EAI Endorsed Transactions on Internet of Things Research Article **EAI.EU**

6G Communication: Envisioning the Key Issues and Challenges

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Abstract

In 2030, we are going to evidence the 6G mobile communication technology, which will enable the Internet of Everything. Yet 5G has to be experienced by people worldwide and B5G has to be developed; the researchers have already started planning, visioning, and gathering requirements of the 6G. Moreover, many countries have already initiated the research on 6G. 6G promises connecting every smart device to the Internet. 6G will provide sophisticated and high QoS such as holographic communication, augmented reality/virtual reality and many more. It will also focus on Quality of Experience to provide rich experiences. Notably, it is very important to vision the issues and challenges of 6G technology, otherwise, promises may not be delivered on time. The requirements of 6G pose new challenges to the research community. To achieve desired parameters of 6G, researchers are exploring various alternatives. Hence, there are diverse research challenges to envision, from devices to softwarization. Therefore, in this article, we discuss the future issues and challenges to be faced by the 6G technology. We have discussed issues and challenges from every aspect from hardware to the enabling technologies which will be utilized by 6G.

Received on 17 October 2020; accepted on 31 October 2020; published on 11 November 2020

Keywords: 6G, Wireless Communication, Mobile Communication, Issues, Challenges, Internet of Things, Internet of Everything.

doi:10.4108/eai.11-11-2020.166959

1. Introduction

Nowadays, 6G mobile communication technology is one of the most demanded research fields. The 6G will revolutionize personal life, lifestyle, society, business and communication systems. It is a crucial time to envision the potential applications, techniques, use cases, and challenges of 6G technology. Noteworthy, 6G will create enormous research possibilities and enable many new technologies. Moreover, the 6G will be proven as a game changer paradigm in diverse fields. Therefore, the visioning of the 6G technology is necessary to revolutionize the modern world. Currently, many countries are deploying the 5G technology in full swing. However, 5G and Beyond 5G (B5G) will be unable to provide the complete requirements of the Internet of Everything (IoE). Therefore, there is a high demand for 6G. Researchers have already initiated solving the challenges of B5G mobile communication. In the next five years, B5G will evolve and it is highly expected that 6G will be fully able operate from 2030. The 6G will be the most prominent research field for next 10-25 years. The 6G research work has already begun in Finland in 2018 and the project name is "6genesis flagship project" [13]. In 2019, USA, China, and South Korea have launched 6G project [5]. Japan has also launched 6G project in 2020 [7]. Also, Nippon Telegraph and Telephone Public Corporation (NTT) has released their white paper in January 2020. Many countries have initiated the 6G project.

We are witnessing that there is a new mobile generation in every decade [3]. Therefore, it is expected that 6G will be deployed in 2030. The maximum data rate of various mobile generation from 1G to 6G is exponential. It is predicted that by 2020 all people will prefer high resolution audio/video content without any regard for the mode of transmission [12]. Bell Labs conducted a study and estimated that by 2016 video streaming will consume two-thirds of all network traffic. Therefore, the 6G is itself a great challenge to

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Figure 1. Envisioning the challenges of 6G

achieve with all the desired parameters stated in Table 1. In a nutshell, the first research paper of 6G appears in 2018 [13]. After this, research is spiking up on 6G. Numerous discussions are performed regarding the requirements of 6G technology [6, 27, 28]. To achieve the requirements of 6G, various visions are provided. Gui *et al.* [10] discusses on various possible applications of mobile broad bandwidth and low latency (MBBLL), massive broad bandwidth machine type (mBBMT) and massive low latency machine type (mLLMT). Zhang *et al.* focuses on further-enhanced mobile broadband (FeMBB), extremely reliable and low-latency communications (ERLLC), ultra-massive machine-type communications (umMTC), long-distance and high-mobility communications (LDHMC) and extremely low-power communications (ELPC) [27]. Dang *et al.* [5] provides future possibilities of 6Gs. Moreover, various works have been initiated by the researchers [1]. Thus, there are numerous research papers in visioning the 6G mobile communication. On the contrary, it is very important to unearth the hardship to be faced by the much awaited 6G technology. Because, the 5G technology is yet to be deployed worldwide in full scale. Moreover, there are numerous issues to overcome in 5G technology. Thus, it motivated us to investigate on the issues and challenges of 6G technology.

