Chapter 11
Review of the Security Risks and Practical Concerns with Current and Future (6G) Communications Technology

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Abstract Gradually, the 6th Generation cellular network standard is being adopted (6G). Due to the creative and distinctive features of 6G, such as the capacity to deliver connection even in space and underwater, governments, corporations, and academics are investing a substantial amount of time, money, and effort in this subject. The next generation technology will be effective around the year 2030–2035. The next generation will be able to provide strong connectivity between machines and mobile devices. The speed can reach 1 Gbps in the downlink and 500 Mbps in the uplink. Edge computing, blockchain, advanced IoT and Li-Fi (Light Fidelity) technologies, as well as Artificial Intelligence (AI), are believed to provide the foundation for forthcoming innovations. Further research into the fundamental architecture of 6G is necessary to pinpoint these areas for development. We have examined a variety of concerns that might arise while employing next generation communication technologies, such as security and practical concerns. All of the physical layer's facts, which are crucial for implementation, were taken into account during the study. The conclusion of the study includes all the pertinent information and arguments that researchers might take into account while they work on next generation communication technologies.

11.1 Introduction

6G or Next Generation (nG) is the successor of the 5th generation (5G) communication technology. NG will definitely use higher frequency bands to provide higher speeds than 5th generation communication systems. Speed is inversely proportional

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to latency, so as speed improves latency will decrease. The researchers hypothesize that nG will support a microsecond latency communication which is much lower than that of 5th generation cellular networks. Which is 1000 times faster than a ms throughput or we can say it is 1/1000th latency of a μs throughput [1]. The next generation will provide hyper-connectivity between machines and mobile devices. NG speeds can reach 1 Tbps in the downlink (according to Dr. Mahayar Shirvanimoghaddam, Senior Lecturer at the University of Sydney) and around 100 Gbps in the uplink. Moreover, it is observed that in the next generation mobile and communication technologies will reach the level that the earlier generations could not reach. The next generation is being seen as the basis for edge computing, advanced IoT, and Li-Fi (Light Fidelity) technologies. Therefore, nowadays many futuristic vendors are investing in NG wireless standards and specifications such as 6G will be a network that will be around for years.

This paper is divided into 5 sections:

Section 11.2: Evolution of mobile cellular networks.

Section 11.3: Benefits of nG over 5G.

Section 11.4: The security issues perceived in 1G–5G.

Section 11.5: Vision for nG Architecture and Challenges while implementing next generation.

Section 11.6: Challenges while implementing next generation technology.

Here we are moving forward toward Sect. 11.1.

11.2 Evolution of Mobile Cellular Networks

We have improved the wireless communication system and expanded its capabilities to make it more powerful and robust. We have all experienced several generations.

Let's discuss each one separately [1–4].

11.2.1 0th Generation

- The pre-cell phones were the radio cell phones that were being used in vehicles before the arrival of mobile cell phones.
- Communication was limited to voice only.
- These cell phones were typically placed in vehicles.

11.2.2 1st Generation

- Calling facility was introduced in this generation.
- Analog signals were used for the communication.
- The Frequency Division Duplexing (FDD) was used for the channel allocation.
- Each channel was of 25 MHz.
- It only provided spotty coverage.
- There is no support for roaming between operators.
- Audio quality was not good.
- Speedy: 2.4 kbps.

11.2.3 2nd Generation

- Transitioning from analog to digital signals.
- SMS and voice both were supported.
- Support for the: Mobile Data, PCS, Wireless LAN, and Digital Cellular segments.
- The 2G WLAN provided a significant data rate and broad coverage.
- The rate is 64 kbps.

11.2.4 2.5th Generation

- 2.5G followed 2G, which made use of the GPRS concept.
- Furthermore, mail and streaming services were introduced.

11.2.5 2.75th Generation

- The 2.5G was replaced by 2.75G, also referred to as EDGE, which provided services more swiftly.
- Internet speeds of up to 128 kbps were offered, and an edge connection was also used.

11.2.6 3rd Generation

- The infrastructure of the Internet was improved.
- Better system and capability.
- Provides quick Wi-Fi internet.
- It was connected using WCMA and UMTS.
- The data rate was 2 Mbps.

11.2.7 4th Generation

- Based upon the IP protocol.
- LTE (Long-term evaluation), mainly focused on the internet. [Application-based mobile system]
- Vo-LTE, often known as voice over LTE, is used for both internet and voice.
- Any desired service may be selected with freedom and flexibility, and with an appropriate QoS.
- Higher usability.
- Affordable multimedia service with transmission capabilities.
- Streaming in HD resolution.
- Speed: −100 Mbps.

