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An Overview of Fifth Generation (5G) Technology for Advanced Mobile and Wireless Communication Services

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Abstract: Continuously the increasing generations of information and technology (2G to 5G), mobile and wireless communication systems have affected the every corner of modern life worldwide. However, with an explosion of wireless mobile devices and services, there are still some challenges that cannot be accommodated even by 3G and 4G systems such as high bandwidth, high energy consumption, the spectrum allotments and their utilization. Mobile and wireless communication system designers have been facing the continuously increasing demand for high data rates and mobility required by new wireless applications and therefore they have focused deep research on fifth generation technology systems. The data rates for 5G communication systems will be more than 5Gbps and the framework is expected to be launched by 2019-2020. In this research paper overview, a potential wireless communication framework for 5G system has been discussed with its future challenges and potential applications.

Keyword: Fifth generation (5G) technology, wireless communication, data rate, MIMO, macro cell etc.

I. INTRODUCTION TO WIRELESS GENERATION COMMUNICATION

The inventive and efficient use of mobile and wireless communication technologies is becoming increasingly important for the global growth [1]. Wireless communication systems and networks are the most significant elements of modern communications. It is one of the top growing and powerful sectors of communications.

The development of wireless systems has really enhanced people's ability to communicate and live in both business and social functions. In early 1980's when the wireless communication just started, it started with the zero generation technology commonly known as radio wireless transmission technology. Then came 0.5 G with bit more improvement in voice clarity after that there came a grand 1st generation technology commonly known as 1G, which not only provide the voice call facility but it also provided the data transfer facility with a maximum speed of 10kbps.2G served as a innovative work done in the field of RF and wireless communication as it provides a very good voice clarity and even increased the data transfer speed up to 64kbps as the increment in 2G, there came 2.5G which provided a maximum data transfer speed of 144kbps [2-3].

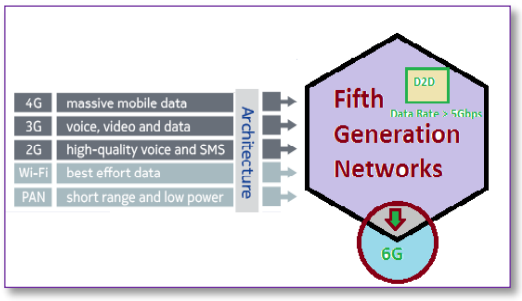

Fig.1: New Generation (2G-6G) Technologies

From the second generation (2G) mobile communication system launched in 1991 to the 3G system first launched in 2001, the wireless mobile network has transformed from a pure telephony system to a network that can transport rich multimedia contents such as video streaming, text, audio and many more. Different types of mobile and wireless communication technologies, such as Wi-max (IEEE 802.16 wireless and mobile networks) , Wi-Fi (IEEE 802.11 wireless networks), LTE (Long Term Evolution), 3G mobile networks (UMTS, CDMA 2000) and 4G as well as accompanying networks, such as personal area networks (e.g., Bluetooth, Zig Bee) or wireless sensor networks.

The 4G wireless systems were designed to fulfill the requirements of International Mobile Telecommunications - Advanced (IMTA) using internet protocols for all services [3]. In 4G systems, an advanced radio interface is used with orthogonal frequency-division multiplexing (OFDM), multiple-input multiple-output (MIMO) and link adaptation (LAD) technologies. 4G wireless networks can support data rates of up to 1 Gb/s for low mobility, such as local wireless access and up to 100 Mb/s for high mobility, such as mobile and wi-max access [4].The figure (1) describes the growth in generation technology from 2G to 5G and then its switching to 6G networks.

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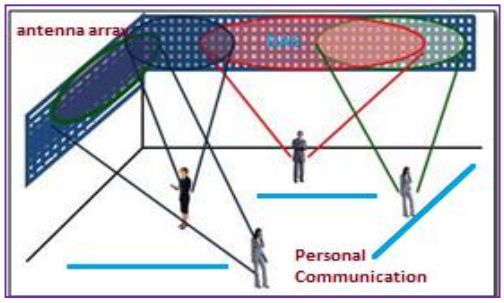