The 6G will change the definition and perception of the modern lifestyle, society, business and communication [17]. It is expected that 6G will associate in revolutionizing several fields which are to be visioned. Figure 1 illustrates the envisioning of the various applications which requires the support of 6G communication services. There are numerous problems in 6G, and thus, we exploit all issues and challenges of 6G from every aspect in this article. Moreover, we survey various requirements of 6G technology. Thus, Section 2 analyzes and compares the requirements of 5G, B5G and 6G. There are many requirements to analyze and acquired before implementing the 6G. These requirements are the challenges of B5G and 6G in the implementation process. Thus, this article explores all prime challenges associated with 6G technology in Section 3. Moreover, this article also uncovers prominent issues of 6G technology in Section 4. Finally, the article draws a suitable conclusion in Section 5.

2. 6G Requirements

Table 1 depicts the requirements and the challenges of 6G. The 6G is expected to deliver truly Artificial Intelligence (AI)-driven communications. Therefore, “the 6G is about the 6th sense”, Peter Wetter, Nokia Bell Labs [22]. Also, it is expected that prices will be 1000× cheaper in 6G era [26]. Zhang *et al.* [26] emphasizes price reduction that there were 10× price reduction from 1G to 2G, and 1000× in 3G and 4G. Hence, it is expected to continue in 5G and 6G era. Moreover, 6G will be backed by Extended Radio (XR) and will replace NR-Lite of 5G. In addition, it requires satellite support with terrestrial communication. The prime requirements of 6G technology are 1 THz operating frequency and data rate of 1 Tbps. Furthermore, the

Table 1. Comparison among 5G, B5G and 6G requirements

Requirements	5G	B5G	6G
Application types [20, 27]	• eMBB • URLLC • mMTC	• Reliable eMBB • URLLC • mMTC • Hybrid (URLLC + eMBB)	• MBRLLC • mURLLC • HCS • MPS
Device types [20, 27]	• Smartphones • Sensors • Drones	• Smartphones • Sensors • Drones • XR equipment	• Sensors and DLT devices • CRAS • XR and BCI equipment • Smart implants
Operating frequency [27]	3-300 MHz	500 MHz	1 THz
Spectral efficiency [20, 27]	10× in bps/Hz/m^2/Joules	100× in bps/Hz/m2/Joules	1000× in bps/Hz/m^3/Joules
Data Rate [20, 27]	1 Gbps	100 Gbps	1 Tbps
End-to-end delay [20, 27]	5 ms	1 ms	<1 ms
Radio-only delay [20, 27]	100 ns	<100 ns	≤10 ns
Processing delay [20, 27]	100 ns	50 ns	≤ 10 ns
Mobility range [27]	100 – < 500 km/h	500 km/h	1000 km/h
Wavelength	3 mm	1 mm	300 μm
Architecture	Massive MIMO	Massive MIMO	Intelligent surface
Core network	Internet of Things	Internet of Things	Internet of Everything
Satellite integration	Partial	Partial	Full
Artificial Intelligence integration	Partial	Full	Truly Artificial Intelligence Driven
XR integration	Partial	Full	Full
Haptic communication integration	Partial	Full	Full
Highlights	Extremely high rate of Streaming	Extremely high rate of Streaming	Security, Secrecy & Privacy

6G is 3D structural communication which defines space, time and frequency with requirements of $100\times$ *in bps/Hz/m^3/Joules*. It expects maximum wavelength of 300 μm to achieve 1 THz.

