remote software intrusion, the device's designer must address local intrusion [14].

5. Main Applications of 5G-IoT

The 5G network has the potential to provide a substantial future for billions of smart devices working together and machines and devices will be able to communicate with one other without interruption from humans[15]. 5G-IoT is a set of devices and solutions for the Internet of Things. Industrial IoT and business applications technologies are being transformed by the use of Spitfire connection to mobile devices, which is enabling improvements in homes, cities, factories, Transportation, Healthcare and other IoT applications[16]. According to [17], It is envisioned that 5G technology, which will be commercially available over the next decade, will enable smart cities and other related applications to operate at higher data rates and lower latency than previous generations of wireless technology while also providing higher peak performance and greater reliability.

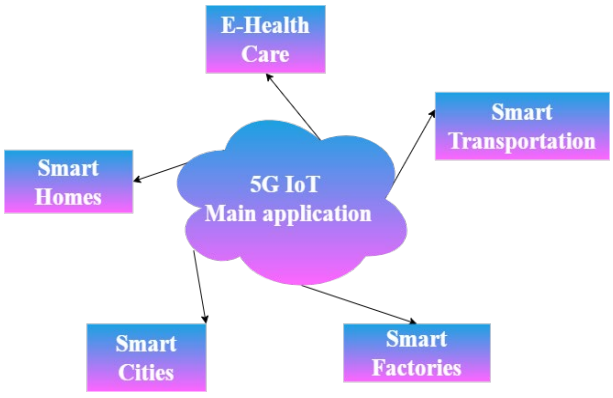

Figure 3. shows the main applications of 5G-IoT

5.1. Smart Cities

Global wireless connectivity is sought for by everyone in order to unite everyone under one roof of wireless technology everywhere, at any time. As much as 10 times quicker than current technology, 5G cellular technology promises to deliver data rates of up to 2 GBPS, enabling smart device connectivity and high-speed internet connections[18]. Better utilization of public resources will allow smart cities to offer better services in the future. Intelligent transportation systems, smart lighting and smart housing are among the many uses of Multi-Tier Communications (MTC). Smart cities are the culmination of all of these initiatives, which are comprised of a number of sub-applications[19]. A single communication network, known as heterogeneous networks, must accommodate all Internet of Things applications. Mobile and internet users will increase in number as well as sophistication in the next generation smart city, which will have 24x7 wireless connectivity.

5.2. Smart Transportation

A major use of 5G internet of things technology is smart transportation, which is also known as intelligent transportation systems. Transport systems will become more reliable, efficient and secure as a result of the development of integrated intelligent transport management, control systems and communications networks in the near future Each smart vehicle in the future will be outfitted with sensors, an electronic control unit, and other components that will enable it to be monitored and controlled. Millimeter wave technology, which travels through fog and rain, will be used in the development of 5G radar to provide collision avoidance systems and automated braking systems in the future of intelligent cars.

There will be communication between vehicles and anything with the use of these channels, which will be accomplished by radar communication. Intelligent transportation systems connect every car in an IoT network to share traffic and road condition information, reducing the risk of significant collisions and providing passengers with a safer ride[20].

5.3. Smart Factories

Industry 4.0 calls for enterprises to move away from Ethernet and other wired technologies in favor of wireless ones in order to provide the manufacturing plants with the agility and self - configuration they foresee. Despite the fact that large corporations have begun testing 5G wireless communication technology, it is still in its early stages of research and has no ready-to-use real-world application [21]. As we can see, smart buildings, smart machines, smart transportation, Smart manufacturing, and industrial robots are some of the criteria for creating smart factories. With advanced low-power network protocols, software algorithms and industrial processes we can see smart factories, not just smart equipment, but a comprehensive infrastructure of advanced technologies. In order to optimize more smart factories, there, is need of incorporating; Cloud Robotics, Advance Sensor Technologies, Cognitive Robotic Internet, and Artificial Intelligence.

5.4. Smart Homes

Smart houses are another key 5G-IoT application. Connecting household appliances with fifth-generation wireless technologies is possible. Machines and devices can communicate without interruption thanks to the 5G network. Appliances like the refrigerator, air conditioner, television, and other electrical devices are all connected to the internet for smooth and effective operation. To accomplish a variety of activities, future homes will feature internet-connected windows and doors, as well as smart sensors and remote controls that make use of this technology. Every equipment in a smart home can communicate with each other thanks to 5G technology, which will allow for lightning-fast internet access throughout the house[22].

5.5. E-Healthcare

Health care is another key industry that must be given the utmost attention. According to a phrase, "Health is wealth," telemedicine is currently the most popular technology for improving health care. By utilizing 5G wireless technology, the healthcare industry is able to communicate with each other over vast distances more effectively. Remote locations can benefit from effective patient monitoring using the 5G telemedicine technology. Patients' vital signs, such as ECG, SpO2, Temperature, and Pressure, are sent from rural hospitals to big hospitals via 5G communication link[23]. Modern electronics and wireless facilities at the largest hospitals allow for faster data transmission and better internet connectivity than ever before. Patients' vital signs will be sent to major hospitals over the same communication link after the doctors have completed their diagnosis. A full duplex communication system for 5G networks is required, and rural hospitals will be able to treat patients according to the diagnosis results sent by big hospitals. To ensure smooth operation and to deliver world-class health care services everywhere, future e-health services will give hospitals with high internet connectivity with communication between hospitals, doctors, pharmacies, and administration[15].

