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How 6G has an Influence on Smart Cities An Overview

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***Abstract*— As automation surges and the uses of virtual reality expand, the necessity for quicker, more secure communication has been augmented. The new archetype of wireless communication is the sixth generation communication. The 6G revolution will focus on how to connect and control billions of machines – from macro to micro to nano – in our digital future. Along with lightning-fast speed will come extreme reliability. 6G will create a framework of ubiquitous wireless intelligence that will serve humanity for decades to come. Our future will be powered by innovations that arise as cutting edge technologies in multiple domains converge at an exhilarating pace. 6G will improve global health, transportation, logistics, security, privacy and much more. All this will contribute to the building of smart cities. The key right solutions include 5G, IoT, Automotive, Energy, High-speed digital, AI, Data analytics, Satellite, Optics, Cyber-security. Systems and resources are intertwined as mobility, communications, energy, water, platforms, monitoring/control, performance management, predictability and forecasting all merge together. 6G senses a vast amount of data exceedingly fast and computes them, controls them and offers the experience to humans. The overview of this paper is to analyze the perks and prerequisites of the 6G technology and how it can influence the building of smart, sensible and sophisticated cities.**

Keywords*— *6G, IoT, IIOE, TeraHertz, Augmented Reality, Machine Learning, Automation, MIMO

I. INTRODUCTION

Although 5G is not officially launched yet, researchers have turned their attention to the 6G communication system. It is expected that future mobile networks should have the capability to support various unknown IoT services, i.e., the network architectures and functionalities must have the capability to adapt to the ever-changing service features and requirements. Hence, the future network should be intelligent first, which can learn the characteristics of the service autonomously, and be aware of their changes. Then, it should be open so that the architecture and functionalities can be easily updated according to the changes.

In order to build an intelligent and open 6G network, each node should be equipped with sufficient communication, computing, and caching resources to support intelligent operations and self-evolution. Data rate goes to triple in 6G, fifty times quicker than quickest 5G network with the tenth of the latency, supports ten times range of devices and is a hundred times lot more reliable. 6G will be able to connect everything, integrate different technologies and applications, support holographic, haptic, space and underwater communications and it will also support the Internet of everything, Internet of Nano-Things and Internet of Bodies. These IoT devices will realize advanced services such as smart traffic, environment monitoring, and control, virtual reality (VR)/virtual navigation, telemedicine, digital sensing, high definition (HD), and full HD video transmission in connected drones and robots. 6G will also deal with satellite networks for global coverage. There are three types of satellite network: telecommunication satellite network, Navigation satellite network and Earth imaging satellite. 6G internet will be a very fast wireless network, a combination of the latest in radio and fibre optics technology is used. Delivery in a 6G network through line of sight, means speed of the internet does not depend on the distance between your business and exchange.

There are basically three drivers of 6G: which include policy lead (role of government),tech-push (technological advancements) and need-pull (societal requirement). These three drivers would move and play a complementary role with each other for the 6G promotion. The distant news is a part of a policy leadership to touch upon social issues and promote dead pool. Coming to the tech push, the government recently put out the sixth GRND strategy and some of the governments have already envisioned 60 daily lives in their white paper and R&D proposal. Based on those we bring on the sixth life where humans and many highly autonomous and intelligent machines live together in physical space and digital twin space. The first key aspect of a physical space is a truly immersive service, connecting real experience to humans including advanced tactile. The second aspect is that autonomous machines interact with humans ultra-precisely and ultra-fast.

We will break 6g technology into four groups one is expanded coverage with non-cellular topologies. It includes satellite, airborne and UAV. It will offer an expanded range and enhanced mobility to make sure the improved connectivity and service continuity. New spectrum and antenna technologies will be one of the key revolutions in the next generation. The sensing and communication in terrorist range, meta material and intelligent service are good candidates for ultra-reliable communication. Free space optics and line of sight memo can be a candidate. Sensing information about localization and propagation can revolutionize medium access technology. The third is a native AI for connected intelligence when the mobile units send and collect data. The data will be split for computing on device or on cloud and then it flows into the network and MEC . The comprehensive AI allows us to automate the real time

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optimization of resource allocation from mobile sense to MEC. Last but not least is the new radio access technology.

Fig. 1. Breaking 6G technology into fundamental groups.