2.1. Network Architecture

6G technology will enable the IoE. Every smart device will be connected to the 6G communication network. Starting from small devices such as smartwatch or smart phones to mobile healthcare, vehicular and so on. IoE and mMTC services will connect all smart devices to one or more wireless-access networks. The wireless-access networks have multiple access points (AP)/base stations (BS) to provide services. To provide services to million smart devices within a small geographical location, the APs/BSs are located densely/ultradensely in 6G network. In such a network scenario, APs/BSs will have overlapping coverage areas, i.e., a small geographical location will be served by multiple APs/BSs. Whereas, multipoint transmissions will have million users served by multiple APs/BSs. Hence, management and efficiency are required in frequency allocation, interference management and efficient handoff. APs/BSs are connected through fast backhauling links. The 6G network will be viewed as a distributed, cell-less massive multiple-input, multiple-output (MIMO) system. In this network, every smart device will be served by more than one APs/BSs using transmission multiplexing or transmission coordination. The APs/BSs are connected to the Cloud for accessing Cloud services. Cloud computing supports large smart applications such as autonomous driving, virtual reality, smart city, industrial control, smart manufacturing and numerous health-monitoring services. The smart devices are connected using peer-to-peer connectivity through single/multihop communications. Moreover, terrestrial cellular systems will be integrated with drone-assisted/aerial networks supported by mobile APs. In addition, these networks will be based on content and application driven more than just data transmission. Another important point is the 6G network will provide 3D coverage. Therefore, 6G will combine both terrestrial and non-terrestrial infrastructure. The nodes in non-terrestrial network are drones, satellites and other mobile nodes. The mobile nodes will be relocated to provide seamless service, for example, in rural areas or during disaster events [9].

3. Challenges

It is expected that most of the issues of 5G will be solved by B5G and the remaining issues by 6G. However, the requirements of communication technology are growing exponentially. Thus, challenges of 6G are much bigger compared to the 5G and B5G. Solving challenges of 6G has two aspects, one is full filling the promises it made such as high frequency communication and high data rate and another aspect is supporting advanced technology such as holographic communication and virtual reality. This section tries to discuss challenges from every aspects of communication technology.

3.1. Terahertz Signal

6G will be using TeraHertz (THz) frequency band for transmission. However, operating in THz is a grand challenge where the wavelength is 300 μm [25].

Generation. The THz signal are generated mainly by three ways, namely, electronic, photonic or graphene based [25]. Electronic based devices use frequency multiplication to generate THz signals. Photonic based devices use photomixing. Graphene based THz signal are generated using electro-optical properties of graphene. THz signals are classified into pulsed and continuous signals. The generation of pulsed THz signal is easy because it is possible to generate the signal with reasonable size and complexity of the antenna/transmitter. But, 6G transmission requires continuous THz signal which is difficult to generate. The generation of continuous THz signal has more strict requirements regarding size and has more complexity in designing the antenna/transmitter. Thus, making the generate of continuous THz signal costly.

Energy Loss. THz signal is a short distance communication signal because it attenuates to zero after travelling a short distance (a few meters) in air. The energy loss of signal occurs due to molecular absorption and spreading loss. The molecular absorption loss occurs due to conversion from THz signal energy to the internal kinetic energy of the molecules present in the air. Moreover, the loss becomes severe with increase in moisture in the air. The spreading loss occurs due to extension of electromagnetic waves in the air and quadratically increases based on the operating frequency and distance between two communication ends. This is a major setback for 6G because such a signal is inappropriate to full fill the 6G requirements. It is not economical to amplify a signal after every 1 meter. However, research continues to make THz signal ideal for 6G.

Spectrum Reuse. spectrum reuse and sharing can increase the efficiency of THz signal. Some techniques already exist for spectrum reuse such as cognitive radio. It helps many wireless systems to access the same spectrum through spectrum sensing and interference management mechanisms [3]. In case of spectrum sharing, temporally underutilized or unlicensed spectrum is utilised to maintain availability and reliability. Symbiotic radio is a new technique to support intelligent and heterogeneous wireless networks and increase efficiency of spectrum sharing. However, deploying these techniques in the 6G wireless network are still big challenges.

