A NEW WAVE OF DIGITAL TECHNOLOGY– 5G AND BEYOND

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ABSTRACT

In this paper, the authors have made an attempt to review various aspects of 5th Generation of mobile wireless technology. The paper throws light vision on 5G, its complex performance requirement, the research priorities in 5G and a discussion on the latest ongoing researches and project on 5G. The authors have paid more attention towards finding the major problems encountered in mobile communication and have also tried to draft out a possible solution for them. Effective reviews are discussed to increase the efficiency of mobile channel with the increase in number of mobile users with leaps and bound. The aim of this paper is to put forward the recent researches going on in the wake of developing a new technology named 5G in mobile communication.

Keywords: LE3S, Radio Access Technology, Interference Handing, Visible Light Communication, Spectrum Packing, Spectrum Crunch.

I. INTRODUCTION

Mobile communication has evolved significantly from early voice systems to today's highly sophisticated integrated communication platforms that provide numerous services and support countless applications used by billions of people around the world. The rapid growth of mobile communication and equally massive advances in technology are moving technology evolution and the world toward a fully connected networked society – where access to information and data sharing are possible anywhere, anytime, by anyone or anything. Next-generation mobile communication systems will become commercially available around 2020. [1].To make this possible, a significant amount of research is ongoing all over the globe. Recent studies and extrapolations from past developments predict a total traffic increase by a factor of 500 to 1000 within the next decade. These figures assume approximately a 10 times increase in broadband mobile subscribers and 50–100 times higher traffic per user. Besides the overall traffic, the achievable throughput per user has to be increased significantly [2].A rough estimation predicts a minimum 10 times increase in average, as well as in peak data rate. High lighting these factors, this paper deals with the essential design criteria, which have to be fulfilled more efficiently in today's systems, the coverage area, latency to reduce response time, and better support for a multitude of Quality of Service (QOS) requirements originating from different services. An emerging factor in the overall design of next generation systems is the energy efficiency of the network components and its deployment.

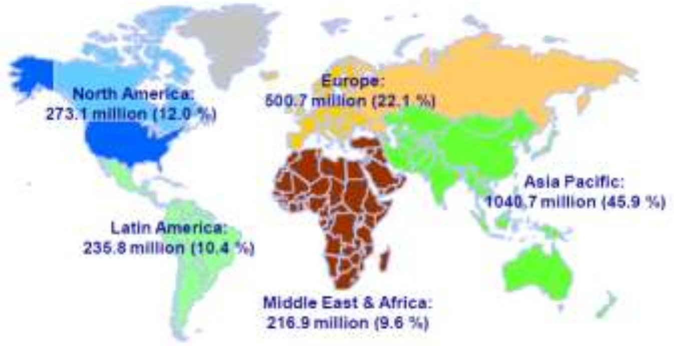

Fig.1 Worldwide Internet Audience

The environmental impact by reducing the CO_2 emissions is essential for the ecosystem. Moreover, increased energy efficiency of the network reduces operational expenses, which is reflected in the cost per bit.5G wireless networks will support 1,000-fold gains in capacity, connections for at least 100 billion devices, and a 10 GB/s individual user experience capable of extremely low latency and response times. Deployment of these networks will emerge between 2020 and 2030 which is reflected in the 3rd section of this paper. 5G (5th generation mobile networks or 5th generation wireless systems) denotes the next major phase of mobile telecommunications standards beyond the current 4G/IMT Advanced standards[9].5G radio access will be built upon both new radio access technologies (RAT),ICT networks and evolved existing wireless technologies (LTE, HSPA, M2M, OFDM, GSM and Wi-Fi). Ultra broadband and intelligent-pipe network features that achieve near instantaneous, “zero distance” connectivity between people and connected machines. These measures are being emphasized in the research priorities and ongoing projects.

In the paper, section II focuses on vision 5G and beyond and the requirements for future wireless systems are also discussed in this section. Section III discusses about research priorities such as network topologies, air interface technology. In section IV, a brief review of the current research projects is given. Finally, section V concludes the paper.

II. VISION 5G & PERFORMANCE REQUIREMENTS

This section of the paper focuses on the various aspects of framework which are suggested for future network research in the field of wireless communication. For future wireless communication low Latency, Energy efficiency, Spectral efficiency, Scalability and Stability (LE3S) is required. The following research topics are considered as essential for sustainability and Growth under LE3S:-

a. New networking technologies must be developed to ensure high information integrity, ultra-reliable ubiquitous connectivity with guaranteed network and service reliability and availability of more than five 9’s, and resilience to potential cyber security threats[11].

b. New research is needed to increase fibre capacity to >100 Tb/s in the core, >10 Tb/s in the metro and 1 Tb/s in the access / backhaul network and to provide a dynamic software and control environment around this.

c. Data, trust, privacy and content delivery need further research in order to ensure that they meet the needs of users.