We can think of three key service scenarios in 6g. They are ultra-broadband, zero energy massive IoT and massive broadband URLLC. We expect a growing demand for this massive broadband dual LLC with a minimum energy consumption in a 6g world. Developing new access technologies such as channel coding, modulation multiplexes, waveforms and full duplex is another big challenge. Low complexity, low processing latency and low power consumptions are the goals and these are the technical requirements and desired features that we think necessary in 6g.

User experience, data rate, peak data rate, 3D connection density, reliability, air latency, spectral efficiency and energy efficiency are the six major performance indicators. We also think of extended performance indicators of enabling technologies which are 3D coverage and mobility and 3D localization precision and end-to-end latency and synchronicity for architecture and service. The key perspectives are open intelligent automated real-time best utilization of power, truly immersive distributed infrastructure enabling real-time interaction between physical and digital worlds.

Trustworthiness also has many desired ones now we move on to the dead pool from societal challenges. We will have to specify each social issue in terms of individuals, households, city and country. We should also include issues on extended cyberspace because in education inequality happens from the individual's perspective, leading to wide income polarization. The education disparity gap between regions is getting deeper from a national perspective in health and welfare.

Some individuals expect quite simply a quicker version of 5G. For example,6G helps in self-driving cars. It helps to observe the hazards in seconds and affiliation cannot drop in any respect. It helps in connecting an automotive to a different automotive mile away. This way self-driving automobiles will avoid tie ups by coordinating with each different car and ensuring no one ever gets stuck within the traffic jam by obtaining notices concerning it.

II. THE EVOLUTION OF WIRELESS COMMUNICATION TECHNOLOGY

A. 0G

Moving from wired communication to wireless was a big revolution first called mobile radio telephone but when the next wireless generations got created it was called pre-cellular or 0G pioneers for this big-step forward. Where Motorola and bell systems giving birth to 0g in 1940's.0g used push-to-talk. Later it got improved to MTS(Mobile Telephone Service) IMTS() and AMTs() were introduced which gave full duplex support and higher voice quality. These telephones were too big to carry normally. They were mounted on cars putting the antennas sanders and transceivers at the back and the phone on the front side. Later a briefcase version was invented which was more convenient .It could not be used by everyone.

B. 1G

First generation of mobile telecommunications was invented in 1979 which opened wireless doors to everyone. In introduced international roaming which let people in different countries speak wirelessly in the fall. In 1G signals can be modulated either digitally or via analog technology.1g used analog signals to transfer information .This was limited to only voice calls with a maximum speed of 2.4Kbps and frequency of 150MHz which led to high coverage but also high latency and battery consumption. The voice quality was also not very acceptable. It could be carried normally.

C. 2G

Second generation of mobile telecommunications was invented in 1991 which includes GSM(Global System for Mobile communication).2G used digital modulation instead of analog .It used TDMA AND CDMA or time division multiple access and code division multiplexes for multiplexing. It had a frequency of 900MHz. It gave an ability to add SMS to voice calls thereby increasing the quality of voice calls. If one cell phone has to send information to another cell phone it has a send information to BTS, where a collection of BTS is controlled by BSC which is a higher tier in GSM network. All BSC was controlled by MSC, which was responsible for managing the whole network .It used its own databases and intercommunication. GPRS was released in 1993 which used packet switching technology. Due to its high speed, it led to multimedia message service which gave users the capability to send media files. G Edge was introduced in 2003.

D. 3G

3G was invented in 1998 aimed at increasing network speed. First standard of 3G used WCDMA-UMTS. The first release used CDMA and packet switching paradigm using 3 main frequency band of 850,1900 and 2100 Mhz. WCDMA was based on GSM but UMTS was new standard. Speed varied depending on movement ranging from 384Kbps to 2Mbps.In 3G people did not pay based on time but on data transferred. Later, it introduced two other standard that is HSPA AND HSPA+.

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E. 4G

4th generation of mobile technology was also known as LTE and was started in 2004 by ITU and was commercially released in 2009.It has two main standards LTE and WiMax. LTE is fully packet switched using IP and uses OFDMA-MIMO. It has a speed ranging between 100Mbps – 1Gbps and frequency 2 – 8 GHz. This has made data transmission faster with low latency and high speed.

F. 5G

It uses a new radio standard for Air interface and was supposed to be released in 2020.It uses time division duplexing instead of FTD and allocates one slot uplink for each three downlinks . It has high speed and capacity, faster data transmission than 4G,supports interactive multimedia, voice streaming, buckle up and is more efficient.

E. 6G

6G is the sixth generation standard currently under development for wireless communications technologies supporting cellular data networks.100 trillion sensors are expected to be manufactured and connected to the internet by the end of 2030 to revolutionize 6G. Hence, 1000 times price reduction will be required to develop a sustainable smart society.

