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A Survey on 5G-Drivers and Technology

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ABSTRACT: Wireless communication network & technologies are pushed to limits by growth in demands for mobile wireless communication, where technologies are driven by applications. Wireless system designers are facing problems with increasing demand for high data rates & mobility required by new wireless applications and thereby research is carried on 5th generation wireless system.4G system have issues such as spectrum crisis & high energy consumption due to wireless mobile devices & services. Main purpose of 5G is to design best wireless world free from limitations & hindrance of previous generations. This paper presents drivers behind 5G evolution, architecture & technologies that are backbone for 5G transition beyond 2020.

KEYWORDS: Dynamic Adhoc Wireless Network, HSPDA, HSOPA, Latency, MIMO, SDN,WCDMA

I.INTRODUCTION

Wireless communication evolved since early 1970's, in past decades wireless technology evolved from 1G to 4G. Cellular generation differs in four aspects such as radio access, data rates, bandwidth and switching schemes.

Fifth generation(5G) technology offers high bandwidth never before provided by any other technology. 5G aims at designing & developing technologies, system and networks that are feasible and dynamically operating upto1Tbit/s. 5G offers more than 4G in terms of network coverage, faster download time & HD-video streaming.

5G deliver improvement over 4G speed& other functionalities so as to satisfy increasing user expectations of quality of experience.5G radio access built upon both new radio access technologies & existing wireless technologies such as LTE, HSPA, GSM and Wi-Fi.

Due to explosion of mobile devices & services with large network capacity, high spectral efficiency, energy efficiency & mobility required by wireless applications 4G is not sufficient to accommodate issues and hence research is carried on 5G wireless technologies.

There are two views of 5G systems: evolutionary and revolutionary. In the evolutionary view the 5G (or beyond 4G) systems will be capable of supporting the www allowing a highly flexible network such as a Dynamic Adhoc Wireless Network (*DAWN*). In this view, advanced technologies including intelligent antenna and flexible modulation are keys to optimize the adhoc wireless networks. In revolutionary view 5G systems would be an intelligent technology capable of interconnecting the entire world without limits

II. PREVIOUS GENERATIONS

First Generation System:

First commercially automated cellular network was launched in Japan by Nippon Telegraph & Telephone in 1979. First generation network launched in USA was Chicago based Ameritech in 1983 using Motorola Dyna TAC mobile phone. First generation was pioneered for voice services, all services were analog system using frequency modulation technique for radio transmission using FDMA with channel capacity ranging from 10-30 KHz and frequency band 824-894 MHz. The need for improved transmission quality, higher system capacity, better system coverage, security and spectral efficiency paved way towards second cellular system.

Second Generation System:

2G network was launched on Global System Mobile Communication (GSM) in 1991. 2G introduced data services for mobile short message services (SMS) text messages, picture messages & multi-media messages (MMS). 2G system operates in 2 phases firstly, offers data rates upto 9.6Kbps and increased upto 300Kbps in second phase with bandwidth of 200 KHz. Two modulation schemes used are TDMA & CDMA. GSM technology use 8 channels per carrier with data rate of 22.8Kbps & frame of 4.6millisecond duration.

Third Generation System:

3G system includes web base access, multi-media services, email & video conference offers data rate upto 2Mbps over 5MHz channel width depending on mobility and spectrum efficiency. This technology makes use of wide band code division multiple access (WCDMA), high speed downlink packet multiple access (HSPDA) and high speed OFDM packet access (HSOPA). HSOPA uses OFDM and MIMO antenna technology and supports upto 10 timers as WCDMA base system and lower processing power.

Fourth Generation System:

4G provides mobile broad band internet access to laptops with wireless modems, smart phones and other devices. 4G supports up to 1Gbps foe low mobility and 100Mbps for high mobility such as mobile access.

III.NEED FOR 5G

5G enhance system performance, new capabilities and applications for mobile connectivity, home automation, smart transportation, security. To overcome explosive growth in video traffic, shortage of spectrum, need to reduce energy requirements of web devices and network infrastructure with higher data rates 5G is essential.

Performance requirements for mobile services which are needed to implement 5G are listed below:

- Latency ranging from one millisecond to a few seconds.
- Signaling loads varying from less than 1% to approximately 100%.
- 1000x bandwidth per unit area.
- Duty cycles ranging from few milliseconds to entire days.

