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The 5G Era : Vision, Challenges and Beyond

Saicloni Sahu[1], Asish Rath[2] and Shubhalaxmi Mohapatra[3]

Ajay Binay Institute of Technology, Cuttack, India

Abstract: The advancements in fifth-generation (5G) wireless networking would offer various possibilities for distributing higher speeds and reduced latency, resulting in increased remote execution capability, a larger range of users linking devices, as well as aiding with the setup of a virtual network. 5G allows for a new type of network to link essentially anyone and everything, including computers, gadgets, and devices. Smaller cell infrastructure and denser distribution of different types of base stations is driving the trend of the next wave of wireless networks in the age of 5G networks. In this paper, we have discussed the principle of 5G technology, potential benefits, and various obstacles that the technology would face in order to deliver an effective and reliable wireless network than its predecessors. The paper begins with a brief review about the 5G wireless networking system and further discussing different features, applications, requirements and privacy schemes in the related field. As a case study, we have also addressed the survey trends and recent advances in the 5G wireless networks, presenting the verdict and finally summarizing the challenges and future directions of the next generation of wireless networks.

Keywords: 5G wireless networking systems, 5G wireless privacy scheme, Beyond 5G, Challenges in 5G, Internet of Things, Security and privacy

I. INTRODUCTION

Wireless networking is a necessity of today's society and is in high demand. As a result, in today's society, resources are favoured, and sales of wireless communication devices are increasing every day. Since wireless networks were first adopted in the late 19th century, researchers predicted that this technique would open up a slew of new possibilities in a variety of fields. When wireless infrastructure is combined with the Internet of Things paradigm, mankind is given a multitude of options to raise technological standards on a daily basis. Wireless networking systems include mobile phones, cordless phones, Zigbee wireless networking, GPS, Wi-Fi, satellite television, and portable computer components, to name a few. 5G and 4G networks, Bluetooth, and Wi-Fi applications are also available in today's smart phones.

Beyond the new 4G/International Mobile Telecommunications(IMT)-Advanced Technologies, 5th generation cellular systems, or 5G, are the next generation of wireless telecommunications [1]. The 5G wireless infrastructure is both an upgrade of legacy 4G broadband networks and a system featuring a slew of modern coverage features. 5G research and development aims to achieve a number of innovative characteristics, including greater bandwidth than existing 4G, a higher density of mobile broadband subscribers, and the ability to accommodate device-to-device (D2D) and large machine-type communications [1]. By default, 5G networks are heterogeneous, with several levels of connection tailored for various types of services. They will not only provide improved mobile broadband connections, but will also enable mission-critical services with low latency and great dependability [2]. If the International Mobile Telecommunications' recommendations are followed, 5G promises to accomplish objectives such as:

- 20 Gbps peak data rate
- 10 Mbps/m^2 for area capacity
- 100 Mbps data rates, even at cell edges
- 1 ms over-the-air latency
- 1 million devices per km^2

This leads to expectations such as a 10X increase in throughput, a 10X reduction in latency, a 100X increase in traffic volume, and a 100X increase in network reliability when compared to 4G [2]. As a result, if we talk of a bigger picture like a smart city, where a hybrid platform for continuous connectivity is required, 5G might be a good way to have that combined framework.

As 5G becomes available in the near future, it is expected to become the cornerstone of the IoT ecosystem. 5G-enabled IoT eco-systems will provide a long-term framework for the IoT eco-growth system. The Internet of Things would be an excellent use for 5G. [3]. Because of the restricted capacity and broadcast aspect of wireless communication, it is feasible but difficult to offer protection to users. User identity management and two-way authentications in the User Equipment (UE) and Base Station, protecting the contact link, and other common security

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methodologies are used in today's forth generation of Wireless Communication (4G). In terms of potential hacks, bugs, and privacy considerations, existing wireless networks have a number of security problems at the media access management layer and physical layer. Traditional networking architectures with security features such as user identity management, mutual authentications between the network and user devices, protecting contact channels, and so on are used to provide voice and data security safeguards [1].