Features	1G	2G	3G	4G	5G	6G
Time Span	1980-1990	1990-2000	2000-2010	2010-2020	2020-2030	2030-2040
Highlight	Mobility	Digitization	Internet Connectivity	Real-time applications	Extreme Data Rates	Privacy, Secrecy and Security
Core Network	PSTN	PSTN	Packet N/W	Internet	IoT	IoE
Services	Voice	Text	Picture	Video	3D VR/AR	Tactile
Architecture	SISO	SISO	SISO	MIMO	Massive MIMO	Intelligent Surfaces
Multiplexing	FDMA	FDMA, TDMA	CDMA	OFDMA	OFDMA	Smart OFDM A plus IM
Maximum Frequency	894 MHz	1900 MHz	2100 MHz	6 GHz	90 GHz	10 THz
Maximum Data Rate	2.4 kb/s	144 kb/s	2 Mb/s	1 Gb/s	35.46 Gb/s	100 Gb/s

Fig. 2. Comparison of different wireless communication generations.

III. EMERGING TECHNOLOGIES

The rollout of 5g technology has already commenced in several components of the globe and may get completed by the tip of 2021. But provided the demand for automation and ever increasing would like information measure the present capability is anticipated to run out of steam by 2030. The worldwide mobile penetration is anticipated to mature to 700 times if we have the tendency to compare knowledge of 2010 with the anticipated demand by 2030.

Thus scientists have already started engaging on 6g that is anticipated to revolutionize the digital world. We are moving towards a totally networked society whereby several civic and human functions would be machine-controlled with the assistance of intelligent machines and processes.

6g would offer the canvas that advanced processes and interfaces would seamlessly operate with minimum human interface. A number of the key technologies possible to be fielded on 6g change networks would be artificial intelligence, virtual reality, improved system capability, higher data rate, radical reliable low latency networks, large machine sort communication, and increased information security and user experience. Smart wearable devices, space and underwater communication, medical implants, self-driven vehicles and drones are the other associated technologies . The virtual reality-based devices would need a phlegmatic data transfer of up to 10 GBPS.

It is calculable that the 6g system driven wireless property would be up to one thousand times additional economical than 5g. All this might result in a wise designed society atmosphere observance and protection disaster mitigation and management. allow us to in short analyze the exciting potentialities. The technologies which would emerge with due respect to the incoming of 6G would be:

- Brain Computer Interface

Humans dominating machines with their minds would possibly sound like a thing from a sci-fi motion-picture show, however it is transforming into a reality through brain-computer interfaces. Understanding this rising technology now will facilitate and ensure that effective policies are in situ before BCI becomes an area of lifestyle. BCI technology permits human consciousness and an exterior device to talk to one another, to exchange signals and information. It provides humans, the power to directly manage and control machines, sans physical curtailments of the body. Wireless brain computer interface (BCI) applications involve sensible wearable headsets, embedded devices and body implants. By exploiting the BCI technology, the human brain is planned to communicate with external devices that in turn will analyze and translate brain signals. 6g can facilitate the transfer of data of the five human senses so as to neatly and remotely move with the environment. In a future 6G environment, virtualization technology thinks wireless BCI tech will allow people to interact with their surroundings and other people via a slew of discrete devices – wearables, 'smart body' implants, and devices embedded within the world – and permit completely different and richer sorts of connectivity. Advanced communication of this type will embody tactual messages, that simulate touch, and ideas associated with affective computing in which a device, through the likes of sensors, microphones, cameras and code logic, has the power to discover and befittingly be responsive to the user's emotions.

- Artificial Intelligence (AI)

Artificial intelligence (AI) and machine learning techniques have stupendous potential to tackle the energy potency challenges in the forthcoming future green 6G. AI methodologies, e.g., deep learning, federated learning and reinforcement learning, can possibly be explored for the planning, design and sophistication of 6G architecture and network orchestration in a cost-efficient way. By learning the complex network topology and the varied approached traffic patterns, AI would tame network complexity for the design

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and planning of 6G air interfaces. The diversified, heterogeneous 6G sanctionative applications, such as smart cities, smart grid, autonomous vehicles, and industrial automation, can build AI more far-reaching and essential in energy savings. Conversely, on the other hand, AI and machine learning techniques typically demand high computation and communication. This could create a massive challenge for the design and implementation of each of the machine learning algorithms and future 6G systems in an energy-efficient manner. One advantage is that 6G's Gb-level transmission rate can presumably bring a radical paradigm shift for AI toward omnipresent AI, taking advantage of distributed machine learning and edge intelligence. Artificial intelligence would facilitate intelligent wit of machines, a huge number of processes would run within the background with minimum human interference. This may be attainable to be widely applied in several fields like law and order as well as in surveillance.

