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A Survey on Various Approaches within the 4G/5G/6G LTE Wireless Networks

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A B S T R A C T

In Wireless Communication Systems, effective spectrum utilization is crucial for achieving better Quality of Service (QoS), synchronized time management, and minimal delays. The current channel assignment methods require improvement in QoS parameters, including end-to-end delay, burst factor, and time factor for channel access. To enhance QoS further, a more efficient solution is needed, addressing issues such as admission control drop, block probability, and implementing an effective channel reservation approach. This approach proves to be a superior solution, particularly for delay-sensitive applications.An in-depth performance analysis is conducted, comparing existing conflict-reduced channel allocation methods, energy-conserving channel assignment techniques, and, as a final method, admission control drop and block probability strategies. The evaluation is based on key metrics such as Packet Loss Rate, End-to-End Delay, and Throughput. The channel capacity is significantly increased to support dense networks by efficiently using existing channels and reserving a few channels for dynamic requirements related to normal and multimedia traffic data.

Keywords: 5G/6G, LTE, QoS, Loss Rate etc.

1. Introduction

As innovation continues to evolve, continuous efforts are made in creating and developing new innovations through ongoing research. Following the progression from 1G to 4G and now to 5G, significant advancements have been implemented. The fifth generation, 5G, stands out by offering improved performance in various aspects such as bandwidth, spectral efficiency, energy efficiency, and more when compared to its predecessor, 4G. The transition from 4G to 5G is a transformative shift, as illustrated in Figure 1. 5G represents a substantial improvement over 4G and 4G LTE. This innovation paves the way for a globally connected world. The cellular network system operates based on radio frequency, with the radio spectrum being limited and expensive. To enhance communication systems, a substantial frequency band is required to handle the growing network traffic efficiently.

Fig.1. Evolution of Wireless Communication Technologies [1].

The 4G technology was deployed between 2000-2010, offering speeds ranging from 2Mbps to 100Mbps. It operates as a completely IP-based system, with a primary focus on delivering high speed, Quality of Service (QoS), and cost-effective services. Utilizing standards like LTE (Long-Term Evolution) and WiMAX, 4G employs CDMA multiplexing techniques along with packet switching. On the other hand, the 5G technology is scheduled to be deployed by 2020, introducing significant features for users, including higher data rates of 1Gbps or more. 5G supports 4G+WWW (Fourth Generation + Worldwide Wireless Web) and operates on the IPv6 protocol. Its goal is to provide unlimited access to information at any location and time with high-speed connectivity.

2. Literature Survey

TABLE I. Literature Survey On 5G wireless communication Technology.

S. No.	PAPER NAME	AUTHORS	WORK DONE
1.	Emerging Technologies and Research Challenges for 5G Wireless Networks.(IEEE)	Woon Hau Chin, Zhong Fan, and Russell Haines	In this paper Research challenges and other merging technologies are Explained along with their new research problems [2].
2.	A Survey of 5G Network: Architecture and Emerging Technologies.	Akhil Gupta, Student Member, IEEE, Rakesh Kumar Jha, Senior Member IEEE	This Paper introduced 5G technology with 5G cellular network architecture in detail. Author's done comparatively study with various parameters and also pose different issues & challenges in 5G technology [1].
3.	An Overview on Resource Allocation Techniques for Multi-User MIMO Systems	Eduardo Castaneda, Member, IEEE, Gameiro, and Marios Kountouris, Senior Member, IEEE	This paper provide a overview of the various methodologies used to approach the aforementioned joint optimization task in the downlink of MU- MIMO communication systems [3].
4.	Next Generation 5G Wireless Networks: A Comprehensive Survey	Mamta Agiwal, Abhishek Roy and Navrati Saxena	In this survey paper 5G Architecture, mm-wave, beam forming, channel model, CRAN ,SDN, HetNets, massive MIMO, SDMA, IDMA, D2D, M2M, IoT, QoE, SON, sustainability, field trials- terms are describe in detail and gives emerging application of 5G communication [4].

3. Architecture and Working of 5G

Searching intelligently for the current 5G network in the market reveals that various access methods within the system are still available and require some modification. Current technologies such as OFDMA are expected to remain viable for the next 50 years. Recognizing this, it becomes evident that a complete overhaul of the wireless setup, as witnessed from 1G to 4G, is unnecessary. Rather, the necessary adjustments should be made at the core network to meet customer requirements.