Augmented Reality and Virtual Reality are two other major services offered by 5G technology. Augmented Reality (AR) is computer-assisted real-time information that is graphically augmented to the display and provides additional meaning to the user. Virtual Reality (VR) creates an environment in which computer graphics mimic the actual life of an object, and the user may communicate with the virtual objects [4].

Network performance can be extremely important in AR and VR implementations, as any compromise can negatively impact the overall user experience. While current 4G networks are suitable for some early adopter AR and VR experiences, the launch of 5G, which is a significant step forward from 4G, would undoubtedly improve existing experiences, allow new ones, and make them usable for mass adoption [2].

The fifth generation of wireless communication has the potential to drastically alter behaviour and accelerate the growth of IoT applications. National alliances can be critical in facilitating cross-industry collaboration in identifying and building the 5G infrastructure as the process of 5G progresses.

II. WHY DO WE NEED 5G ?

It's easy to understand why wireless communications has become more important over time. Advances in wireless communications have facilitated advancements in industry, education, and technology around the world by allowing improved access to information on the go.

The 5G wireless network has the ability to be an invaluable technology due to the speeds and capacity it promises. As we step into the Fourth Industrial Revolution and discover all that 5G has to bring, including items we haven't even considered yet, 5G technology is critical for both customers and companies.

III. INTERNET OF THINGS AMID 5G

5G is on the brink of becoming a possibility, and it will be a game-changer for present and future IoT gizmos. 5G networks can have a greater level of abstraction, making management easier. Sensors and actuators, wearable computing, communications and protocols, network, storage, and computing resources, as well as differing data and analytics, are all needed for the Internet of Things to comprehend vast amounts of information.

Moving predominantly small bursty packets of data to and from a large range of end devices, as well as large data packet transfers, is needed for the integration and automation of anything from home appliances to whole factories [7].

The following are the core criteria for a viable communication between IoT devices using next-generation wireless networking :

- Adaptable Quality of Service (QoS) support
- Significantly reduced latency
- Significant increase in spectral and network efficiencies
- Typically, equal bandwidth in both uplink and downlink directions
- Energy saving
- High integrity
- High system capability, huge interface networking, and the ability to handle small to large devices with differing traffic characteristics

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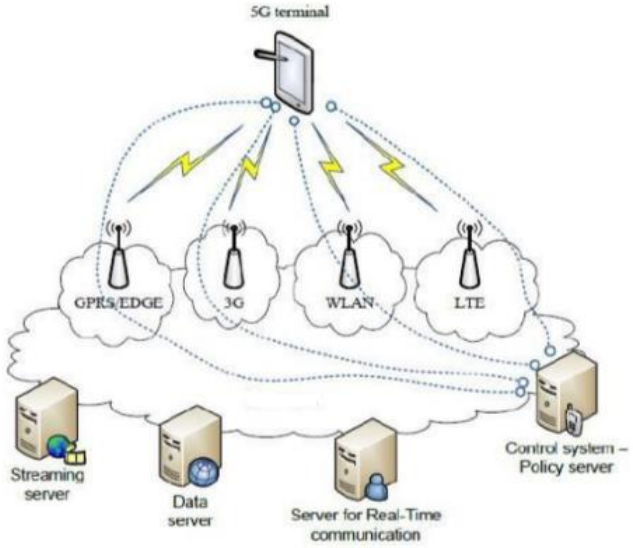

Since 5G technology has such a large spectrum, this data can be wirelessly distributed to control or central computers[3]. IoT can take advantage of 5G's new capabilities to perform more efficiently.

IV. WHAT DOES 5G HAS TO OFFER ?

Every futuristic mobile device must have a high data rate and follow all IP principles. The obvious goal is to support the inexorable increase in mobile data use[4]. Samsung has outlined the main criteria for 5G in the form of seven key performance indicators :

Cell Edge Data Rate (Gbps)

The data rate in the cell's edges is lower in 4G; however, 5G addresses this by improving the data rate regardless of the user's location.

