6G Vision Framework

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Abstract -- **We are amidst significant developments in the area of mobile communications. From 1G in the year 1979 to 5G and now upcoming 6G is poised to impact our lives via a variety of applications. Such new advances make everyday tasks easier and in some cases completely eliminate old ways of doing things. Basically, 6G aims to reduce congestion on mobile networks, aims 1000 times faster downloads, ultra-low latencywith peak speeds up to 1 terabit per second besides low energy consumption. It will support advancements in technology, such as virtual reality, augmented reality, metaverse and artificial intelligence.**

The sixth generation (6G) communications systems are expected to support an unforeseenmenu of applications, pervading all aspects of human life. Interoperability of terrestrial networks with non-terrestrial technologies such as satellites is a useful feature as per ITU's approval of the document titled, '6G Vision Framework'. As of 2023, 6G is still in the conceptual and research phase: Industry, academia and authorities are fruitfully collaborating with each other to actualize this transformative technology by the year 2030.

Keywords: 6G, Ultra-low latency, Low energy consumption, 3GPP, Internet of senses

I. INTRODUCTION

SMART-PHONES are in for a major change as the mobile telecoms business never stands still.High-speed Internet access has become crucial in today's world where homes, schools, business, personal life and emergency communications take place via a handheld device.The International Telecommunication Union (ITU), in a significant milestone, approved the '6G vision framework' in June 2023. It is matter of pride that India played a pivotal role in formulating this framework [1].

While we rely on a Wi-Fi network at home or in office, or in a café, cellular networks take over on moving out of range of a router. Thus both complement one another. Phones and Internet-connected devices automatically switch between the two to provide seamless connectivity. But all of us have experienced irritating network congestions: Our new aspirations need faster download speeds for watching videos, or playing games besides time-sensitive applications like surgeries in remote locations. 6G networks is the next generation of wireless technology, which provides substantially higher capacity and much lower latency. Feverish research efforts are undergoing in the area of 6G networks resulting in publication of over 200 research papers. Interestingly, India has secured more than 200 patents on 6G and set up a formal 'Bharat 6G Alliance' -- a professional body of industry, academia and the GOI to undertake the 6G related works in mission-mode [1]. China leads the world in this arena with over 40% of global patents.

The specs behind 5G were 'frozen' by standards body 3GPP in June 2018 and fully specified by September 2019. 3GPP is a global 3rd Generation Partnership Project set up in December 1998 with the goal of developing a specification for a 3G mobile phone system, within the scope of the ITU. 5G can support frequencies up to 100 GHz. For 6G, transfer data across waves is planned in the hundreds of gigahertz (GHz) or terahertz (THz) ranges. According to IEEE Standards body, by advancing extended reality, artificial intelligence, machine learning, digital twinning, and more, 6G shows potential to optimize communications, interoperability, and sustainability.

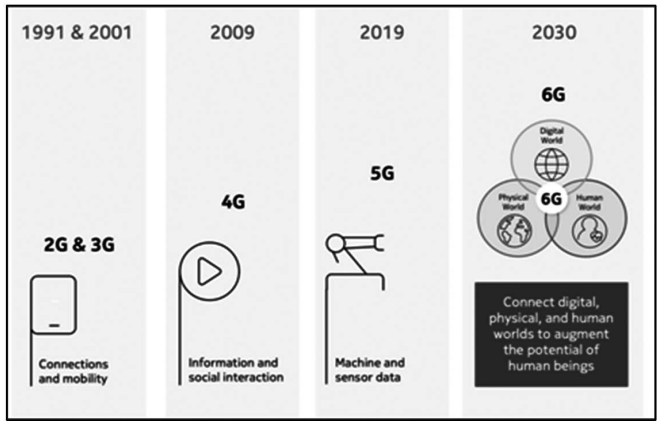

Figure 1. Summary of features of various generations of cellular communication evolution [1].

The 6G vision document released by Department of Telecom (DoT) states that while 5G technology promises a speed of 40-1100 Mbps with the potential to hit maximum speed of 10,000 Mbps; 6G will offer ultra-low latency with speeds up to 1 terabit per second. This is 1,000 times more than the top speed of 5G. Faster data exchange leads to new possibilities:

- Robots performing dangerous jobs in place of humans, for example, in mines, drones to supplement the hospital and delivery service industries

- RF sensing of 'where devices are' to offer new cyber-security options
- Human communication with robots, IoT devices and wearables.

Other innovative features of 6G are as under.

II. SELF-SUSTAINING CONNECTIVITY

Limited battery life of handsets is a common knowledge and quite bothersome to users. R&D efforts are focused on making 6G advances that will enable devices to operate without batteries by **harvesting ambient energy** from vibrations, light, temperature gradients, or even radio-frequency waves. This will be attractive for smart city applications and boost IoT use cases, namely agriculture, environmental monitoring, logistics, warehousing, shipping, tele-health, etc.

III. INTERNET OF SENSES

According to experts, 6G networks will allow its applications to sense their surroundings and turn the network into 'our sixth sense.' This will accelerate the development of new experiences, such as immersive mixed reality and holographic and multi-sensory communication.