11.2.8 5th Generation (Moving Generation)

This generation has already started coming into existence in many countries, and it will soon do so in many more countries. Here are some important details about this generation [3, 5].

- Higher data rates as compared to 4G (4th Generation).
- Significantly lower data latency will result in faster and more secure connectivity.
- Enormous network capacity.
- It is 30 times faster than 4G.
- The flexibility of the network would rise.

11.3 Benefits of 6G (nG) Over 5th Generation Cellular Networks

11.3.1 Use of Different Spectrum

As we know that each generation of cellular communication networks uses a different spectrum which is increasing with respect to generations. So, we can say that the 5G network is working on 6–24 GHz frequency band then nG communication systems will have a spectrum from 95 GHz to 3 Thz. This will surely increase the diversity of the network in many aspects [3, 6, 7].

11.3.2 Faster Than 5G Technology

As discussed earlier, 6G (nG) will operate over a much larger frequency band, so it will provide data rates of 1 terabit per second in the downlink (theoretically) and latency between 1 ms and 1 μs. The speed of the next generation will be 100 times faster than 5G [3, 6, 8].

11.3.3 IoT Booming After 5G

IoT is an emerging field nowadays. IoT (Internet of Things) was launched in the era of fourth-generation communication technologies, but due to some constraints, a large number of devices were not supported by 4G (compared to 5G), the existence of IPv4 (Internet Protocol version 4) due to which large number of global IPs were not available. But as 5G is launched in conjunction with IPv6, IoT is going to become more popular with the birth of 5G. Now we are trying to move on to another generation (6G) which will be 100 times better than 5G so it will definitely accelerate the popularity of IoT [3, 6, 8].

11.3.4 Low Latency/Delay

The time taken by an information packet to be transmitted over a single frequency channel is called latency or delay. It was observed that the latency of the 5th generation was around 50 ms which was 10 times less than the 4th generation networks. As per the study, 6G (nG) is giving latency between 1 ms and 1 μs which is 5 times less than the 5th generation communication network, which means that nG will provide a better data rate per second than 5G [3, 6, 8].

11.4 Security Issues Perceived During 1st to 5th Generations

11.4.1 1G

The first generation was introduced in the 1980s. This generation offered telephonic communication services for the first time. This generation was entirely based on analog signals. Many issues were observed during the first generation, such as semi-reliable, hands-off issues, data security, etc. The main issue was security in fact this generation transferred data in a non-encrypted form so data was insecure during transmission. Therefore, users were not sure about data privacy and administrators

Table 11.1 Security issues in mobile communication generations

Security issues in mobile communication generations				
1G	2G	3G	4G	5G
Data Transfer was in Plain Text (**No Encryption**)	One Way Authentication was there. **Base Station to UE**	IP Vulnerabilities and OA Attacks	New device threats, MAC Layer Issues, and OA Attacks	Cloud Threats

did not feel secure about the network. The data can be accessed by intruders and unauthorized users [9–11].

11.4.2 2G

The second generation saw a transition from analog to digital communication. This generation was based on Time Division Multiple Access (TDMA) which provides voice data transmission and a short message service (SMS) facility. This generation is often referred to as GSM which provides all the services like authentication, and data privacy for both the users and the network. Network providers check the authenticity of users with the help of a random challenge and response approach. Data encryption has also been introduced in this generation. The SIM (Subscriber Identity Module) encrypts the data with the keys and transfers the data over the channel. Sadly, after the security improvements in the first generation, the second generation also lacks one-way authentication. It means the network can authenticate users by this one-way authentication but the user was not able to authenticate to the network. Therefore, base stations can act as legitimate members to steal users' private data and information. This was a huge threat in the second generation [9–11] (see Table 11.1).

11.4.3 3G

The third-generation communication system was introduced in 2000 capable of providing data rates up to 2 Mbps. Such speeds were not achieved by previous generations. This generation enabled advanced services like video streaming, high-speed internet access, and IP calls which were not possible in previous generations. This generation addressed many of the security weaknesses of the second generation. Here Two-way authentication was introduced which provides the ability for authentication between the user and the network or vice versa. Another authentication was also introduced in this generation known as Authentication and Key Agreement with open-air security which protects the data while traveling through radio waves in the open air. The third-generation was the release of the third-generation partnership project which gives this generation additional capabilities such as secure tracing, user tracking, and

user identification. Internet Protocol (IP) vulnerabilities, end-to-end communication wireless attacks such as integrity attacks, unauthorized access, denial of service, etc. are considered threats in third-generation communication systems [9–11].