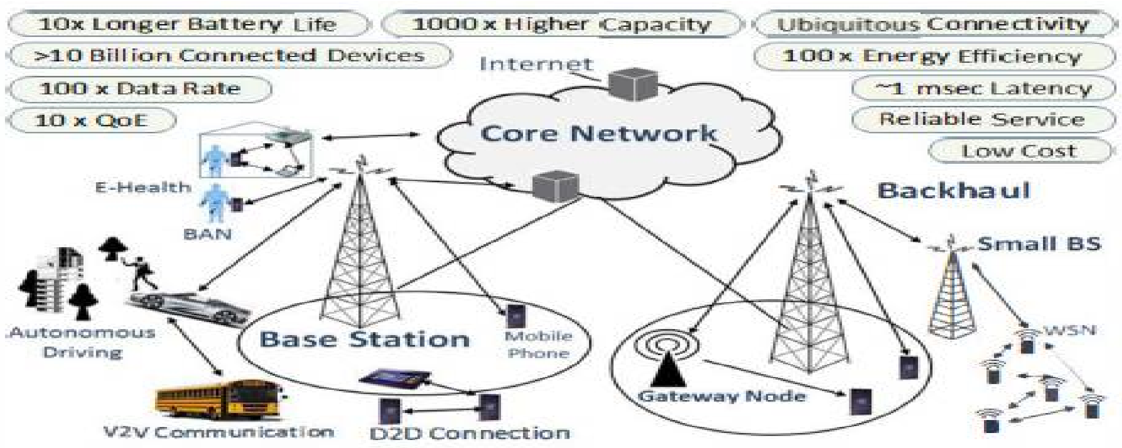

Fig 1: 5G performance requirements

Requirement for 5G network are below:

- Data rates: Data rates of at least 1 Gb/s or more that support ultra high definition video and virtual reality applications.
- Zero distance connectivity: For supporting mobile cloud services data rates of the order of 10 Gb/s are required.
- Massive capacity: 1000 fold gains in capacity. Currently mobile network systems are supporting approximately 5 billion users, which will expand to several billions of applications and machines.
- Zero latency and response time: Real time mobile control, vehicular applications and communications etc require a latency of less than a millisecond.
- Zero-second switching: Switching time of maximum 10 milliseconds amongst different radio access technologies to provide uninterrupted services.
- Energy efficiency: Improving battery life by reducing energy-per-bit usage by a factor of 1000.

IV. KEY DRIVERS FOR 5G

Ultra high throughput, network capacity, ultra low latency, ubiquitous connectivity, energy efficiency, high reliability, low cost devices and quality of experience are the vision for driving the 5G technology.

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Broadband Mobile with Higher Throughput:

Huge growth of data traffic volume is one of the main drivers behind 5G and the annual 25-50% growth of data rate is expected to increase by 2030. Due to the ever-increasing needs for higher capacity, mobile wireless communication with ultra wide bandwidth will be the key motivation behind 5G evolution. 5G networks will transfer data much faster than today's 4G LTE-A and a major increase in speeds will help in applications like ultra-fast HD-video streaming and instant app update.

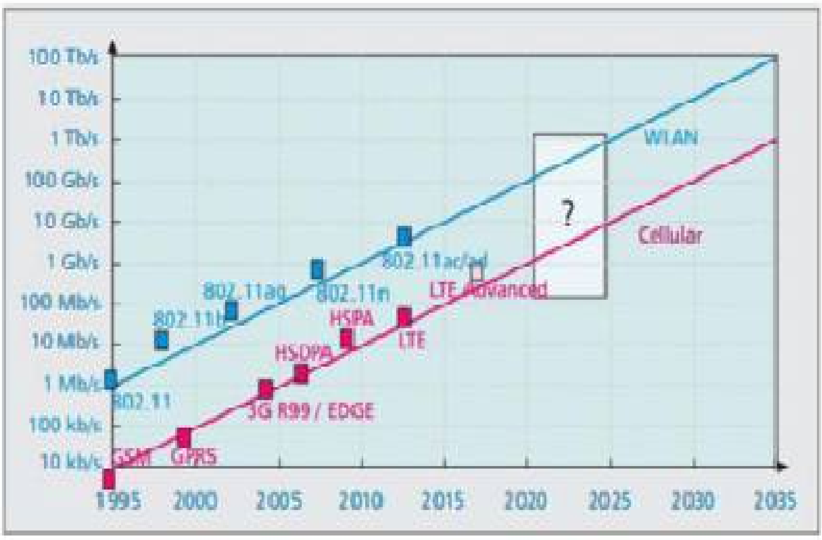

Fig 2: Growth of data rate till 2030

Spectrum impact:

Freeing up additional spectrum along-with flexible and efficient utilization of non-contiguous spectrum is a major requirement. Cloud architecture and Software Defined Networking will ensure that programmable air interface and spectrum map service requirements to optimum combinations of frequency and radio resources.

Multiple access and advanced waveform:

Developments in coding and modulation algorithms are a prerequisite for betterment of spectral efficiency. This will also account for the much needed scalability for Internet of Things and lower the access latency.

