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6G Scenarios and Network Design Principles

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Abstract – Tremendous need of data over cellular network increases the development of new communication technology 6G. 5G mobile networks cannot fulfil the technological requirements required for various applications like deep sea and space tourism, collaborative robots and in holographic tele-presence. Development of 6G systems and applications has been an admired theme in the research community. The new generation communication system developed in every 10 years improves the quality-of-service metrics by incorporating new features and services. Even though 5G is not a commercial reality, 6G is expected to be available in 2030. This paper enlightens a vision on 6G technologies and network design principles.

Keywords – Augmented Reality, Extended Reality, Virtual Reality, 5G, 6G, Communications.

I. INTRODUCTION

COVID-19 pandemic shows the high utilization of video conferencing in almost all the parts of life, especially in govt. sectors, medical fields and in businesses, expecting many more developments in live video conferencing. Technologies like holograms and multi sense communications including smell and tastes are possible by the use of 6G [1].

5G does the integration of licensed and unlicensed bands and there by developing man-machine communication to an extent. But it will not be possible to automate everything into service even though 5G offers significant development over the existing system [2]

As compared to the data traffic of 2010, it is expected by the ITU (International Telecommunication Union) that mobile traffic volume increases 670 times in 2030 [3]. Around 10,000km sky coverage and 20 nautical miles sea coverage are expected by the integration of terrestrial and satellite system in 6G [3-4].

6G summit conducted in Levi, Finland in 2019 with the theme "Pave the way for the arrival of 6G" with experts and officially released the white paper titled "Key Drivers and Research Challenges for 6G Ubiquitous Wireless Intelligence". It shows that by 2030, many dreams become a reality with the advent of 6G technology which covers ground, satellite and airborne networks, a 10 to 100 times faster technology than 5G. Most of the countries like Japan, US, South Korea and Europe have already invested in 6G research projects [5].

II. TECHNOLOGIES

Augmented Reality technique enables a live view with the support of computer-generated sensor inputs like audio, video and GIS (Global Positioning System) data. Mixed Reality combines the real-world characteristics with artificial content. Virtual Reality experiences imaginary 3D realistic sensations using headsets and various technologies [6-7].

A dependable remote-monitoring system enhances the advent of remote surgery in health care systems as 6G can transfer colossal amount of medical data quickly. 6G will characterize the automation of devices, systems as well as manufacturing processes in high speed [8-9].

Orbital Angular Momentum Multiplexing technology superimposes various types of electromagnetic waves and thereby increases the spectral efficiency. A vast number of antennas can be incorporated for communication with the help of the shorter wavelength property of THz frequency band [10].

III. KEY PERFORMANCE INDICATORS

It has seen that 6G will contain the similar KPIs as previous generations but with higher capacity. The desirable KPIs for the 6G wireless accessing are:

Supreme data rates
Up to 1 Tbps data rates are expected for both indoor and outdoor connections.

Enlarged Spectral efficiency
MIMO technology enhanced the spectral efficiency and expected up to 60b/s/Hz

Wide bandwidth
Band width of 10 GHz can be supported in mmWave bands. THz and Visible light bands provide 100 GHz band width for data communication.

Low Latency and high reliability
It reaches down to 1 microsecond latency and reliable on various types of applications.

Massive machine type communication
Around 1000 times elevated multiple wireless connectivity than 5G is expected in 6G with more than 99.99% reliability

Wireless Brain-Computer Interactions
Signals from brain have been transmitted to a digital device for command interpretation for further action. The basic properties of 6G such as big data rates, remarkably low latency and extra reliability makes actual implementation of wireless brain computer interactions easily. Other than that, 6G transfers' data obtained from five senses such as hearing, sight, taste, touch and smell to experience the world remotely [11-18].

IV.   CORE REQUIREMENTS AND 6G SCENARIOS

In order to integrate the communication between planes, ships and trains for react to the changing conditions, interconnection of space and networks are required with tremendous computing capacity and the same is possible with the advent of 6G. 6G should cover:

- Entire spectra: There will be a hyperspectral system, from microwave to terahertz wave.
- Whole coverage: Broader and deeper coverage of domains such as space, sea, aerial and terrestrial is within the bounds of possibility.
- Uncut dimension: Precise and accurate operations encompasses the fine grained analysis of everything in data communication.
- Extensive convergence: Converging processes of communication, control, sensing, computing, and imaging makes to deliver multiple services simultaneously.
- Complete photonics: Elements such as array of antennas with photo detector, photonic engine, and spectrum computing are the key features of 6G which give an efficient energy utility [4-6,19-22].