3.2. New Communication Alternatives

The generation of THz signal is costly, whereas, 6G claimed low cost communication services. Furthermore, THz signal has many issues as discussed above. Hence, new communication alternatives are also explored to have a better option instead of THz signals. Visible Light Communication (VLC) uses cheap light emitting diodes (LED) to achieve higher frequency bands [2]. However, the VLC has issues with coverage and noise interference from other sources of light. Thus, VLC is used in a confined arena that does not have any interference from other sources of light. Another option is molecular communications (MC) [11]. It uses biochemical signals for data transmission. Biochemical signals are particles having size from a few nanometers to a few micrometers and propagates in a gaseous or aqueous medium. The advantages of MC signals are biocompatible, consumes less energy for production and transmission, and gives high data rates. However, it creates challenges for security and effective interface between chemical and electrical domains. Third option which is explored is quantum communication (QC) [11]. Quantum particles or photons are utilized to encode data in a quantum state. It makes the data access and cloning by hackers difficult. The advantages are high security, high data rates and effective long distance transmission. However, its at an early stage of development and have a long way to be considered as an alternative of THz signal.

3.3. Underwater Communication

6G is also aiming to provide underwater communication. In reality, the underwater environment is a different scenario compared to air or space. The underwater environment is unpredictable and complex due to high signal attenuation, physical damage to equipment and complicated network deployment. Radio signals are highly attenuated in salt water. Therefore, acoustic communication is the only option for communication. But, low node density is maintained because deployment of nodes is expensive and difficult in underwater environment. Furthermore, node mobility is difficult due to flow and density variation of the water. Underwater sensors are expensive because these sensors are designed with extra protection for the underwater environments. In addition, it requires complex transceivers and a large memory. The power supply has to be large because solar power cannot be utilized. Fouling and corrosion increase the failure of underwater sensors. Due to these reasons the best choice is optical fiber, however, it is expensive. Another option is quantum communication, but, it is at an early stage of research. Thus, to achieve an efficient underwater communication, 6G has to fight against the challenges of underwater circumstances.

3.4. Design of Transmitter and Antenna

Hardware. The 6G demands highly efficient transmitter and receiver antenna. The required radio frequency transceiver should have high integration. It is achieved by implementing advanced silicon nodes with CMOS SOI, bulk CMOS and SiGe BiCMOS along with attentive co-design with off-chip and highly efficient antennas. To meet the requirements of 6G, new balance between radio frequency technologies, communication and signal processing is essential [13]. Highly efficient radio frequency will help in achieving high data rates. In addition, the materials used to construct the antennas also influence the data rate. The materials influence the intrinsic and extrinsic composition-structure-property relationships. If this relationship is poor, then the attenuation is more and leading to low data rate. Currently, research on new materials are being conducted such as nanomaterials, bio-based, foams, room-temperature fabricated materials and ultra-low permittivity. These materials are self healing and electrically tuneable [13].

Transmission mode. The smart devices pose the most issues in satellite assisted IoE. In satellite assisted IoE, first, data are collected from smart/IoE devices which are transmitted to satellite antennas at the ground connected to core networks through wireless or wired channels. However, IoE devices have hardware constraints which makes the data transmission to satellites difficult. Suppose, 6G follows a direct transmission mode i.e., the IoE devices directly send the data to satellites. In such scenario, IoE devices need to provide high power to the signal to reach the satellite which is impractical due to low power source of IoE devices. Another solution is hybrid transmission mode. A data aggregator collects the IoE data and transmit to the satellite. 6G requires mitigation/interference coordination techniques along with varieties of MIMO multi-antenna transceivers for good transmission [13].

Types of antenna. Directional antenna will be preferred for transmission because it helps in concentrating THz signal in a defined direction and decreases interference to neighboring 6G nodes. However, it includes challenges such as efficient topology control algorithms that require optimisation of tradeoff between jump stretch and node degree, neighbor-discovery algorithms in time asynchronous systems and multiple access control (MAC) protocol supporting higher access capacity. Besides, it has to consume less resources [3].