11.4.4 4G

The fourth-generation was introduced in release 5 of 3GPP. 4G was launched under the name LTE (Long-Term Evolution) which emphasizes internet service and Vo-LTE (Voice over Long-Term Evolution) which emphasizes internet as well as voice communication. 4G was providing asynchronous data rates in both downlink (1 Gbps) and uplink (500 Mbps). OFDMA (Orthogonal Frequency Division Multiple Access) and SC-FDMA (Single Channel Frequency Division Multiple Access) were implemented for downlink and uplink, respectively. 4G provides a latency of 1 ms so it was able to handle all complex applications like high-definition TV broadcasts and high-definition video broadcasts. The threats observed in this generation are related to wireless radio communication such as data tampering, data theft, data modification, denial of service (DoS), and unauthorized access. Hence, the large number of user participation in the network makes it more vulnerable to security than older generations. Medium Access Control (MAC) layer vulnerabilities are also there [9–11].

11.4.5 5G

The 5th generation communication technology was introduced in 2020. 5G has been launched in some countries and telecommunication companies are planning to launch 5G in other countries soon. The 5G is launched with 3 different applications:

1. eMBB (enhanced Mobile Broadband).
2. URLLC (Ultra-reliable low latency communication.
3. MTC (Machine Type Communication).

The 5G provides 1 Tbps speed in downlink (theoretically) and 1 Gbps speed in uplink (theoretically).

As 5th generation is able to connect a large number of devices with good quality of service index across the network. Security and privacy issues can be identified by examining the network architecture. There are 3 parts to 5G network architecture, namely access network, backhaul network, and core network. Each network and its devices have different security and privacy issues. For example, the handover process between different networks or different devices can lead to privacy issues or attacks. The backhaul network is sandwiched between the access network and the core network, and the backhaul's connectivity with both is via microwave, wireless channels, and satellite links. Because the backhaul network has the least security

issues as compared to the other two. Security issues are delivered to the core network by moving backhaul sensors i.e., 2022, 22, etc. to the data plane using SDN and NFV technologies. Enhanced mobile broadband applications provide higher data rates as well as various security and privacy concerns.

To overcome these problems, 2 mechanisms have been developed so far. The first mechanism provides data communication between devices using basic authentication and key management technology. On the other hand, the second mechanism uses a protocol to group the devices with the help of the AKA-based Grouping Protocol. 5G deals with a large number of devices as it uses MIMO extensively. These multiple input and output streams also lead to a lot of privacy and security concerns. Additionally, the nature of 5G networks is an open architecture so the network as well as private information about users may be accessible to intruders or attackers. Therefore, these addressed security issues must be resolved to make it a more secure network in the future. The following Figs. 11.1 and 11.2 show the architecture and security issues of the 1st to 6th/next generation of 5G respectively [3, 9–11].