Evolution of IoT and M2M:

Internet of Things (loT) proliferation calls for wireless network densification and provides justification for transition to 5G. Prediction of tens of billions of IoT and machine to machine (M2M) devices is presenting a unique set of demands from wireless network service. Smart city/home, smart grid, smart vehicle, e-health, emerging wearables, wireless industry and logistics are some of the important drivers for 5G.Distributed sensor networks will be remotely controlled to monitor decentralized distribution and consumption of energy. Smart city and smart grid type of applications will work with low- data rate and low-power sensors, but will need efficient, reliable and low-cost environments. Vehicular industry is another important driver for 5G connected vehicles, remotely controlled and self-driven automobiles requires ultra-low latency and highly-reliable wireless communications between infrastructures, human entities and automobiles using dense networks and intelligent sensing nodes.With the implementation of M2M and loTs, wireless communication is connecting an extensively large number of devices in real time requiring highly-reliable communication link with low latency and high efficiency.

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Baseband and RF architecture:

Adaptive air interfaces and techniques such as mass scale MIMO demand innovations in baseband and RF architecture. Designs for combining a large number of antenna and RF radio elements will be required.

V. Enabling Technologies 5G

The evolution from 4G to 5G has not been standardized yet, and industrial and academic have not reach a consensus on the ultimate 5G technologies and how to combine these technologies appropriately. There are some emerging and promising technologies, aiming at significantly improving date rates, realizing green communication and perfect user experience, attract much attention. Moreover, the breakthroughs brought by 5G are not limited to this the explosive growth of mobile traffic data communication implies that the fusion of mobile communication and data transmission will become the mainstream. These technologies can generally be classified into two groups.

1. Network architecture
2. Air interface characteristics

1. Network Architecture:

Device to Device Communication:

Device-to-Device (D2D) communication communicate directly while remaining controlled under marco base stations, emerges as a promising technology to improve local spectral efficiency and reduce connecting latency. Firstly, since D2D link reuse cellular frequency resource which causes inter-cell interference. Secondly, net gain achieved by D2D imposes limitations of communication environment, the subtle condition of D2D mode triggering and switching should be determined. Thirdly, building a direct D2D link requires peer discovery and a series of physical layer procedures, which generate extra overheads.
5G system-level simulation made in the following aspects:

- Interference Calculation:the introduction of D2D communication changes frequency duplex structure in traditional 4G network, interference brought by D2D links should be taken into consideration.
- Resource Scheduling:new resource scheduling schemes need to be carried out mitigating inter-cell interference caused by D2D links.
- Peer Discovery:the detailed process of D2D pairs discovery considering real user mobility and distributed management should be added appropriately.
- Extra Physical Layer Procedures:channel information of D2D links acquisition requires multiple physical layer procedures like channel estimation and channel feedback.

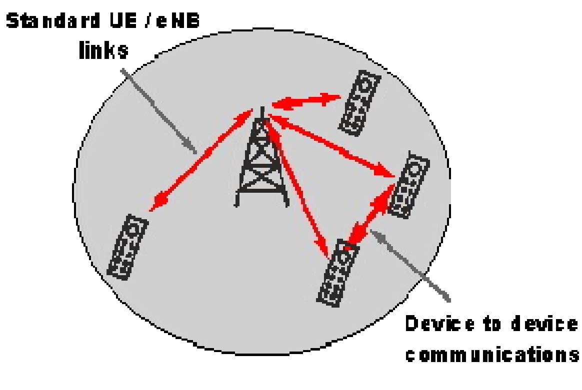

Fig 3: Device to device communication

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Software Defined Network:

The concept of Software Defined Networking (SDN) is originated by Open Flow(2008) of Stanford University, where network data plane and control plane are isolated through function abstraction With separable control planes and data planes, network management can be simplified and previously unavailable services and configurations can be introduced conveniently. In this way, the future network can realize dynamic flexible topology control and afford programming ability to deal with ``big data," which is the necessary trend in future communication networks. Although academic and industrial groups have not arrived consensus about the definition of SDN, according to Open Networking Foundation (ONF), SDN is expected to be programmable, open source and flexible. Applying SDN into mobile wireless communication systems can simplify the management of network for commercial operators and endorse the exponentially increasing data flow in foreseen 5G. SDN brought to provide a fusion of network, data, computation for future networks, communication systems with SDN presentrelevant challenges. Firstly how to strike a balance between system performance and flexibile through-optimal programmability switch strategy. Secondly the complexity of standardization and interoperability on the way of transform traditional network to SDN model.