V.   6G NETWORK DESIGN PRINCIPLES

While 1G and 2G concentrated on speech, 3G enables data transfer and basic accessing of internet. Mobile internet with downloading facilities with a higher rate introduced in 4G and 5G makes machine-to-machine communication and Internet of things. But there are some limitations of fast data transfer and internet availability. With the help of digital domain, 6G makes conversation of man and machine in a more interactive way [23-24].

6G require a network with embedded trust; need to protect information from attackers. Situation adapted flexible networks are available in 6G.

The three technology enablers are distributed massive MIMO are jointly-processed coordinated multipoint transmission and ultra-dense networks.

Dynamically changing clutches of access points are the peculiarity of the 6G network rather than the fixed network. Also ultra long battery life with advanced technology for energy harvesting is the added feature of 6G.
Some network characteristics are as follows [22,25-26].

Satellite Integration Network
For ubiquitous connectivity, satellite communication is essential. It covers different geographical location irrespective of land, air and sea. Inorder to obtain the objective of 6G, it is expected to the integration of terrestrial and satellite systems.

Connected Intelligence
6G promote the theme of connected intelligence rather than connecting things. In every step of communication process, Artificial Intelligence has been introduced to attain the maximum quality.

Unification of wireless data and energy transfer
6G provides power in order to charge battery devices. No need of separate charging of mobile devices while using 6G.

Ubiquitous super 3D connectivity
Accessing network on air, space, earth and sea with technologies make 3D connectivity, a reality.

VI.   QUANTUM INFORMATION TECHNOLOGY

Quantum Key Distribution technique, a secure communication method adopted for two parties by producing and distributing a secret key and able to detect the presence of a third party. The key can be utilised with any encryption algorithm and then can be transmitted through communication channel. The qubits are the encoded information that is used for fast secure communication in 6G [27-32].

VII.   CONCLUSION

Absolutely modern services such as holographic tele-presence and mixed reality will be attainable by high resolution imaging and sensing, wearable displays, mobile robots and drones, specialized processors, and next-generation wireless networks. The ultra-new traits of 6G will drive faster the process of molding societies and ultimately leads to quality life in every walk. Mobile phones will be replaced by thin glasses that give extended reality experiences.

References

[1]. H. Tataria, M. Shafi, A. F. Molisch, M. Dohler, H. Sjöland and F. Tufvesson, "6G Wireless Systems: Vision, Requirements, Challenges, Insights, and Opportunities," in Proceedings of the IEEE, vol. 109, no. 7, pp. 1166-1199, July 2021, doi: 10.1109/JPROC.2021.3061701.

[2]. Nawaz, Syed Junaid, "Quantum machine learning for 6G communication networks: State-of-the-art and vision for the future." IEEE access 7 (2019): 46317-46350

[3]. Series, M. "IMT Vision–Framework and overall objectives of the future development of IMT for 2020 and beyond." Recommendation ITU 2083 (2015): 21

[4]. Nakamura, Takehiro. "5G Evolution and 6G." 2020 IEEE Symposium on VLSI Technology. IEEE, 2020

[5]. M. Z. Chowdhury, M. Shahjalal, S. Ahmed and Y. M. Jang, "6G Wireless Communication Systems: Applications, Requirements, Technologies, Challenges, and Research Directions," in IEEE Open Journal of the Communications Society, vol. 1, pp. 957-975, 2020, doi: 10.1109/OJCOMS.2020.3010270.

[6]. K. B. Letaief, W. Chen, Y. Shi, J. Zhang and Y. -J. A. Zhang, "The Roadmap to 6G: AI Empowered Wireless Networks," in IEEE Communications Magazine, vol. 57, no. 8, pp. 84-90, August 2019, doi: 10.1109/MCOM.2019.1900271.

[7]. W. Saad, M. Bennis and M. Chen, "A Vision of 6G Wireless Systems: Applications, Trends, Technologies, and Open Research Problems," in IEEE Network, vol. 34, no. 3, pp. 134-142, May/June 2020, doi: 10.1109/MNET.001.1900287.

[8]. C. D. Alwis, "Survey on 6G Frontiers: Trends, Applications, Requirements, Technologies and Future Research," in IEEE Open Journal of the Communications Society, vol. 2, pp. 836-886, 2021, doi: 10.1109/OJCOMS.2021.3071496.

[9]. M. Giordani, M. Polese, M. Mezzavilla, S. Rangan and M. Zorzi, "Toward 6G Networks: Use Cases and Technologies," in IEEE Communications Magazine, vol. 58, no. 3, pp. 55-61, March 2020, doi: 10.1109/MCOM.001.1900411.

[10]. B. Han, M. A. Habibi and H. D. Schotten, "The Road Towards 6G: A Comprehensive Survey," in IEEE Open Journal of the Communications Society, vol. 2, pp. 334-366, 2021, doi: 10.1109/OJCOMS.2021.3057679.