Peak Data Rate (Gbps)

In comparison to its predecessors, 5G networks would be able to have a higher per-user data rate. This technology is projected to accept data speeds of 10-50 Gbps for low-mobility customers, and it will provide gigabit-rate internet services independent of the user's present location. The potential peak data rate offered by the 5G system is greater than 50 Gbps; however, the first commercial devices only offer 6 Gbps.

Latency(ms)

4G services have a 50 millisecond end-to-end latency and a 10 millisecond over-the-air latency. However, 5G networks are supposed to have a 5ms end-to-end latency and a 1ms over-the-air latency, which is a tenth of the latency offered by 4G systems. Low-latency services such as self-driving vehicles, public safety systems, and augmented reality will all benefit from this functionality.

Cell Spectral Efficiency

In comparison to today's network, 5G must be able to cover a larger area and handle more traffic. This is the most crucial criterion for the future network. It is estimated to have 1000 times the device power per square kilometre as the LTE system.

Mobility

5G can provide mobility at current speeds as well as at higher rates. Small cells that are designed for versatility must be able to support high speeds. It is also possible to accurately locate a computer here, which is becoming more critical as location-based reality augmentations become more prevalent.

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Simultaneous Connection

5G would facilitate the simultaneous connecting of a huge number of devices in order to accommodate all-time connected cloud services and IoT.

Cost Efficiency

It needs to have more bandwidth and a lower cost per unit network. As a result, it will be a better future network.

V. CHALLENGES IN 5G WIRELESS NETWORKING

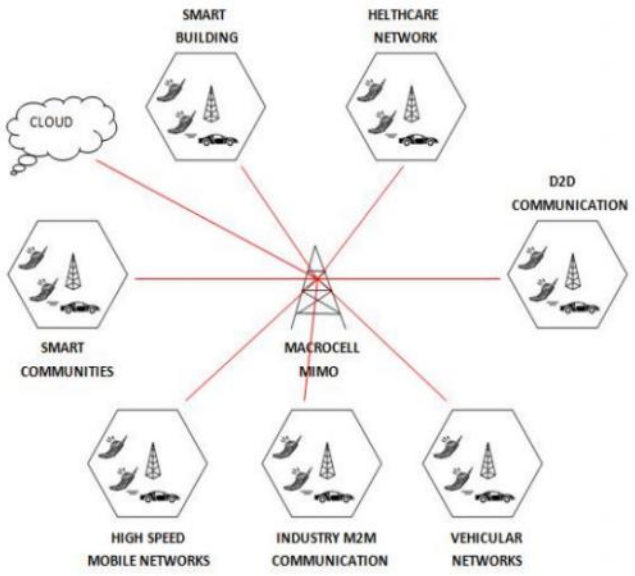
Implementing 5G into real world is what researchers and developers are solely investing their skills upon. With so many use cases and embedded technologies being used in 5G, security agencies face many challenges in addressing 5G advanced features. The authors from [9] proposed various challenges related to implement 5G into the reality overcoming cyber forms of security and are discussed below :

NEW TRUST MODEL

Not only are people and society benefiting from the advanced services provided by 5G wireless networks, but new services are also being applied to vertical industries such as smart grid, smart home, vehicular networks, and m-health networks. For various use cases, there has been research on trust models. The authors in [9] suggested a framework concept for safe data transfer over 5G wireless networks. Vehicle-to-vehicle connectivity is possible. Because of the large number of devices connected to 5G wireless networks, new trust models are needed to increase the efficiency of security services such as encryption. In the case of IoT users, authentication is required. Different security demands can necessitate different security criteria in the corresponding trust model. A high security level demand, for example, could necessitate both password and biometric authentication at the same time.