3.5. End-to-end Delay and Reliability

The 6G data rate requirement is 1 Tbps which will enable many applications, to name a few, virtual/augmented reality, smart healthcare [17], UAV, smart electric car, and smart city. Such applications require high data rate with low latency. Notably, 6G focuses on QoE. For instance, a car discusses with passengers which enable the teaching/learning process. Also, electric car need to charge while travelling without the intervention of the human. To provide a high QoE, it demands low end-to-end delay. To achieve lower end-to-end delay, smaller frame sizes or data packets have to be transmitted. Moreover, 6G will require flat network architectures. Reliable transmission requires efficient Forward error correction (FEC) schemes. Efficient FEC schemes requisite long transmission time or using parallel diversity channels in large numbers [13]. Long transmission time is not possible because 6G has to maintain a latency of < 1 ms. This challenge need to be addressed in physical and networking layers. Technology such as AI is also considered to reduce latency, for example, deep learning based transmission prediction [21]. It helps in predicting the user requests and change in channel state to reduce the transmission latency. The 5G is backed by URLLC and it's reliability is 99.999%. On the contrary, 6G has to increase its reliability and requires extremely reliable low latency communications (ERLLC) to support a reliability rate of 99.99999999%. Therefore, 6G has to enhance URLLC and provide higher reliability rate than 5G and B5G.

3.6. Energy

Every device in 6G, such as smart devices and applications will implement sophisticated signal processing mechanisms. Moreover, they have to process Big data which require heavy processing and high energy. Therefore, energy is also an issue in 6G. 6G will be using emerging technology such as Edge and AI in its network nodes that also require high energy. Thus, 6G has to solve the issue of harvesting, charging and conservation of energy. Another important point is energy cooperation among 6G network nodes. Also, data transmission demands more energy as discussed in the transmission mode. Therefore, new waveform and modulation is required to have low peak to average power ratios (PAPR) to reduce power consumption [3]. Besides, higher energy is consumed to compute complex algorithms to provide high level security. On the contrary, embedding AI with 6G will reduce the energy consumption becasue these AI algorithms are low compute-intensive and requires less power. Qi *et al.* [19] proposed an algorithm for integrating energy, computation and communication. The BSs use wireless power transfer to charge the smart devices connected to the BSs. The smart devices also harvest energy to perform computation and communication.

3.7. Capacity

6G is a key enabler of IoE that connects billions of smart devices and smart wearables. Moreover, 6G promises many high QoS applications, e.g, virtual/augmented reality. The IoE devices will produce huge traffic which will degrade QoS. Moreover, the aim of <1 ms latency is achievable in case of low traffic. Therefore, capacity is a big challenge for 6G. 6G capacity is enhanced mainly by four ways, namely spectrum bandwidth, spectrum efficiency, spectrum reuse and network node density. Increasing the spectrum bandwidth increases network capacity. Enhancing the spectrum efficiency in the air, i.e., the bits per second per Hertz is achieved by implementing good channel coding or new modulation technique. Orbital angular momentum (OAM) [24] is a new resource for modulation in the 6G network. OAM modes are topological charges. Many OAM modes are present in between OAM spacing and different OAM modes are orthogonal to each other. It gives the opportunity for multiplexing/demultiplexing the OAM modes together which enhances the capacity of the signal. However, OAM modulation has many issues such as beam divergence, transmission and transceiver misalignment. Divergency in OAM beams constraint the long distance transmission and efficient reception. Efficient transmission depends on converging OAM beams. This can be solved by using anti-divergence based antenna, but the beams have central hollow structure after travelling long distances. Reflection and refraction of OAM waves changes the wave-front of OAM modes and makes the signal transmissions difficult during fading scenarios. In practical scenarios, the transmitter and receiver are misaligned and at the receiver end it leads to difficulty in differentiating different OAM modes. Another solution to enhance 6G capacity is increasing the node density. The mobile nodes are deployed to hotspot network areas to reduce the load of the nodes. Nevertheless, the repositioning of mobile node affects many factors such as handover control and network topology. Manually handling the repositioning is difficult, hence, AI is deployed.

3.8. Global Coverage

6G will rely on the low-earth orbit (LEO) satellite having a height of 500 to 2000 km from the orbit to provide global coverage. LEO will aim for less path loss, lower transmission delay and much more. Nonetheless, LEO have issues such as doppler variation, doppler shift, long transmission delay and more path loss [3]. LEO satellites travel very fast compared to the rotation of Earth. This leads to doppler variation and doppler shift in the network communication and cause random access, synchronization, signal detection and signal measurement issues. Other issues are long transmission delay and more path loss in LEO compared to terrestrial transmission.