AI will possibly alter and improvise the transmission of data seamlessly. It will be supported by meta-materials, intelligent networks, independent and self-sufficient wireless networks and inherent machine learning. In the health care sector, remote surgeries are reaching to be attainable exploitation robots and AI. Thus, the convergence of AI and 6G will promise to overcome the defect of network complexness and explore a path towards a sustainable and an efficient ecosystem. However, restricted research and analytic efforts have been made and few studies can be found concerning the convergence of 6G and AI from an energy-efficiency perspective. Challenges still stay untouched on the ways to tailor AI on nervy nodes and consistently work for a green 6G and the way 6G networks will support AI. This Special Issue (SI) aims to pile researchers from academic domains and industry to explore recent advances and progress on the convergence of AI and 6G integrated design and optimization.

- Industrial Internet of Everything (IIoE)

Even though the 5G mobile system will possibly support varied IoT services, it might not be able to utterly fulfil the needs and necessities of IoE novel applications. Hence, 6G mobile systems are explicated to concur restrictions of the 5G wireless system. IoE based smart services raises the requirement for 6G wireless networks and includes four pillars: data, things, people, and processes that are intelligently connected and describes a world where billions of objects have sensors to differentiate measurement and appraise their state of affairs. Additionally, IOE is a thought that maximizes the IoT prominence on machine-to-machine (M2M) communications to outline an augmented complex system that also encircles people and processes connecting over private or public networks with the usage of proprietary and/or standard protocols. IoE applications are classified from sensor tools, smarter mobile devices, machine learning(ML) systems, interfaces used for remote appliances to machine learning systems to different types of distributed intelligent machine-driven hardware. The Industrial Control System (ICS), which are closely associated with people's lives, play a essential role in the development of the IIoE whose security affects the complete IIoE. ICS is connected to the web and unprotected within cyberspace. To guard these precious assets, intrusion detection systems(IDS) have drawn a massive amount of attention.

6GIIoE architectures within the literature is non-existent. This study argues for the support of 5-layer design for 6GIIoE ecosystem and also the trends provide the formulation of design for the succeeding generation infrastructure. CII is the fusion of 6G, IoE and other rising relevant technologies which guarantees new potentialities, opportunities ,services and immersive user experiences ubiquitously providing connected intelligent industrial applications like connected intelligent factories (CIF), connected intelligent transportation (CIT), connected intelligent cities(CIC), connected intelligent robots and drones(CIRD), connected intelligent food and beverage (CIFB), connected intelligent retail (CIR) and various other connected intelligent applications. Based on the 6G connectivity vision, with 6GIIoE applications, the CIIW is expected to revolutionize endowing digitization towards personalization for each form of trade to produce huge edges.

- Blockchain

The sixth-generation (6G) network should offer higher and efficient performance than previous generations to fulfil the desires of rising services and applications, like multi-gigabit transmission rate, higher accuracy and authenticity, and sub-1 ms latency and pervasive affiliation for the Internet of Everything (IoE). However, with the need of spectrum resources, economical resource management and distribution are crucial for achieving all these bold necessities. One doable technology to achieve all this is the blockchain. Due to its inherent properties, the blockchain has recently reached a very important position, which is of huge significance to the 6G network and other networks.

Being specific, the integration of the blockchain in 6G will persuade the network to observe and manage resource utilization and sharing with maximum efficiency.

It would additionally offer many applications and service opportunities that embody industrial applications for Beyond Industry 4.0 by providing holographic communications for industrial use-cases like remote maintenance or large-scale connectivity of industrial manufacturing instrumentation. Additionally, it provides seamless environmental monitoring by permitting decentralized cooperative environmental sensing applications which might be realized on an overall global scale with 6G. Optimization in healthcare and implementing smart health units has been of tremendous importance globally and therefore have to be compelled to take one step further to unravel incumbent issues in 5G networks. Specifically, user-controlled privacy and secure information storage should be enabled with blockchains without a centralized trustworthy third party.