[11]. P. Yang, Y. Xiao, M. Xiao and S. Li, "6G Wireless Communications: Vision and Potential Techniques," in IEEE Network, vol. 33, no. 4, pp. 70-75, July/August 2019, doi: 10.1109/MNET.2019.1800418.

[12]. R. Shafin, L. Liu, V. Chandrasekhar, H. Chen, J. Reed and J. C. Zhang, "Artificial Intelligence-Enabled Cellular Networks: A Critical Path to Beyond-5G and 6G," in IEEE Wireless Communications, vol. 27, no. 2, pp. 212-217, April 2020, doi: 10.1109/MWC.001.1900323.

[13]. Y. Liu, X. Yuan, Z. Xiong, J. Kang, X. Wang and D. Niyato, "Federated learning for 6G communications: Challenges, methods, and future directions," in China Communications, vol. 17, no. 9, pp. 105-118, Sept. 2020, doi: 10.23919/JCC.2020.09.009.

[14]. https://www.globenewswire.com/news-release/2021/03/08/2188690/0/en/In-the-6G-era-holographic-interaction-has-become-a-new-application-scenario-and-WIMI-will-become-the-first-stock-of-holographic-AR.html

[15]. Ziegler, Volker, et al. "Stratification of 5G evolution and Beyond 5G." 2019 IEEE 2nd 5G World Forum (5GWF). IEEE, 2019.

[16]. Jiang, Wei, and Hans D. Schotten. "The kick-off of 6G research worldwide: An overview." 2021 7th International Conference on Computer and Communications (ICCC). IEEE, 2021.

[17]. Tripathy, Asis Kumar, Suchismita Chinara, and Mahasweta Sarkar. "An application of wireless brain–computer interface for drowsiness detection." Biocybernetics and Biomedical Engineering 36.1 (2016): 276-284.

[18]. Jafri, Syed Rehan Abbas, "Wireless brain computer interface for smart home and medical system." Wireless Personal Communications 106.4 (2019): 2163-2177.

[19]. B. Zong, C. Fan, X. Wang, X. Duan, B. Wang and J. Wang, "6G Technologies: Key Drivers, Core Requirements, System Architectures, and Enabling Technologies," in IEEE Vehicular Technology Magazine, vol. 14, no. 3, pp. 18-27, Sept. 2019, doi: 10.1109/MVT.2019.2921398.

[20]. P. Shylaja, "Towards 6G: Key Enabling Technologies and Perspectives", in Arun Chakravarthy R, "Emerging Trends in Information and Communication Technology", (pp:35-45), ISBN: 978-93-93502-11-7, DOI: https://doi.org/10.22271/int.book.120,

[21]. C. Wang and A. Rahman, "Quantum-Enabled 6G Wireless Networks: Opportunities and Challenges," in IEEE Wireless Communications, vol. 29, no. 1, pp. 58-69, February 2022, doi: 10.1109/MWC.006.00340.

[22]. Scarani, Valerio, "The security of practical quantum key distribution." Reviews of modern physics 81.3 (2009): 1301

[23]. Renner, Renato. "Security of quantum key distribution." International Journal of Quantum Information 6.01 (2008): 1-127

[24]. Gottesman, Daniel, "Security of quantum key distribution with imperfect devices." International Symposium onInformation Theory, 2004. ISIT 2004. Proceedings. IEEE, 2004.

[25]. Cabello, Adán. "Quantum key distribution in the Holevo limit." Physical Review Letters 85.26 (2000): 5635.

[26]. H. Tataria, M. Shafi, A. F. Molisch, M. Dohler, H. Sjöland and F. Tufvesson, "6G Wireless Systems: Vision, Requirements, Challenges, Insights, and Opportunities," in Proceedings of the IEEE, vol. 109, no. 7, pp. 1166-1199, July 2021, doi: 10.1109/JPROC.2021.3061701.

[27]. Liu, Fan "Integrated sensing and communications: Towards dual-functional wireless networks for 6G and beyond." IEEE journal on selected areas in communications (2022).

[28]. Wu, Wen "AI-native network slicing for 6G networks." IEEE Wireless Communications 29.1 (2022): 96-103.

[29]. Pan, Cunhua, "Ieee Access Special Section Editorial: Reconfigurable Intelligent Surface Aided Communications for 6G and Beyond." IEEE Access 10 (2022): 19443-19446.

[30]. Xu, Minrui "Secure and reliable transfer learning framework for 6g-enabled internet of vehicles." IEEE Wireless Communications (2022).

[31]. Rasti, Mehdi, "Evolution Toward 6G Multi-band Wireless Networks: A Resource Management Perspective." IEEE Wireless Communications (2022).

[32]. Tan, Jingbo, and Linglong Dai. "THz Precoding for 6G: Challenges, Solutions, and Opportunities." IEEE Wireless Communications (2022).