3.9. Density

Density is the number of network nodes per square kilometer. 6G will have more network node density to have a smooth and high QoS. However, deploying a number of network nodes will increase the communication cost. The communication cost refers to the congestion control, scheduling, synchronization, failure detection etc. The economic cost will also be high because 6G include both non-terrestrial and terrestrial nodes. The non-terrestrial nodes are very costly compared to terrestrial nodes. Furthermore, more network nodes require more maintenance.

3.10. Cost

One of the goals of 6G is providing the services at a cheaper cost [26]. The 6G network nodes are both non-terrestrial and terrestrial. The terrestrial nodes are comparatively low in cost, although their maintenance will incur money. The non-terrestrial nodes such as satellites, drones and other mobile nodes are very expensive. Deploying satellites to space is a costly affair. Their repair and maintenance is another issue in terms of cost. In addition, underwater communication also requires expensive infrastructure. Moreover, the 6G requires high quality network nodes to maintain highest QoS and sophisticated and high quality network nodes are costly. The smart devices are costly and may not be affordable to everyone which is a challenge to reduce the cost to make it affordable to everyone.

3.11. Heterogeneity

To provide global coverage, 6G will connect variety of smart devices and network nodes. Not to mention, the communication network will be different at different geographical location. It is impossible to provide just a single global coverage to connect the whole world. The communication network will be divided into sub-networks and these sub-networks will not be homogeneous. In addition, 6G will integrate both non-terrestrial and terrestrial communication networks, whereas both are very heterogeneous by nature. Their different heterogeneous features have to be considered to efficiently integrate them together. Heterogeneity is also present in the protocol that these communication networks will follow. Thus, 6G is taking a big challenge of integrating various heterogeneous components together.

3.12. Security, Secrecy and Privacy

Dang *et. al* [5] propose that security, secrecy and privacy are the key features of 6G. It is expected that 6G will be able to deliver the highest level of security, secrecy and privacy. THz communication will make the 6G eavesdropping and jamming proof. Similarly, quantum computing will feature the unbreakable security to the 6G, for instance, quantum cryptography for secrecy. The privacy is the key concerns of individuals, particularly, healthcare requires the highest degree of privacy protection. Blockchain is the most prominent technology to achieve a higher degree of privacy, secrecy and security. Deploying federated AI also increases security. Another important point to note is 6G promises to provide physical layer security. It will be achieved by integrating AI to 6G. Various research works are going on to explore this option [1]. Although 6G will provide high level of security, but it has to protect many vulnerable points. One such vulnerable target of 6G is the power system of the network devices. For DoS attacks, attackers are adopting sleep deprivation or battery draining. To achieve sleep deprivation attacks, the attacker transmits many requests to Edge devices or other network nodes pretending as a legitimate user. The nodes will respond to the requests and exhausts the power [14]. In battery draining attack, the attacker uses any means to exhaust the power. For example, executing power consuming subroutines in the 6G network nodes. Thus, such simple trick will be able to cut off the network nodes and will impair the communication.

3.13. Heavy Computation

6G will combine computation with communication, for instance AI in Edge computing/Edge analytics and federated AI. 6G networks are ultra large scale, complex and multidimensional. It is also dynamic due to network topology, consumer demands, traffic load and radio resource. Thus, automatic network configuration is required for wireless connection. Similarly, the 6G network requires intelligent mobility management for positioning the mobile node during a disaster or node failure. However, all these tasks require heavy computation. To solve that 6G will rely on new technologies such as edge computing, federated AI, etc. Henceforth, the services of 6G requires heavy computation. Furthermore, implementing these technologies has many sets of issues. One important point to note the issues has two aspects, one is issues in individual technology and other is issues in integration with 6G.

3.14. Five Senses Communication

The 6G is a sixth sense communication system. Therefore, it is expected that 6G will be able to support five senses of communication system. The five senses are sight, hearing, smell, touch and taste. Some examples of such advanced applications are holographic communication, augmented/virtual reality etc [16]. Nevertheless, 6G requires a very high data rate with extremely low latency for achieve this goal. Moreover, the sensors must able to reproduce the five senses from remote locations to provide real experience to the users.