Fig.2 Technology & Standards Evolution

d. Built on a vision of massive machine-type connectivity, with tens of billions of low-cost connected devices and sensors deployed, the Networked Society requires the mass-availability of low-cost devices. These devices not only need to be affordable, they also need to be able to operate on battery for several years without needing to be re-charged – implying strict requirements for low energy consumption along with sustainable development (green technology).The major requirements for next generation wireless communication are:

1. 5G rainbow requirements

- Peak data rate (>50gbps)
- Cell edge data rate (1000 mbps)
- Cell spectral efficiency (10bps/Hz)
- Mobility (1000 km/hr.)
- Cost efficiency – 1000x bit/dollar (50 times more than 4g)
- Simultaneous connection (10^4/km^2)
- Latency (< 5 m sec)

2. Network

- Higher capacity
- Energy & cost efficiency
- Ease of deployment & operation
- Robustness

3. User experience

- Higher user data rates
- Lower latency
- Mobility
- QoS, QoE

4. Future proofness- flexibility for evolution

5. Enablers for public security- support of Device-to-Device communication

6. Enablers for internet of things

- Support of more connected devices
- With a wide range of traffic patterns

- High reliability

III. RESEARCH PRIORITIES

In this section, authors have tried to approximate researches in different fields of communication according to their possible priorities.

IV. NEW WIRELESS NETWORK TOPOLOGIES

On a network topology level, the solutions to the problem of spectrum are denser node deployments and enhanced coordination. However these require advancements in several other areas to make this feasible both technologically and economically:

4.1 Multilayer Multi Radio Access Technology Networks

Due to both economic constraints and the availability of sites, the future networks will need use multi radio access technology (RAT).They will become more heterogeneous in terms of: transmit power, antenna configuration, supported frequency bands, transmission bandwidths, and duplex arrangements. The radio-network architectures of the nodes will change from base stations to systems with different degrees of centralized processing, depending on the available backhaul technology [10].

4.2 Radio Access Resource Sharing

The reduced distance between antenna clusters will boost capacity and reduce total radiated power and thus energy consumption. Exploitation of cloud technologies, resource sharing and virtualization are key enabling technologies to serve higher traffic at lower cost. These technologies are, however, still in their infancy, needing many refinements to reach a stable status for deployment.

V. NEW AIR INTERFACE TECHNOLOGIES

The air interface is the foundation of any wireless-communication infrastructure. The properties of different air-interface protocol layers (physical layer, MAC layer, retransmission protocols, etc.), and their operation are very important for the quality-of-service, spectral and energy efficiency, robustness, and flexibility of the entire wireless system. Some important air interface technologies are given below

5.1 Basic Transmission Technologies

Orthogonal Frequency Division Multiplexing (OFDM) is the transmission technology used in the most recently developed wireless technologies[4].Being a type of *multi-carrier* transmission scheme, OFDM provides a low-complexity means to handle, and even take advantage of, radio channel frequency-selectivity, due to the small sub-carrier spacing and the possibility for scheduling in the frequency domain.

5.2 Advanced Multi-Antenna Transmission/ Reception

The use of multiple antennas at the transmission and receiver side is an important way of greatly enhancing the efficiency and robustness of the air interface, much can still be done to fully exploit all its potential, both on link and system level. This includes more robust multi-antenna transmission, as well as extending the capabilities of the multi-antenna transmission schemes to provide efficient and flexible multi-user multiplexing. A more advance step is to extend current multi-antenna schemes, consisting of just a few antenna ports at each transmitter/receiver node, towards massive multi-antenna configurations, consisting of several hundred antenna ports.

5.3 Advanced Interference Handing

The main problem faced by link performance in mobile broadband systems is interference from other nodes of the system. In all systems of today (apart from simple repeaters), such interference is handled by separation of transmission and reception either in frequency (frequency division duplex) or in time (time division duplex).If the interference of the transmitted signal could be suppressed by other means, such as advanced receiver processing and specific antenna configurations.

5.4 Visible Light Communications

Due to scarcity of radio spectrum, visible light communication has become a subject of great interest for researchers. White LEDs are expected to replace the conventional lighting sources, particularly as efficiency of these devices is continuously improving. White LEDs are a good source of illumination; they can be modulated with high-speed data, resulting in visible light optical links. There is more than 300 THz of bandwidth readily available in such optical channels. Moreover, optical transceivers are typically simple, inexpensive and low power. For indoor scenarios, optical downlinks are possible where information is confined within the room. Furthermore, as no radio waves are used, no interference to other equipment is created.

VI. OTHER TECHNOLOGICAL ADVANCEMENTS

The Capacity and coverage have been continuously enhanced for many years, but never match completely the increasing demands. To continue the process of improvement and innovation with respect to these wireless networking characteristics, many key enabling technologies are available, but there are still many issues unsolved and require in-depth investigation before they can be deployed.

6.1 Radio Access Network Operation

The tendency in radio network management is to allow system optimization at local level as much as possible. As small cells will have a more important role in the future and optical fibre backhaul is becoming more feasible to deploy, the system architectures based on local centralized clusters of small cells become of interest for global optimization of the cluster operation.