6. Next Generation Protocols

A ccording to the Research Report Gartner Symposium 2015, they projected that by 2020, the Internet of Things (IoT) is expected to have grown to 21 billion devices, creating over 44 zeta bytes of data. IoT-connected gadgets

aren't the same as traditional communication endpoints with regular network interfaces[24]. That's, why now the Next Generation protocols comes in to solve these challenges which may arise due to the ever increasing IoT devices, data, security issues. The purpose of the Next Generation protocol is to encourage the growth of a Next Generation Network architecture that has been informed by needs from a variety of use cases and implementation models. Next Generation protocol matches its objectives with the objective of increasing the efficiency of the Internet from origin to destination. Below is the figure which represent how the Next Generation Protocols will work in different application[25].

Multiple approaches, protocols, and strategies have been created in response to the ever-growing number of devices linked to the Internet in order to handle the increasing volume of traffic. One of these ways is the alleged transition from Internet Protocol version 4 (IPv4) to Internet Protocol version 6 (IPv6), which would result in the protocols' addressing capabilities being expanded by one generation. When it comes to IPv6, the neighbour discovery protocol (NDP) is believed to be a substitute for the address resolution protocol (ARP) functionality that was previously used in IPv4 [26]. For complex and scattered network applications in the Internet of Things (IoT) and Industry 4.0, the IPv6 protocol is considered to be a highly beneficial protocol. In the meantime, its industrial application in smart manufacturing processes is gradually becoming more popular[27]. According to [28] coined that the number of devices in the network increases, therefore also the received data gets complicated and sophisticated each and every day that necessitate the development of more efficient techniques to data collection, sorting, and processing in order to attain greater Quality of Service values.

The Next Generation Protocol comes in to overcome different challenges which the IoT devices that are being explained above[25] and it mainly focus on building up a variety of self-organizing, self-managing, and self-configuring network protocols that can meet the entire 3GPP specifications and establish an unbroken network[29]. The researchers are focusing on researching on the IoT and the IPv6 under the project known as IoT6, even though there are some challenges but there is a progress. In this project they are trying to find the way on how they can incorporate the IPv6 with IoT to form IoT6 which will be the answer to the current shortfalls and challenges of IoT[30]. As of right now, the most pressing issue is integrating IoT with IPv6 and the associated protocol so that various applications, such as automated homes and cities, may be offered. However, in order to develop an effective protocol, it is necessary to explore more on IoT applications and its associated major challenges, such as integration, complexity, scalability, security, dependability, flexibility, and homogeneity.

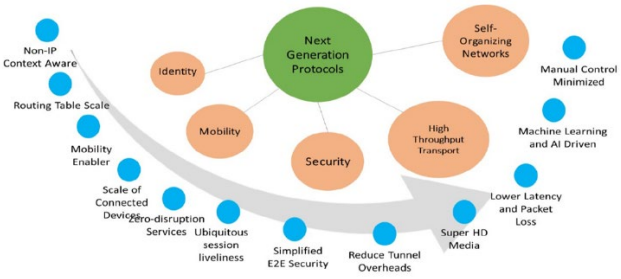

Figure 4. Main Goals and Focus areas of NGP[25]

7. The Proposed Way Forward

In the future research we need to include more technologies and innovation in it. As far as 5G is in progress of being implemented, there need to include the Big Data concepts in order to improve the work of the 5G-IoT which will make the IoT devices to be able to more intelligent than ever. Instead of handling the data which are extracted from IoT devices. The Devices will be able to analyze the data and send the responsible devices.

We also need to think about the energy efficiency as the 5G brings in more features and devices together. In order for these devices to work they need power up. Therefore, if it is taken into consideration it will help to improve the IoT devices. There is also need of the trade-off among the catching, computing and communication among the devices which are in the network. It will be better to choose the better communications between them, at the same time it should be fast when transmitting data between them.

Existing IoT and prospective IoT solutions are always being researched in terms of security and privacy because of these issues. End-to-end protection, identity and location privacy protection from active attackers are all part of the 5G-IoT security and privacy solutions. Secure infrastructure, trust models, service delivery models, heightened privacy concerns, and a threat environment are just some of the rapidly expanding 5G-IoT security needs. Therefore, Security and privacy issues need to be checked always when implementing the IoT application and there should be more research and continuity on this issues because data being collected is more important.

8. Conclusion

Integration of developing 5G technologies with the IoT is the goal of 5G-IoT. 5G and the Internet of Things (IoT) are examined in this article. As a starting point, I have described some basic information and recent studies on 5G and IoT. Then I have analyzed the challenges of 5G -IoT and the next generation protocol which will play a major as far as 5G – IoT is concerned by solving the current challenges since the projected number of devices increase each and every day. After that I have detailed the main

applications of 5G-IoT as well as the way forward in the future IoT.

Declaration

This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

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