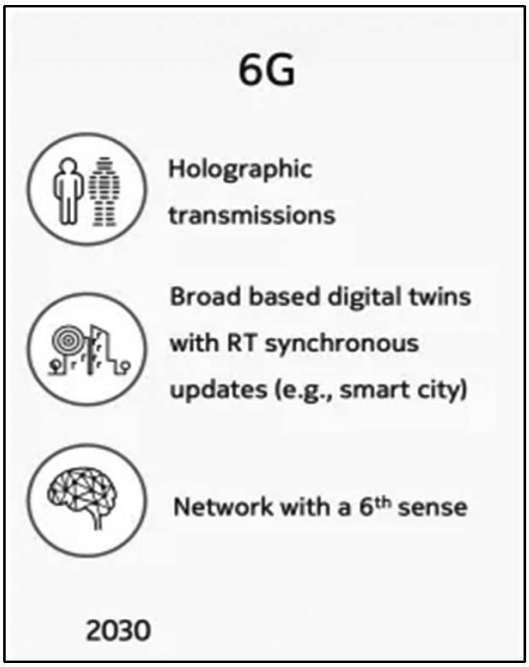

Figure 2. Seamless interactions between the physical and the digital worlds will be key characteristics of 6G (RT: Real Time).

IV. USEFUL APPLICATIONS

Often, a marketing hype gets created to justify introduction of new technologies. Doubting thomases and cynics tout diametric opposing views. But for 6G, global cooperation between academia and industry ensures that the range of applications are only limited by our imagination [IEEE]: (*i*) The 6G network will be more efficient than 5G and consume less power (*ii*) more efficiently manage supply chains to reduce energy and water usage and carbon emissions (*iii*) 6G would enable implementation of renewable energy and smart grids to optimize energy distribution (*iv*) Smart agriculture can use sensors to control water, monitor livestock, and provide accurate pesticide use to reduce carbon emissions (*v*) 6G would enable smart transportation where connected electric vehicles, cameras, and roads communicate to optimize traffic flow (*vi*) IoT will control appliances and reduce electricity usage and contribute to optimization for automated manufacturing, connected vehicles, drone agriculture (*vii*) Achieve energy efficiency.

Figure 3. Cobots, the collaborative robots which allow humans and robots working together need high-accuracy sensing, positioning, and reliability in increasingly complex industrial environments.

V. 6G SECURITY CONCERNS

6G networks aim to support a massive volume of mobile and IoT devices with ultra-low latency and seamless connectivity. Industry's major concern is availability of spectrum, which is being decided by ITU's World Radio Communications Conference, WRC 2023 in Dubai during December 2023. Spectrum scarcity has been a major concern in the past for achieving the desired QoE (quality of experience). Hence, the concept of 'spectrum sharing' systems emerged as a major enabler. For instance, the 3rd generation partnership project (3GPP) standardized coexistence of 4G LTE License Assisted Access (LAA) network with WiFi in the unlicensed 5 GHz bands, and the 5G New Radio Unlicensed (NR-U) with WiFi 6/6E in 6 GHz bands [4].

Unprotected spectrum sharing in coexistence network environments provides rogue entities with a channel that cannot be detected by existing security mechanisms. Since security architectures have not adapted at the same pace as the new wireless technologies, cyber-threat vulnerabilities persist and this is an abiding area of research.

VI. WORLD RADIO CONFERENCE 2023

Recently held WRC-23 at Dubai, UAE took few major decisions as follows:

WRC-23 approved the recommendation of the Radio Regulations Board to allow 41 countries to acquire new and usable orbital resources for satellite broadcasting. The countries were unable to use their assigned orbital slots in recent years due to factors such as lack of coordination and interference from other satellite networks.

Identified spectrum for International Mobile Telecommunications (IMT), which will be crucial for expanding broadband connectivity and developing IMT mobile services, also known as 4G, 5G and, in the future, 6G. That new spectrum includes the 3300-3400 megahertz (MHz), 3600-3800 MHz, 4800-4990 MHz and 6 425-7 125 MHz frequency bands in various countries and regions. The WRC also recognised the use of 6425 to 7125 MHz for wireless access and RLANS in the Radio Regulation table of frequency allocations for the first time.

Approved new studies for identification of IMT in 4.4-4.8 GHz, 7-8 GHz and 15 GHz for additional 2 GHz mid-band spectrum for 4G, 5G and 6G at WRC-27.

Identified a number of IMT bands below 2.7 GHz for use of high-altitude platform stations for IMT base stations (HIBS) and established regulations for their operations. HIBS contribute to bridging the digital divide in remote and rural areas and maintain connectivity during disasters.

For non-geostationary fixed-satellite service Earth Stations in Motion (ESIMs), WRC-23 identified new frequencies to deliver high-speed broadband on-board aircraft, vessels, trains, and vehicles. These satellite services are critical during disasters where local communication infrastructure is damaged or destroyed.

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Dr Ranjit Singh, FIETE, LF-IAFI (b. 17 Aug 1948) obtained B.Tech, M.Tech. and Ph.D degrees from Indian Institute of Technology, Kanpur in 1969, 1971 and 1975 respectively specializing in the area of Electronic circuits and devices. Has abiding passion for research and innovative approach to teaching. Guided B.Tech, M.Tech and Ph.D scholars. He is founding Editor-in-Chief of the '*AKGEC International Journal of Technology*', which is running in fourteenth volume.Earlier served IETE as Editor during 1975-1987; Technical Editor at *Telematics India* during 1987-2001 and Editor of *Industrial Purchase* journal during 2002-2008.

From September 2008 to February 2015, he taught at Ajay Kumar Garg Engineering College where, he was a Professor in the EC department. Thereafter served as Head of the ECE and EI departments, IEC Engineering College, Greater Noida from April 2015 – May 2016, where he supervised setting up of e-Yantra lab.

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- Big Data: Challenges and Opportunities (Feb 2017)
- Smart Cities (April 2017)
- Lure of ISM Band (July 2017)
- Lithium Ion Batteries: Answer to Communications Energy Crunch (May 2018).

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