6.2 Energy Efficient Operation

In an intelligent future wireless network, the service plane should be intelligent enough to use the least amount of radio resources and energy as possible and utilize the maximum allowed latency as much as possible. This is important from both energy efficiency and quality of experience (QOE) points of view. Furthermore, availability of ample spectrum allows transmitting data with lower spectral but higher energy efficiency.

6.3 Inter Layer Network Optimization

The future wireless communication networks must provide a large range of services, including voice, data and streamed multimedia at reasonable cost and QOS, comparable to competing wire-line technology. This increased demand may lead to a need for employing new network topologies, such as multi-hop wireless networks,

6.4 Cognitive Radio Technology

Cognitive radio technology, also known as smart-radio allowing different radio technologies to share the same spectrum efficiently by adaptively finding unused spectrum and adapting the transmission scheme to the requirements of the technologies currently sharing the spectrum. This dynamic radio resource management is achieved in a distributed fashion, and relies on software-defined radio.

6.5 Massive Distributed MIMO

The fundamental problem in designing the complex network systems is the derivation of a network control mechanism, comprising flow control, routing, scheduling and physical resources management that can provide QOS guarantees and ensure the network stability under a large set of service demands. Massive Dense Networks also known as Massive Distributed MIMO providing green flexible small cells 5G Green Dense Small Cells. A transmission point equipped with a very large number of antennas that simultaneously serve multiple users. With massive MIMO multiple messages for several terminals can be transmitted on the same time-frequency resource, maximizing beam forming gain while minimizing interference.

6.6 Multi-Hop Networks

A major issue in beyond 5G systems is to make the high bit rates available in a larger portion of the cell, especially to users in an exposed position in between several base stations. [1]In current research, this issue is addressed by cellular repeaters and macro-diversity techniques, also known as group cooperative relay, where also users could be potential cooperative nodes thanks to the use of direct device-to-device (D2D) communications.

VII. VARIOUS RESEARCH ACTIVITIES

This section presents various research programmes undertaken by different countries:

1. In 2008, the South Korean IT R&D program of "5G mobile communication systems based on beam division multiple access and relays with group cooperation" was formed.

2. In 2012 the UK Government announced the setting up of a 5G Innovation Centre at the University of Surrey – the world's first research Centre set up specifically for 5G mobile research.

3. In 2012, NYU WIRELESS was established as a multi-disciplinary research center, with a focus on 5G wireless research as well as in the medical and computer science fields. The center is funded by the National Science Foundation and a board of 10 major wireless companies (as of July 2014) who serve on the Industrial Affiliates board of the center (www.nyuwireless.com). [6]NYU WIRELESS has conducted and published some of the world's first channel measurements that show that millimeter wave frequencies will be viable for multi-Gigabit per second data rates for future 5G networks, and shares its extensive propagation database with the industrial affiliate sponsors of its research center. NYU WIRELESS hosted the first Brooklyn 5G Summit (B5GS) held on its Brooklyn, NY campus on April 24-25, 2014, where global leaders working on 5G provided thoughts and early results. The B5GS is an annual event that will be held in April, to bring together the research and technology leaders who are working on 5G [7].

4. In Europe, Neelie Kroes, the European Commissioner, committed in 2013 50 million euros for research to deliver 5G mobile technology by 2020. In particular, the METIS 2020 Project is driven by a car manufacturer and several telecommunications companies and aims at reaching world-wide consensus on the future global mobile and wireless communications system. The METIS overall technical goal is to provide a system concept that supports 1000 time higher mobile system spectral efficiency as compared with current LTE deployments [8]. In addition, in 2013 another project has been started, called 5GrEEn, linked to project METIS and focusing on the design of Green 5G Mobile networks.

5. The world's first extensive radio propagation and channel models for millimeter wave wireless communications may be found in IEEE papers: "Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!" in IEEE Access, Vol. 1, May 2013; "Broadband Millimeter-Wave Propagation Measurements and Models Using Adaptive-Beam Antennas for Outdoor Urban Cellular Communications, in IEEE Trans. Antennas and Propagation, April 2013, and many other peer-reviewed conference and journal papers by NYU WIRELESS students and faculty.

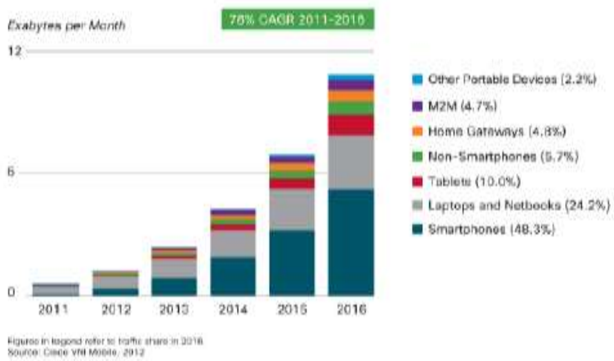

Fig.3 Update Data Traffic for Different Devices

VI. CONCLUSION

This paper deals with the essential design criteria, which have to be fulfilled more efficiently in today's systems, such as coverage area, latency to reduce response time and better support for Quality of Service (QOS) requirements originating from different services .The aim of this paper is to put forward the recent researches going on in the current technological scenario.

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