- Extended Reality (XR)

5G can provide extended reality a massive boost, however it probably won't be possible until 6G that we can see anything truly exceptional. However, of explicit interest is the role of intelligent networks that host extended reality resources. Once combined, these technologies might bring about very powerful applications of XR. A number of these might possibly include multisensory experiences, telemedicine and implants.

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In 6g we tend to change our perspectives towards battery-less devices whereby they will be powered by the network remotely and intelligently, therefore removing the necessity of battery packs. In various devices, extended reality or XR to include virtual, increased and mixed reality would be created and be accessible commercially. It will primarily be a computer-generated reality expertise. XR would basically be a combination of real and virtual world, computer games can provide a 3d expertise which can amend advanced vice, simulation and lots of different such applications. Extended reality (XR) has huge amounts of untapped potential and all thanks to current limitations with wireless technology. That's a giant part of why proponents are thus excited about 5G and beyond. Self-driven vehicles are planned to be supported by technologies like audio-visual sensors, radar gps and measuring systems. Equally, uavs are going to be exploited in massive means, supporting military intelligence, agriculture, law and order, product delivery, aerial photography and disaster management. Although many of us believe that it will be 5G that finally makes XR sustainable, we suspect that it will require 6G to harness its capabilities completely. Nonetheless, extended reality will continue to sophisticate in power and advancements as new technologies emerge.

- Tera-Hertz enabled Wireless Communication

The seek for increasing data rates persists, in spite of all the economical roll-out of fifth-generation (5G) wireless networks with a high-frequency millimetre-wave (mm Wave) spectrum. Towards this conclusion, higher frequencies over the terahertz (THz) band (0.1-10 THz) would be midway to ubiquitous wireless communications in beyond-5G or sixth generation (6G) networks. Peculiarly, THz frequencies promise to support adequate spectrum, exceeding hundred Gigabit per-second (Gbps) data rates, efficient connectivity, denser networks, and intensely secure and authentic transmissions. THz data measure permits nano devices to control within the soma on good and remote commands by supporting the event of nano sensors therefore. Multiple leading 6G initiatives probe THz rate communications, including the ``6 Genesis Flagship Program (6GFP)", the European Commission's H2020 ICT-09 THz Project Cluster, and the "Broadband Communications and New Networks" in China. In the US, in 2014, US Defence Advanced Research Projects Agency (DARPA) identified THz technology as one of the four major and most important analytical areas that could have a grip on the society larger than that of the Internet itself. Similarly, THz was also identified as one of the four most essential components of successive IT revolution by the US National Science Foundation and the Semiconductor Research Consortium (SRC).

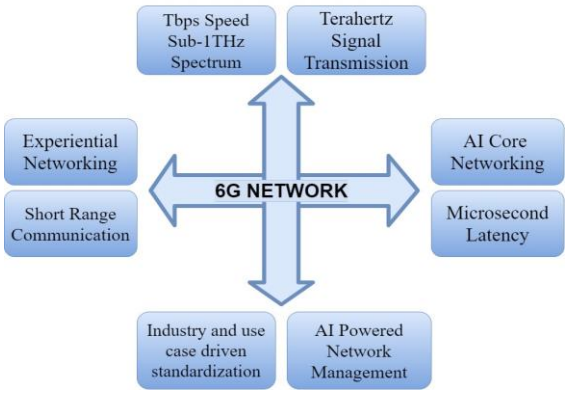

Fig. 3. Emerging Functionalities of the 6G Wireless Network.

IV. 6G VISION

From the network perspective in the middle, we can bring up two key aspects, one is the expanded service coverage for all humans and machines around the world, the other is AI native for all the services devices and infrastructure. 6g will be connecting intelligence over the expanded coverage in the physical world and it will also bring on open network architecture in the digital world combining this style in the physical world.

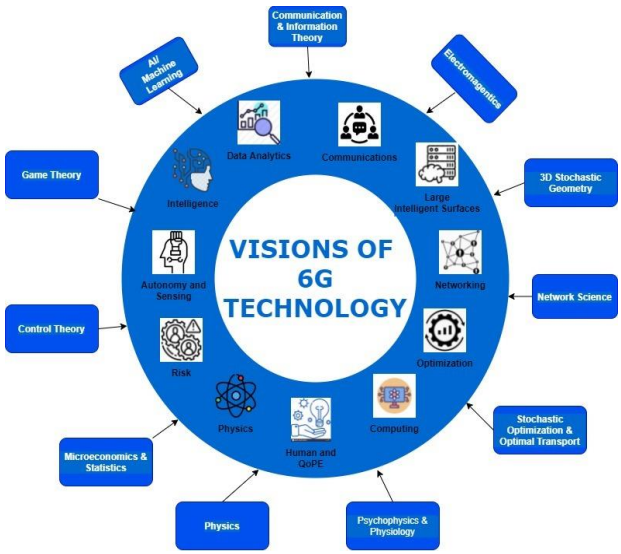

Fig. 4. Necessary foundations and associated analytical tools for 6G.