Fig.2: Personal Communication using wall Antenna Array

5G Technology stands for 5th Generation Mobile Technology (5GMT). 5G technology has changed to use mobile phones within very high spectrum bandwidth. 5G is a packet switched wireless system with wide area coverage and high throughput. 5G will create an important difference and will add more services and benefits to the wireless world over 3G and 4G services [5-8]. It will be more advanced that will interconnect the entire world in the form of worldwide wireless web. 5G technology will provide very high data rates over high band widths that the customers have never experienced before. In figure (2), personal communication has been shown with the help of DSA. 5G technologies use CDMA and millimeter waves (mmw) with data speed greater than 100Mbps at full mobility and higher than1Gbps at low mobility. The 5G technologies include all types of advanced features which make 5G technology most powerful and in huge demand in the near future. Small wireless devices such as sensors, nodes, access points will be integrated with the help of 5G technology.

II. ARCHITECTURE OF 5G WIRELESS COMMUNICATION TECHNOLOGIES

The basic architecture of fifth generation wireless communication is shown in this figure (3). To meet challenges and 5G system requirements, there is a need of remarkable changes in the design of cellular architecture.

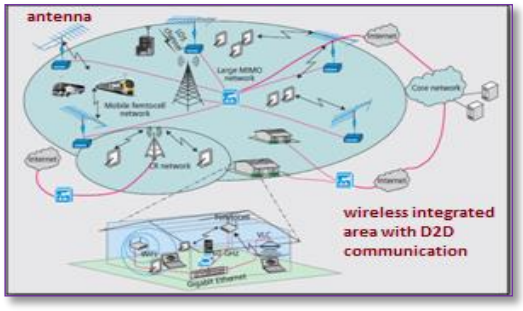

Fig.3: Infrastructure of 5G Technology

The conventional cellular architecture normally uses an outdoor base station (BS) in the middle of a cell communicating with mobile users. For indoor applications, customers communicating with the outdoor BS, the signals have to go through building walls, and this causes very high penetration loss, which significantly damages the data rate, spectral efficiency, and energy efficiency of wireless transmissions for medium to large ranges.

5G mobile and wireless architecture separates the outdoor and indoor scenarios so that penetration loss through building walls can somehow be avoided. It is assisted with the help of distributed antenna system (DAS) and MIMO technology [9], where geographically distributed antenna arrays are deployed. The current MIMO systems utilize two to four antenna arrays to improve the overall gain and efficiency of the system. Outdoor BSs will be equipped with large antenna arrays with some antenna elements distributed around the cell and connected to the BS via optical fibers, implemented both with DAS and MIMO technologies.

Outdoor mobile and wireless users are normally equipped with limited numbers of antenna elements, but they can collaborate with each other to form a virtual large antenna array, which together with BS antenna arrays will construct virtual MIMO links [4-6, 7]. Large antenna arrays will also be installed outside of every building to communicate with outdoor BSs or distributed antenna elements of BSs, possibly with line of sight (LoS) components. Large antenna arrays have cables connected to the wireless access points inside the building communicating with indoor users. This will certainly increase the infrastructure cost in the short term while significantly improving the cell average throughput, spectral efficiency, energy efficiency shown in figure (4), and data rate of the cellular system in the long run.

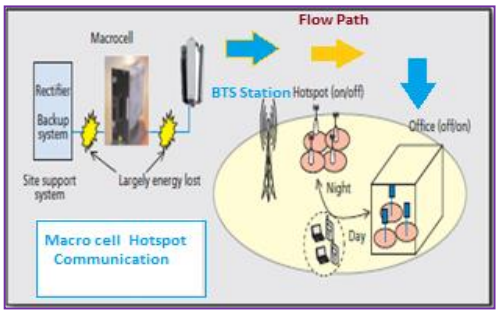

Fig.4: Energy Savings for Hot-Spot Mobile Communication

Using such a cellular architecture (5G), as indoor users only need to communicate with indoor wireless access points (not outdoor BSs) with large antenna arrays installed outside buildings, many technologies can be utilized that are suitable for short-range communications with high data rates. Some examples include wifi, femto cell, ultra wideband (UWB), mm-wave communications (up to 300 GHz) [7,9], and visible light

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spectrum communications (VLSC) (400-490 THz).The 5G cellular architecture should also be a diverse one, with macro cells, microcells, small cells and relays. To accommodate high mobility users such as users in vehicles and high speed trains femto cells are deployed.