3.15. Industrial Revolution

It is expected that Industry 5.0 will evolve and revolutionized soon. There is a high chance of shifting of Industry 4.0 to Industry 5.0 in 2030. Industry 4.0 is "*Digitalization*" and Industry 5.0 is "*Personalization and Intelligentization*" which requires 5G, B5G and 6G. Industry 5.0 will allow the customer to customize the services. 6G will enable Industrial Internet of Everything (IIoE). Further, it will revolutionize the industries a step ahead and motivate to introduce "*Intelligentization*". Moreover, we foresee that 6G and B6G will be a great enabler of Industry 5.0 which is "*Intelligentization*" of industries.

3.16. Paradigm Shift

6G will enable paradigm shift and we will evidence the shift from 2030 onward. Furthermore, 6G will enable the conversion from smart devices to intelligent devices, for instance, intelligent vehicle, intelligent mobile, intelligent wearables, intelligent healthcare and many more [17]. It will be possible with the combination of AI and 6G communication technology. However, integration of intelligence and the conversion from smart to intelligent devices involve many issues. Therefore, new sensors, new devices and new methods have to be devised to achieve this challenge.

4. Issues

Apparently, the 5G technology has just begun to deploy. There is no user experiences on B5G and the B5G has to experience many things in real scenario than a lab. Henceforth, B5G mobile communication is yet to be developed completely. Therefore, there are many issues while envisioning 6G technology.

4.1. Lack of Technology

Fitzek and Peeling [8] argues that there is a lack of real technology to implement the 6G requirements. The 6G has many promises to deliver which are hindered by underdeveloped real technology which could drastically advance 5G technology to 6G. The requirements increase exponentially from 5G to 6G mobile communications. 6G has no underpinning technology, thereupon poses doubt on the envisioning in this stage [8]. The 5G technology has just begun. Thus, deficient in wider user experiences of 5G poses many issues. Obviously, networking can be effectively utilized using softwarization. Huge modifications are required on Software-Defined Radio, Software-Defined Network and Network Function Virtualization of 5G technology to achieve 6G [8]. In addition, the AI has to be embedded in 5G technology to advance 6G. The 6G is truly AI-Driven communication technology, consequently, the AI has to be deployed in every layer of 5G. Notably, 5G will partially support AI to communicate.

4.2. Over Expectation from 5G

Another key issue is the exponential difference of 6G with its predecessor. The 5G is an enhanced version of its predecessor and not exponential growth of requirements. However, 4G is modified immensely to introduce 5G as uninterrupted mobile communication. We acknowledge Fitzek *et al.*, the issues of 5G have to be solved before developing 6G technology. Currently, the 5G is deployed as a campus solution in a local area [8]. Moreover, the 5G does not support high mobility. As a consequence, the 6G mobile communication technology will face a huge problem in providing the mobility support of 1000 km/h. It is important to realize that this issue can delay the deployment of 6G to 2032 or beyond. Taking one example to emphasize on the point of over expectation from 5G is current state-of-the-art technology is unable to provide network coverage to the passengers in an aircraft [5]. The reason is due to various issues, but, the most important issue is high mobility. Although this issue can be addressed by satellite communication, however, it is very costly. Therefore, another alternative is required to solve the issue. Furthermore, it is expected that 6G will solve the issue. However, there is no clear roadmap to provide low cost connectivity to the passengers with 6G parameters.

4.3. Interoperability of protocols

6G network will integrate both non-terrestrial and terrestrial communication networks. The TCP/IP protocols used in terrestrial communication networks are unsuitable for non-terrestrial communication networks, i.e., satellite communication. Because, efficiency of TCP/IP protocols is lower due to long transmission delay, ultra wide bandwidth and higher bit error rate. Therefore, modification in TCP/IP protocol is required to support both non-terrestrial and terrestrial communication networks with efficiency. Moreover, different protocols are implemented in both types of communication networks. In that case, interoperability of protocols will be an issue [3].