NEW SECURITY ATTACK MODELS

According to recent Physical Layer Security (PLS) studies, the most popular attack model consists of a single eavesdropper with a single antenna. The number of eavesdroppers on 5G wireless networks, on the other hand, can be exceedingly great. Large MIMO technology can also be added to eavesdroppers. Different forms of attacks can occur in real-world scenarios. PLS does not accept the cooperation of jammers or eavesdroppers so it only considers one type of threat, which can make PHY defence more complicated. While increasing the sender's transmission power will help, it can raise the risk of eavesdropping attacks when defending against jamming attacks. However, no novel security threat concepts or remedies have been developed.



PRIVACY PROTECTION

Wireless networks pose significant questions over privacy theft related to open network platforms, as data is used in a variety of emerging implementations in 5G. For a variety of applications to be developed, privacy security is a must. For example, to protect patients' privacy, the proposed protocol includes data access control and shared protection

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between patients and physicians. Privacy security in vehicular communications is defined as the protection of a vehicle's identity as well as the video content. With such large amounts of data, encryption and decryption can breach others' wireless service requirements. Protecting privacy effectively is a difficult task, particularly when dealing with powerful data processing techniques like Machine Learning (ML). Instead of relying solely on device, adding all this together makes it more challenging to provide satisfactory privacy protection in 5G wireless networks.

FLEXIBILITY AND EFFICIENCY

The security protocols must be scalable in order to meet diverse security conditions for different applications and complex architectures of the 5G architecture, focused on virtualization. Since the protection configuration must be customized and optimized, a modular security infrastructure is required for each security service. Security dependability is another key need of 5G wireless networks to fulfil both latency and Energy Efficiency (EE) standards, aside from the simplicity of security architecture and processes. Since 5G wireless networks are supposed to have better EE and latency than legacy wireless networks, security reliability must be maintained to protect the success of 5G wireless networks. Since nodes in IoT applications typically have restricted computing and battery capacity, effective protection measures are needed. As a result, all security design and security protocols must be strengthened to increase the performance of 5G wireless networks.

UNIFIED MANAGEMENT

Despite the fact that 5G wireless networks allow a wide range of services, connection systems, and devices, a security framework with a core set of security features including access authorization and confidentiality of sensitive protection is required. However, in 5G cellular networks, there are many new views on these security features, such as protection management through heterogeneous connectivity and security management across a wide range of devices.

VI. VERDICT ON 5G WIRELESS COMMUNICATIONS

5G wireless networks with high capacity and low latency can link anything from health care to self-driving cars to vital infrastructure. The greater use of virtualization and software-defined networking, 5G networks would be much more complex than 2G, 3G, or 4G networks. Concerns have also been raised on how to protect consumer privacy. The ecosystem – telecom carriers, physical infrastructure suppliers, vertical industries such as automotive, and regulators – must work together rapidly to ensure 5G protection.

5G's real-world dangers are already being illustrated. Researchers revealed 5G bugs at the Black Hat security conference in 2019, allowing them to control consumer locations and initiate attacks on smartphones.

When the telecom and industry experts were asked if they expect security challenges to escalate with the advent of 5G wireless communication and networks, about 94 percent responded that they were positive about facing sheer security and challenges in implementation of 5G into the real world, while the rest were either unsure or certain that it would go smoothly without much hurdles.

The next generation of wireless communication has been dubbed the "catalyst" for the world's fourth technological revolution, and it is critical to prepare for it. A new generation of startups and innovators will emerge as a result of 5G. In a 5G environment, augmented and virtual reality will become so popular that it will be considered standard practise for many companies.

VII. CONCLUSION

This paper discusses the fundamental requirements of 5G Wireless communications networks, which would be the next generation of mobile technologies. It also includes the obstacles that 5G roll-out is likely to encounter, as well as the services that 5G networks will provide. We've spoken about the roadblocks to 5G wireless networking implementation as well as potential solutions. Because of the disruptive improvements in radio and antenna technologies, spectrum, and network architecture, 5G is a significant enabler for the Internet of Things. As a result, 5G is a potential system that will be able to link the whole globe wirelessly with no limitations, and smartphones will be able to connect via IoT using 5G technology.

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