To address customer needs and overcome challenges posed by the 5G framework, an effective transformation in the strategy for designing 5G wireless cell architecture is essential. Researchers observe that a significant portion of wireless users spends up to 80% of their time indoors and 20% outdoors. In the current wireless cell network design, when a mobile user wishes to communicate either inside or outside, an external base station located at the center of a cell facilitates communication. However, when indoor users need to communicate with an external base station, the signals must traverse through the building's walls, resulting in high penetration loss. This, in turn, diminishes spectral efficiency, data rate, and energy efficiency in wireless communications. To address these challenges, a new design approach has emerged in the market, implementing separate outdoor and indoor configurations. This approach, facilitated by technologies like massive MIMO (Multiple Input, Multiple Output), utilizes geographically dispersed arrays of antennas, including tens or hundreds of antenna units.

Implementing a massive MIMO network involves two main stages. Firstly, external base stations are equipped with large antenna arrays, distributed around hexagonal cells and connected to the base station via optical fiber cables, utilizing massive MIMO technologies. Mobile users located outside are associated with a few antenna units, forming a large virtual antenna array that collaborates with the base station to create virtual massive MIMO links.Secondly, each building is equipped with large antenna arrays for outdoor communication with base stations using line-of-sight components. For indoor communication, wireless access points are installed inside the building, connected to the large antenna arrays via cables. This enhances energy efficiency, cell average throughput, data rate, and spectral efficiency of the cell system, albeit at an increased infrastructure cost.

For short-range communications (indoor communication) with high data rates, technologies such as Wi-Fi, small cells, ultra-wideband, millimeter-wave communications, and visible light communications are highly useful. However, some technologies, like millimeter-wave and visible light communication, require higher frequencies, which may not be suitable for cellular communications. In conclusion, the presented 5G cell network architecture addresses both front-end and backhaul network considerations. The architecture includes key elements such as Massive MIMO networks, Cognitive Radio networks, mobile and static small cell networks, Network Function Virtualization (NFV) cloud, Direct-to-Device (D2D) communication, small cell access points, and the Internet of Things (IoT). This comprehensive 5G cell network architecture lays the groundwork for future 5G standardization initiatives.

4. Comparative Study of 4G and 5G

Table II. Technical Comparison between 4G and 5G [2, 3, 4, 5].

S. No.	Specification	4G (Fourth Generation)	5G (Fifth Generation)
1.	Data Bandwidth	Up to 100Mbps	Greater than 1Gbps
2.	Frequency Band	2GHz to 8GHz	3GHz to 300GHz
3.	Standards	OFDMA, MC-CDMA, N/W-LMPS	CDMA and BDMA

4.	Technology	unified IP, seamless integration of broadband, LAN/WAN/PAN and WLAN	4G and advanced technologies based on OFDM modulation used in 5G
5.	Service	Dynamic information access, wearable devices, HD streaming, global roaming	Dynamic information access, wearable devices, HD streaming, any demand of users with all Capabilities
6.	Multiple Access	CDMA	CDMA,BDMA
7.	Core Network	All IP network	Flatter IP network, 5G network Interfacing(5G-NI)
8.	Hand Off	Horizontal and vertical	Horizontal and vertical
9.	Initiation Form	year-2010	year-2015
10.	Multiplexing	CDMA	CDMA
11.	Switching	Packet	Packet
12.	Antenna Type	Sub wavelength antenna	Array antennas
13.	Radiation Pattern	Omnidirectional	Directional fan-beam
14.	Diversity and MIMO	Present	Present
15.	Deployment	2000-2010	By 2020

5. Features and Challenges

Capacity Enhancement - A thousandfold increase in data volumes and data rates up to 10-100 times higher for end-users[2].

Reduced Latency - A reduction in latency by a factor of 5, facilitating services like remote presence and tactile internet.

Expansion of Connected Devices - Each access point capable of serving up to 300,000 connected devices[1].

Improved Efficiency - Enhanced energy and spectrum resource utilization.