The design of 5G wireless systems should take into account minimizing the energy consumption in order to achieve green wireless communication systems [5]. Wireless system operators around the world should aim to achieve such energy consumption reductions, which consequently contribute to the reduction of emissions of various toxic gases such as CO_2 and CO. The indoor communication technologies are promising deployment strategies to get better energy efficiency. This is because of the favorable channel conditions they can offer between the transmitters and receivers. Moreover, by separating indoor traffic from outdoor traffic, the marcocell BS will have less pressure in allocating radio resources and can transmit with low power, resulting in a significant reduction in energy consumption [10]. VLC and mm-wave technologies can also be considered as energy efficient wireless communication solutions to be deployed in 5G [11] wireless systems.

III. FEATURES OF 5G TECHNOLOGY FOR COMMUNICATION SERVICES

The latest features and advantages of 5G technology are listed below:

- 5G technology offer high resolution for crazy cell phone user and bi-directional large bandwidth shaping.
- The advanced billing interfaces of 5G technology makes it more attractive and effective.
- 5G technology also providing subscriber supervision tools for fast action.
- The high quality services of 5G technology based on Policy to avoid error.
- 5G technology is providing large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- 5G technology offer transporter class gateway with unparalleled consistency.
- The traffic statistics by 5G technology makes it more accurate.
- Through remote management offered by 5G technology a user can get better and fast solution.
- The remote diagnostics also a great feature of 5G technology.
- The 5G technology is providing up to 25 Mbps connectivity speed.
- The 5G technology also support virtual private network.
- The new 5G technology will take all delivery service out of business prospect
- The uploading and downloading speed of 5G technology touching the peak.
- The 5G technology network offering enhanced and available connectivity just about the world.

IV. FUTURE CHALLENGES FOR 5G TECHNOLOGY FOR COMMUNICATION

Every growing communication technology has number of benefits, advantages and disadvantages. With the invention of new developments and trends in 5G communication technologies, there are many challenges still ahead. For a complete and reliable infrastructure of 5G wireless systems, optimal performance metrics should be considered. These may include spectral efficiency, energy efficiency, delay, reliability, fairness of users, QoS, implementation complexity etc. Other challenges for 5G include realistic channel models with proper accuracy complexity trade-off are essential for some 5G platforms, such as massive MIMO channels and high-mobility channels (e.g., high-speed train channels and vehicle to vehicle channels). Conventional MIMO channel models cannot be directly applied to massive MIMO channels in which different antennas may observe different sets of clusters for communication.

One other technical challenge in developing MIMO systems for 5G mobile and wireless communication system is the complexity of signal processing. As transmit and receive signals are quite lengthy, the search algorithms must be performed over many possible configurations of system. Another major issue is the interference-tolerant in 5G. It is related to reliably and practically management of the mutual interference of the components of the communication system. In addition to these issues, energy consumption shall be decreased significantly in 5G system. But it is impossible in the current framework and distributive base stations. But it is possible to reduce power by off loading majority of data traffic to local small or micro cells. Another issue is spectrum problem. For 2G/3G and even 4G, most allocated spectrums are mainly below 3 GHz. In addition, the spectrum usage reaches almost the maximum efficiency. A new work item should be established to seek new potential spectrum for the future terrestrial mobile and wireless communication. It seems that the new available spectrum for the future generation is mainly above 3GHz or even higher. Those spectrums will be suitable for local scenarios to improve capacity rather than for a macro scenario to improve coverage.

V. CONCLUSIONS

The future traffic development brings new requirements and challenges to future mobile and wireless communication systems, including higher traffic rate, hotspot traffic, traffic asymmetry, and spectrum, energy and cost efficiency. Technologies are thus needed, including local IMT small cells, MIMO, energy saving strategy and flexible spectrum usage. The development of 5G is influenced significantly by industrial scale and smooth evolution of the mobile and wireless system

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environment. DAS and MIMO technology has been used inside 5G infrastructures. Strong communication technologies such as Wi-Fi, femto cell, VLC, and mm-wave communication technologies, can be seen as promising candidates to provide high quality and high data rate services under full reliable conditions. Some important issues have been discussed in this review paper, which may be improved for providing better mobile and wireless communication services.

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