The visions for 6G include-

- Intelligent Personal Edge : Features of this application include augmented projection interfaces, physical to cyber fusion health analytics services. Personalized AI, projection interface using cross-service architectures with wireless multi-access connectivity would serve as the fundamental technologies.
- Sensor to AI Fusion : Features include ambient sensing intelligence, scanning health indicators as well as smart clothing and environment. These functionalities would need machine learning, cyber-security, edge analytics sensor fusion and blockchain.
- Super-Functional Products: Multidimensional design technologies with electronics and edge analytics using

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functional materials. These would require On-The-Fly configuration, Product gamification, IoT and hologram UIs.

- Smart Materials: Features include printed electronics products, customizable UIs and sensors as well as personalization. For these to be functionally efficient, we would require 3D IoT design, augmented sensing. reusable materials and printed electronics.
- Mobility as a Service: This would sophisticate mobility with advanced objects and infrastructure communication, autonomous safety management and logistics guidance. Technologies such as wireless multi-radio connectivity, stream analytics, multi-object IoT and edge computing should be considered as a prerequisite for the same.
- Smart City Services: Functionalities such as AI observing and catering services, management of entire city logistics and sentient safety and comfort and much more. For the efficient operation of these functionalities, we would require massively scalable systems, AI, IoT and cyber-security.
- Personalized Surfaces: Printed electronics fused with IoT, AI and wireless services offering contextual applications. These functionalities would require prerequisites such as consent management, context processing, edge computing as well as smart surface technologies.
- Multi-Object Tracking: This application would include features like programmable IoT associations, edge-connectivity and sensing networks. Consent management, swarm analytics, cyber-security and blockchain will form as the fundamental technologies for their functioning.
- Bio-Cybernetic Identity : This would include identity critical service architectures, sensing based machine learning and distribution of trust. This application would need technologies such as context processing, machine learning, cyber-identity and biometrics.
- Autonomous Port: Logistics of people and goods, swarm-based operations and collaborative mobility would be the features of this 6G application. For these functionalities to process efficiently, wireless IoT, system interoperability, data patterns analytics and stream analytics would form as prerequisites.
- Smart screens : Programmable augmented materials. context-aware content production, preference-based user experiences would be the key features. Technologies such as multi-channel connectivity, printed electronics, context-free IoT and smart surface would play a major role.

V. CHALLENGES

One of the fundamental challenges in 6G analysis ought to dwell sending up to one Tbps per user. The employment of the spectrum within the terahertz regime would force it to be organized counting on absorption and reflection properties. Besides, extra key performance indicators (KPIs) area unit required except the technical ones. This can be in terms of the international organisation SDGs that can't be neglected because of vital international challenges.

Furthermore, the extended spectrum towards terahertz can facilitate the mixing of communications with new applications like 3D imaging and sensing. For this, a brand-new paradigm for transceiver design and computing are needed to realize 1Tbps. Semiconductors, optics and alternative connected materials can have opportunities during this space.

The 6G network needs to protect against attacks. The technology can open knowledge markets wherever privacy protection with clear rules for the market are key drivers. Overall, the 6G network would like the Associate in Nursing upgraded paradigm for trust and privacy so it becomes a successful network platform.

VI. CONCLUSION

Although 6G offers terribly exhilarating anticipation, nonetheless the scientists around the world can ought to overcome a couple of obstacles within the next five to ten years. Because of broad information measures, the latest multiple channel models have to be compelled to be developed to beat the matter of frequency dispersion.

New modulation and cryptography techniques would want to be developed. High power and frequencies can have associated health problems likewise. Compatible devices can have to be compelled to be developed to support AR and XR. Integration of terrestrial satellite and mobile networks into an even wireless system will also be a necessary necessity before launch of 6g services. 6g can connect smartphone devices used in automation, artificial intelligence, extended reality good cities, drones and satellites.

All this can necessitate new security techniques with innovative cryptographical strategies
to ensure foolproof cyber security. The net of everything can have the requisite network intelligence to bind all folks, information processes and physical objects into one system.

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