Enhanced Reliability - 5G ensures highly reliable connections, typically achieving 99.999% availability. It supports applications in Internet of Things, Smart Home Appliances, Autonomous Cars, and various sectors such as Health, Transport, Agriculture, and Education[1]. 5G provides consistent, uninterrupted connectivity globally[5]

A. HETEROGENEOUS NETWORK

The 5G network employs a heterogeneous architecture that includes picocells, macrocells, and small cells to reduce energy consumption and enhance cost efficiency. This diverse network provides numerous access points with varying efficiencies and utilizes different spectrums, allowing for the use of different transmission power levels to achieve higher data rates[2]. It also encompasses sub-challenges such as inter-cell interface management, efficient medium access control, distributed interface coordination, device discovery, and link setup.

B. DEVICE-TO-DEVICE COMMUNICATION

Device-to-Device communication in 5G prioritizes high-end user mobility by enabling direct communication between terminals or sharing radio frequency connections to exchange data, thereby reducing interference in communication. 5G operates as a full-duplex system[1], allowing devices to transmit and receive signals simultaneously, thereby reducing time complexity. It employs a simple two-tier architecture, ensuring a traffic-free environment for base stations [2].

C. MASSIVE MIMO

Massive MIMO involves deploying a very large antenna array at each base station, connecting with multiple tens of users. This technology enables the simultaneous service of a large number of users without consuming excessive radio spectrum. Additionally, Massive MIMO reduces dead radio spectrum, minimizes dead zones, and provides high-quality data transmission [4].

D. RADIO WAVES

While radio waves facilitate cellular network communication, major issues such as capacity, efficiency, availability, and security persist. Traditional radio waves operate within limited spectrum bands, which can be expensive. 5G addresses these challenges by utilizing new spectrum bands above 6GHz, achieving very high data rates, low latency, energy efficiency, and ultra-high reliability [7].

EMERGING APPLICATIONS

A. ***D2D Communication*** – Peer to Peer[2] or direct device to device communication[2], eliminate IP based or Base station oriented connectivity.

B. ***M2M Communication***- Intelligent machines automatically done all data operations, like data generation, processing and Transfer [2].

C. ***Internet Of Things***- Supports IoT concept which is large scale development smart homes as well as smart objects connected together via Internet. Internet of Things Connecting “Anytime, Anyplace, Anyone, Anything” [1].

D. ***Internet Of Vehicles***- Supports vehicle to vehicle communication through Internet and traffic, collision reduces [1,4]. It provides low latency and high mobility connectivity.

E. ***Health Care***-Advance sensor and communication technology enables health monitoring, real time communication, data storage [1]. Wearable technology provides health care solution.

F. ***Smart Home And Smart City***- Applicable for smart homes and cities in Automation, Appliances, Embedded system and security.

6G Applications

6G wireless technology was still in the early stages of research and development, and specific technical details were not fully defined. However, 6G is expected to be the next generation of wireless communication technology, succeeding 5G. While the full specifications and capabilities of 6G are yet to be determined, there are several potential features and objectives that researchers and industry experts are exploring:

Higher Data Rates: 6G is expected to provide significantly faster data rates compared to 5G, aiming to support terabits per second (Tbps) data speeds.

Lower Latency: Ultra-low latency is a key focus for 6G, aiming to reduce communication delays to unprecedented levels, potentially in the order of microseconds.

Advanced Spectrum Use: 6G is likely to explore the use of higher frequency bands, including the terahertz (THz) range, to achieve greater bandwidth and data capacity.

AI Integration: Integration of artificial intelligence (AI) is expected to play a significant role in 6G networks, enabling intelligent network management, optimization, and advanced applications.

Wireless Sensing and Localization: 6G is anticipated to enhance capabilities for wireless sensing and localization, enabling applications such as precise positioning and environmental monitoring.

Global Coverage and Connectivity: 6G aims to provide ubiquitous and reliable connectivity on a global scale, including in remote and challenging environments

6. Conclusion

In this concise overview, we delve into the fifth generation (5G) technology, covering its architecture, challenges, emerging applications, and a comparative analysis with 4G. This overview provides insights that can effectively guide researchers in addressing future issues and challenges. As this technology remains in the research phase, numerous issues and challenges are being explored. The full development of 5G is anticipated in 2020 or even sooner, promising advancements in communication and digital experiences through enhanced performance. It's important to note that the development of 6G technology is a collaborative effort involving researchers, industry stakeholders, and standardization bodies. The specifications and features of 6G are likely to evolve as research progresses, and the technology is expected to be deployed commercially sometime in the 2030s. For the latest information on 6G development, it is recommended to check with authoritative sources in the telecommunications industry.