2. *Air Interface Characteristic:*

Massive MIMO:

Key concept behind MMIMO is exploitation of directivity of spatial signatures of user links allowing crosswise interference nulling Similar to MIMO technology 10 years ago many technical challenges have to be tackled for successful early prototyping and proof-of-concept including a wide range of systemic issues. These aspects include tight synchronization of analog front-ends to support stable spatial nulling, integration of antennas elements together with power amplifiers, LNAs, diplex-filters, efficient channel estimation for high number of antennas TDD vs. FDD, full-duplex transmission to avoid diplexers, efficient group antenna selection for hybrid beamforming, frequency dependency and hardware impairments measurement and compensation. Finally form factor and cost efficiency determine the feasibility of prototyping complex MMIMO systems.

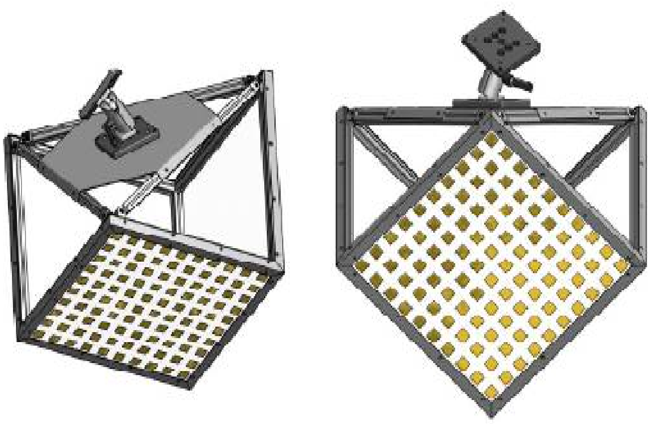

Fig 4: Massive MIMO antenna

Fig.4 shows a MMIMO antenna array example designed for the 3.6 GHz band. The antenna cube with 8x8 active antenna arrays on 3 sides is to be used for densely populated areas with moving user clouds like e.g. train stations, shopping malls. Each 8x8 antenna patch array is currently being assembled and uses 8 RF-radio units one for each 8-antenna column.

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Full Duplex Communication:

In an FD communication scheme, an FD transceiver is capable of transmitting and receiving on the same frequency at the same time. FD communication has the potential to double the spectral efficiency at the physical layer through the removal of a separate frequency band/time slot for both uplink and downlink transmission. FD technology can also solve problems in existing wireless networks such as hidden terminals, loss of throughput due to congestion and large end to end delays FD communication schemes can reduce the latency by simultaneously receiving feedback signals (i.e., channel state information (CSI), ARQ/ACK control signalling, etc.) from the receiver during transmission. FD communication also enables a wireless node such as a BS to perform RF energy transfer while receiving uplink transmissions from UE.One possible approach to minimize SI in FD radios is to combine the antenna cancellation, RF interference cancellation, and digital interference cancellation techniques For a particular wavelength l, two transmit antennas are placed at d and l/2 + d away from the receive antenna. Hence, by offsetting the two transmitters by half a wavelength, we can let the signals add destructively. As a result, the receiver antenna receives a much weaker signal (e.g., less self-interference) compared with any one of the local transmit signals. After performing the antenna cancellation, the RF interference cancellation and the digital interference cancellation techniques can be employed to further decrease the SI. In the RF interference cancellation technique, a noise canceler chip can remove a known analog interference signal from a received signal. Since the transmitted symbols are already known, a coherent detection mechanism is used in the digital interference cancellation phase to reconstruct the signal.

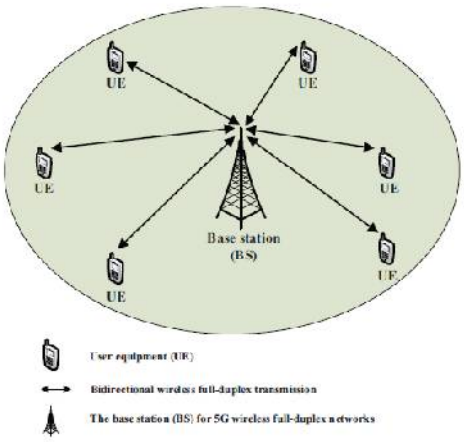

Fig 5: Full duplex communication

For a multi-user channel-sharing situation, in addition to intra-cell interference (among the users in a cell), there are inter-cell downlink-to-uplink interference and inter-cell inter-user uplink-to-downlink interference.

VI. CONCLUSION

We have provided an overview of several emerging technologies for 5G cellular wireless networks. Some of the open research problems have been outlined, including those related to testing and measurement of 5G systems. In addition to the technologies discussed above, technologies such as mm-wave and massive-MIMO will also impact the design and development of 5G networks. Future 5G cellular wireless networks will definitely be a combination of different enabling technologies. However, the biggest challenge will be to integrate all of the enabling technologies and make them all work together

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