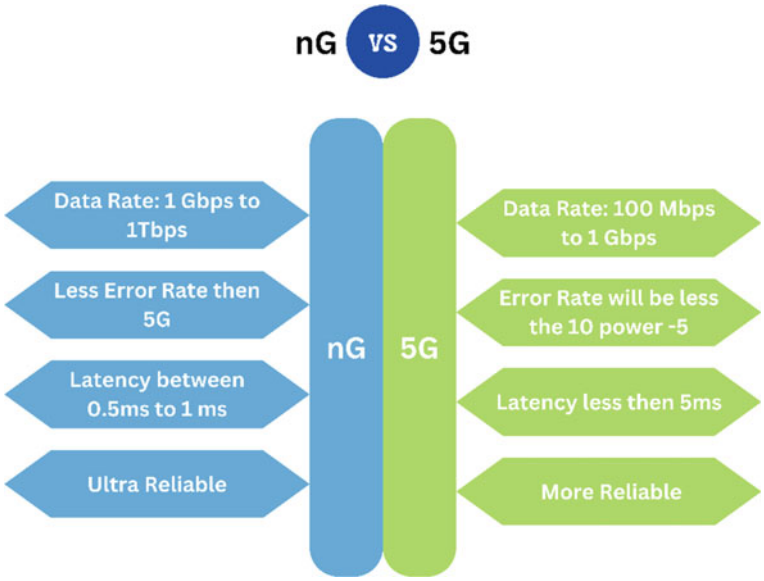


Fig. 11.1 Comparison among features of nG and 5G

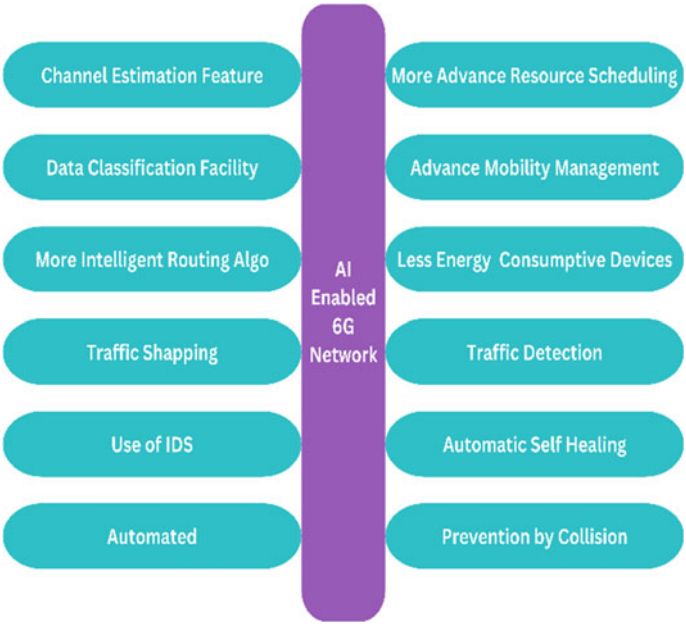
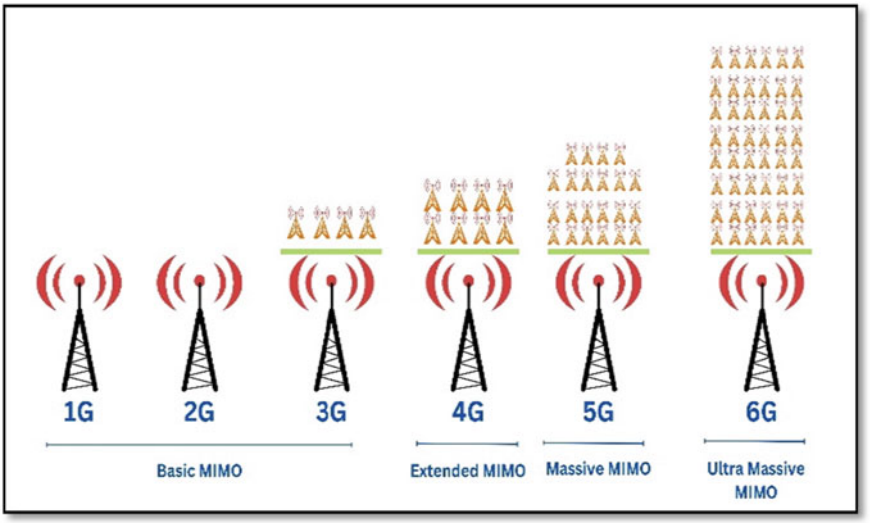


Fig. 11.2 AI-based network benefits

11.5 Vision for nG Architecture and Challenges While Implementing Next Generation

Figure 11.3 shows the detailed architecture of 5th generation communication networks. There are 6 core modules namely AMF, SMF, UFP, UDM, PCF, and Data Network which play a complete role in providing 5G Internet/Cellular connectivity to the users. The 6th generation (NG) architecture, on the other hand, will look like this: There's no doubt that we'll be seeing much faster speeds and higher-power signals that will entice customers of NG services. But what will be the architecture of ng and modules that will cover the whole realistic and robust future network? NG connectivity, power, and speed will serve as the backbone for the further development of networks and technologies that were predicted earlier. Certainly, the successor always overcomes the shortcomings of the predecessor, so NG will overcome the shortcomings of the existing networks in terms of network connectivity, better infrastructure, stronger connectivity, massive data rates, lower latency, and much more. Advanced IoT, Li-Fi, advanced AI, and edge computing will take advantage of the fast speed of NG to coordinate with complex systems and powerful connectivity [12].



. 11.3 Use of ultra massive MIMO

11.6 Challenges While Implementing Next Generation Technology

- Possibility of pure coverage.
- High-frequency range communication.
- AI-based network.
- Pure use of frequency bands.
- Security of the data and network.
- Flexible Network and Self-healing capability.
- Energy Saving Networks.
- Moving toward the possibility of certainty.
- Transparency (Openness) and Customizable.