References

[1] C. white paper, “Cisco Visual Networking Index; Global mobile data traffic forecast update, 2018–2023,” 2019.

[2] A. Shahraki and Ø. Haugen, “Social ethics in internet of things: An outline and review,” in 2018 IEEE Industrial Cyber-Physical Systems (ICPS). IEEE, 2018, pp. 509–516.

[3] M. Cave, “How disruptive is 5G?” Telecommunications Policy, vol. 42, no. 8, pp. 653–658, Sep. 2018.

[4] S. Filin, H. Murakami, K. Ibuka, H. Kawasaki, K. Ishizu, and F. Kojima, “5g and b5g technologies to implement private operators supporting high quality video production in dense user environments,” in 2019 22nd International Symposium on Wireless Personal Multimedia Communications (WPMC). IEEE, 2019, pp. 1–6.

[5] Z. Zhang, Y. Xiao, Z. Ma, M. Xiao, Z. Ding, X. Lei, G. K. Karagiannidis, and P. Fan, “6G wireless networks: Vision, requirements, architecture, and key technologies,” IEEE Vehicular Technology Magazine, vol. 14, no. 3, pp. 28–41, Jul. 2019.

[6] L. Zhang, Y.-C. Liang, and D. Niyato, “6G visions: Mobile ultrabroadband, super internet-of-things, and artificial intelligence,” China Communications, vol. 16, no. 8, pp. 1–14, Aug. 2019.

[7] J. Chai, L. Feng, F. Zhou, P. Zhao, P. Yu, and W. Li, “Energy-Efficient Resource Allocation Based on Hypergraph 3D Matching for D2DAssisted mMTC Networks,” in Proc. IEEE Global Communications Conference (GLOBECOM), Abu Dhabi, United Arab Emirates, Dec. 2018.

[8] D. Jiang and G. Liu, “An overview of 5G requirements,” in 5G Mobile Communications. Springer, Oct. 2017, pp. 3–26.

[9] S. P. RM, S. Bhattacharya, P. K. R. Maddikunta, S. R. K. Somayaji, K. Lakshmanna, R. Kaluri, A. Hussien, and T. R. Gadekallu, “Load balancing of energy cloud using wind driven and firefly algorithms in internet of everything,” Journal of Parallel and Distributed Computing, Aug. 2020.

[10] R. Gupta, A. Shukla, and S. Tanwar, “BATS: A blockchain and AI-empowered drone-assisted telesurgery system towards 6G,” IEEE Transactions on Network Science and Engineering, Dec. 2020.

[11] L. U. Khan, I. Yaqoob, M. Imran, Z. Han, and C. S. Hong, “6G wireless systems: A vision, architectural elements, and future directions,” IEEE Access, vol. 8, pp. 147 029–147 044, Aug. 2020.

[12] Z. Lv, L. Qiao, and I. You, “6G-enabled network in box for internet of connected vehicles,” IEEE Transactions on Intelligent Transportation Systems, Nov. 2020.

[13] S. Nayak and R. Patgiri, “6G: Envisioning the key issues and challenges,” arXiv preprint arXiv:2004.04024, Jun. 2020.

[14] S. Zhang, J. Liu, H. Guo, M. Qi, and N. Kato, “Envisioning deviceto-device communications in 6G,” IEEE Network, vol. 34, no. 3, pp. 86–91, March 2020.

[15] F. Tang, Y. Kawamoto, N. Kato, and J. Liu, “Future intelligent and secure vehicular network toward 6G: Machine-learning approaches,” Proceedings of the IEEE, vol. 108, no. 2, pp. 292–307, Dec. 2019.

[16] P. Yang, Y. Xiao, M. Xiao, and S. Li, “6G wireless communications: Vision and potential techniques,” IEEE Network, vol. 33, no. 4, pp. 70–75, Jul. 2019.

[17] K. David and H. Berndt, “6G vision and requirements: Is there any need for beyond 5G?” IEEE Vehicular Technology Magazine, vol. 13, no. 3, pp. 72–80, Jul. 2018.

[18] H. Tataria, M. Shafi, A. F. Molisch, M. Dohler, H. Sjoland, and ¨ F. Tufvesson, “6g wireless systems: Vision, requirements, challenges, insights, and opportunities,” Proceedings of the IEEE, pp. 1–34, 2021.