4.4. Artificial Intelligence

6G will be truly AI-driven mobile wireless communication, i.e., communication system will be intelligent enough to route the data. Moreover, federated AI will help in knowledge sharing among the intelligent devices. Furthermore, quantum machine learning [15] will enhance the performance of 6G by intelligent data analysis. However, most of the techniques are in the initial phase of research. All AI algorithms have high computation. The high computation task requires a long execution time and consumes more power. Whereas, 6G is unable to provide such relaxation. Another issue is the dynamic nature of the network. Once inferences are obtained by AI algorithms, it is used to predict future incoming data. However, communication networks are very dynamic, therefore, the inferences will become obsolete quickly. Training the AI module after a short interval will be very costly for 6G. Therefore, 6G will face huge challenge to deploy AI in the communication. Furthermore, physical layer will be assisted by AI. However, implementing AI in physical layer is difficult due to the complexity of the physical layer and bounded learning capacity of AI algorithms. Yang *et al.* [23] proposed a novel network architecture to use Big data analytics for optimization of the physical layer. Deep learning algorithms have shown high performance. However, it has many issues, for example high dimensionality due to complexity of physical communication networks and increase in the training phase of deep learning with increase in the number of codewords.

4.5. Big Data

Currently it is the era of Big data. The huge amount of data produced by the smart devices leads to Big data. Big Data technology is to re-architect and redefined for the massive scale of tiny data. These small data poses new challenges for Big Data research community; even, terabytes of tiny data causes performance impact in Big Data. Processing of these Big data requires the support of Big data analytics. However, 6G requires the integration of Big data analytics and deep learning for advanced automation and self-optimization [4] in the communication. Big data analytics in 6G need to reduce Exchange-to-Exchange (E2E) delay. Combining Big data analytics and deep learning will automatically determine the shortest path to reduce E2E delay. Currently the number of smart devices is few when compared to the goal of 6G to serve millions of billions of smart devices. When 6G will be commercial, it will not be the era of Big data but rather Big data 2.0. Big data 2.0 requires a supercomputer to compute and analyse data [18].

4.6. Edge Technology

Edge technology was introduced to provide Cloud services in smart devices. The Big data produced by the smart devices mostly contain garbage data. Transmitting these data to Cloud leads to wastage of bandwidth and network resources. Another reason is distance of Cloud from smart devices. The distance is creating privacy concerns to the users. Another important point is some requests are very small, but waiting for response from Cloud is increasing latency. These are some of the major reasons for the emerging of Edge technology. Edge technology will play an important role in 6G because they will be the majority network nodes in 6G. However, Edge technology also has many issues. Edge nodes/devices have small power sources and memory. Edge analytics mostly rely on AI. However, due to the incapability to execute heavy computation, the AI algorithm is executed in the Cloud and the inferences are transmitted to Edge nodes. But, the dependence of the Edge on the Cloud will reduce the performance of 6G. Moreover, the issues of AI will influence the performance of Edge and then it will adversely influence the performance of 6G. As discussed in the Big Data section, the massive data will be stored in Edge nodes. 6G is planning to have a high density. However, with limited storage Edge nodes will be incapable of storing information and have to transmit the data to the Cloud within a very short time interval. Thus, communication cost will be incurred upon data transmission to the Cloud. Currently, researcher are focusing on development of Edge technology because if the issues are not solved to improve the performance of Edge devices then the communication technology will be unable to provide services and maintain QoS. In worst case scenario, the communication network will suffer from maximum congestion all the time leading to a state of standstill. Furthermore, Edge technology has created an opportunity to develop AI and machine learning algorithms computing within a constraint environment.

5. Conclusion

6G is an important communication technology that will enable many new technologies. In this article, we have surveyed the desired parameters of 6G technology. We also have compared the 5G, B5G and 6G mobile communication technology to depict the differences and needs of the 6G technology. However, the differences are significant. Therefore, there are huge challenges of 6G to achieve the desired parameters and deliver the promises. All issues and challenges of 6G have been uncovered from every aspect. Finally, we conclude that 6G will revolutionize many areas and will also be proven as game changing technology in diverse fields.

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