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The Race Towards 6G Wireless Networks: Importance, Technologies and Challenges

Amjad Alsaleem

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Abstract: 6G wireless network is an emerging communication technology that is expected to revolutionize internet and thus pave the way for new advanced technologies. This article explores the need for 6G networks and show the major difference between 6G and 5G. Then, it discusses some of the technologies that could pave the way for 6G including artificial intelligence, terahertz communications, visible light communication, ultra-massive MIMO, quantum communication, and intelligent reflective surface. The research gives insights on the importance of 6G network, and what technologies can play roles in enabling it while highlighting some of the challenges.

Keywords: *6G; Technology; Network; Communication; Internet.*

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I. INTRODUCTION

Since 1990s, several wireless communication generations have emerged (1G-5G), with each generation providing great advancements in different telecommunications measures.

5G is a great improvement over 4G, as it provides user-experienced data rate of 0.1Gbps, which as 10 times faster than 4G, while peak data rate can reach up to 20 times faster than 4G. In addition, in 5G the latency is only 1ms which is 10 times smaller than 4G.

However, Internet usage has been increasing rapidly in terms of number of users as well as required data rates, especially with new technologies such as IoT and video streaming. Therefore, there is a real need for a new communications generation. 6G network technology is expected to improve the above mentioned Key Performance indicators (KPIs) by factors of 10-100 times. This paper will discuss the crucial need for potential internet improvements in 6G networks, then discuss its key enablers and their challenges.

II. IMPORTANCE OF 6G NETWORKS

There are numerous emerging advanced applications that require internet with super KPIs such as extremely high data rates, ultra-low latency, massive connectivity, enhanced energy efficiency and high level of security. These features might pave the way for many advanced applications. For example, holographic communication which would allow people to attend events faraway without the need of travel. In addition, extended reality applications which would allow people to try exceptional activities, and experience special environments virtually. Smart cities technology is another example which would lead to integrated smart systems for energy, transportation and public services.

There are several technical difficulties in 5G, that might be obstacles for all these technologies, thus comes the need for 6G to mitigate them. For example, 6G might be able to provide a thousand times faster internet speed. In addition, 5G requires time buffer, which affects real-time services, whereas 6G should not require time buffer, therefore latency will be much smaller. Additionally, 6G technology should allow connections of huge number of devices, perhaps up to 10M/km^2

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III. TECHNOLOGIES AND CHALLENGES

There are several technologies that could enable the development of 6G networks. For example, artificial intelligence, terahertz communications, visible light communication, ultra-massive MIMO, quantum communication, and intelligent reflective surface. However, these technologies are not fully grown, and each of them faces many challenges. Further elaboration of each of these technologies is discussed below

A. Artificial Intelligence

Artificial Intelligence (AI) would be essential technology in 6G networks as it can help in intelligent network management and optimization.

The vision of 6G is to build AI and ML Layers on top of 5G technology to provide automation and intelligence in the network.

This enables the network to monitor and evaluate the needs of customers, and enables real-time decision-making to optimize utilization of wireless resources, enhance network management, thus leading to faster and more efficient internet with high reliability and low latency.

However, there are several challenges for using AI in networks as it requires high energy consumption, standardization, high computational power, and access to large amounts of data to train models.

B. Terahertz communication

Terahertz (THz) communication is one of the technologies that can help in the emergence of 6G. THz provides high-speed connection of up to terabits per second using frequency range above 100GHz. However, THz communications require high power consumption and its transmission distance is limited.

C. Visible Light communication

Another technology that could pave the way for 6G is Visible Light Communication (VLC). VLC is an optical wireless communication that uses visible light spectrum 400-800 THz. This can provide high-speed data transfer. However, VLC faces some challenges in implementation. For example, it might interfere with other light sources.

D. Ultra-massive MIMO:

Multiple-input, multiple-output (MIMO) technology is one of the key enablers for 6G network. Massive MIMO improve network capacity and efficiency by using large arrays of antennas. Massive MIMO is defined as having at least 10 antennas serving each user, whereas Ultra-massive MIMO aims to reach hundreds or even thousands of antennas for each user. However, it would be difficult to implement this as it significantly increases cost, energy consumption and infrastructure complexity.

E. Quantum Communication

Quantum communication is a method of communication that utilizes principles of quantum mechanics. It has the potential to provide extremely secure communication with high-speed. This technology can specifically be used for sensitive communication such as in military, and in financial transactions.

However, quantum communications technology has many challenges that needs to be overcome in order for it to be integrated in 6G networks. For example, quantum communication currently is limited to short distance, and researchers are trying to solve this issue by developing quantum repeaters and amplifiers.

F. Intelligent Reflective Surface

Intillegent Reflective Surface (IRS) is a planar surface composed of plenty of passive reflective elements which can reflect the incident signal in a desired direction. IRS can be used to solve wireless channel fading and interference issues by establishing virtual line of sight links between base stations and users. This is especially crucial for high frequency signals in 6G communications. In addition, by using IRS signals from multiple paths can be added in the reciever to improve coverage. However, integrating IRSs into the network is not easy due to many challenges such as complexity of design and dynamic environments.

IV. CONCLUSION

Advanced applications require advanced technology. More specifically, smart cities, holographic communication and extended reality and similar emerging applications require internet with great KPIs such as high speed, efficient power consumption, low latency and huge number of connections. Thus, 6G technology is needed to fulfill these requirements.

Many emerging technologies could pave the way for 6G networks. For example, AI could be integrated in communications systems to help in real-time decision making in order to improve network management and efficiency. In addition, exploiting terahertz frequencies or visible light frequencies could significantly improve internet speed. Moreover, using ultra-massive MIMO can help enhancing network capacity and efficiency. Furthermore, exploiting principles of quantum mechanics in communication can have significant benefits such as improving internet speed and optimizing security. Finally, using intelligent reflective surface can efficiently guide the signal between users and base stations which would contribute to improving power efficiency as well as internet speed. However, these technologies face many challenges, and are not fully grown yet. Therefore, researches and innovative developments are needed in each of them in order to pave the way for 6G wireless networks.

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