11.6.1 Possibility of Pure Coverage

Mobile phones have made our lives very easy as we can talk to anyone at any time and can access the internet facility. But in this era, around 3 billion people are not able to avail the communication services. This is because of the non-deployment of the base stations/service providers in the remote area due to many hurdles like cost, unreachability, geographic conditions, etc. The next generation can work on space-earth integration. That integration can provide satellite internet and a communication system through which the remote and distinct areas can have access to the communication system [11, 13, 14].

11.6.2 High-Frequency Range Communication

As we know the next generation (6G) will work on the Tera Hertz frequency. Which may cover from 95 GHz to 3 THz. If it uses this frequency, it means the nG will exploit with no limitations. But the use of higher frequency will lead to some issues like [11, 13, 14]:

- Less coverage distance.
- Very high cost of deployment.
- Premature ecosystem of terminals.
- Environmental issues.
- Less penetration power.

11.6.3 AI-Based Network

Nowadays Artificial Intelligence has already been applied in many sectors of the industries like Image detection, voice recognition, and other types of automation. With the development of the advanced network low latency, high data rates, stability, and reliability are very important factors. We are working to achieve these factors but in a large network, the satisfaction of these factors is a very tedious task. So, our researchers are working on the improvement of these factors by implementing AI to automate the network and to provide robust and powerful network services [11, 13–15].

To overcome these leading issues all the telecommunication researchers and companies have to work together.

11.6.4 Pure Use of Frequency Spectrum

The communication technology is based upon the Spectrum. So, the sharing of the dynamic spectrum is being studied for the next generation like many different sectors namely AI, Blockchain and other applications will use the spectrum. Now the allocation unit has to emphasize each and every factor while distributing the spectrum for every type of application. That will provide a stable and robust nG network. The Massive MIMO was used in the 5G era but an ultra-massive MIMO technique must be used to provide a fair use of spectrum and user satisfaction [11, 13, 14, 16].

11.6.5 Security of the Data and Network

The digital network is playing a very important role in this era. But when we are moving forward with digitization the factor of security must be considered. The benefits of 5G nowadays include low latency, outstanding dependability, large bandwidth, and especially network security. In the next generation networks, the PQC (Post-quantum Cryptography), QKD (Quantum Key Distribution), and other techniques are being implemented to provide a better and more secure network [11, 13, 14].

11.6.6 Flexible Network and Self-healing Capability

The network must be intelligent enough to provide a resilient and self-healing capability. Because these facts are too specific to be obtained without any automatic network. The network should be automated which will calculate all the necessary things through which it can decide whether the users are experiencing the fair facility of the network or not. If a problem occurs in the network, the network should be intelligent enough to detect the problem and fix the problem automatically. This can be achieved by implementing AI in the network (as discussed earlier) [11, 13, 14].

11.6.7 Energy Saving Networks

Nowadays there is a drastic increase in the number of users in the network (human beings and machines (IoT)). To satisfy the needs of each and every user the deployment of the base stations is also increasing. As the number of users are increasing the system resource consumption is also increasing in parallel. Therefore, the devices must be less energy consumptive which will help us to save our precious resources and to save our ecosystem as well [11, 13, 14].

11.6.8 Moving Toward Possibility of Certainty

The services provided by mobile internet in the past were fraught with ambiguities and instability. In the 4G era, these services may easily satisfy customers. After all, a small amount of packet loss and network latency won't prevent users from watching movies and making purchases online. However, the delivery of low latency and high dependability is required for the spread of the 5G and 6G networks across all sectors and device types. In order to deliver end-to-end network service capabilities, the concept of slicing and MEC is associated with 5G. Network services are expected

to be more dependable and better equipped to adapt to a range of scenarios across a wide range of enterprises in the 6G era [11, 13, 14].

11.6.9 Transparency (Openness) and Customizability

We all know about the two internet pillars—sharing and transparency—help it to develop. As we enter the 5G era, mobile networks should actively motivate the combination of Communication Technology and Information Technology. This will make it possible for numerous industries to join the digital revolution. The pillars of transparency and customizability will grow in the next generation by providing flexible and responsive services with a good interface which will help the industries to adapt the networks and customized applications [11, 13, 14].

11.7 Conclusion

In this paper, we have studied real life and all the challenges related to network security through various resources. These challenges are very effective for next generation technologies. Therefore, the researchers have to emphasize these challenges to build a reliable, scalable, robust, flexible, secure, automated, and effective network.

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