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# PROMISING TECHNOLOGIES INTENDED FOR 5G WIRELESS NETWORKS: A REVIEW

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**ABSTRACT- After 4G, there is an increasing interest in technologies that will define the next generation (5G) technologies standard. In this paper we will describe several emerging technologies which will change and tells the future generation of telecom standards. 5G denotes the next major phase of mobile telecommunications standards beyond the current 4G/IMT-Advanced standards. 5G has speed beyond what the current 4G can offer. This paper identifies several emerging technologies which will change and define the future generations of telecommunication standards. Some of these technologies are already making their way into standards such as 3GPP LTE, while others are still in development.**

**KEYWORDS- Mobile Communication, Multiple-Input/Multiple-Output, Cellular Networks, Long Term Evolution, Multiple Access, Heterogeneous Network.**

## I. Introduction

The mobile phone has evolved rapidly over the past decade from a monochrome device with a minuscule screen and little processing power to one with high resolution, palm sized screen and processing power rivaling a laptop. A mobile phone combines technologies, mainly telephone, radio and computer. Long Term Evolution(LTE) and its extension, LTE-Advanced, as practical representative of 4G systems. However, the numbers of users are increasing day by day who subscribe the mobile broadband services every year, leading to the exponential growing of mobile data. However, the continuously increasing demand for higher data rates, larger network capacity, higher spectral and energy efficiency, and ubiquitous mobility required by new applications are putting more pressure to the data operator. Thus, a new generation of mobile communications, the fifth generation (5G) becomes indispensable. The ubiquitous goal of 5G is to achieve up to 100 times higher user data rates such that in dense urban environments the typical user data rate will range from 1 to 10 Gb/s.

## II. Generations of Mobile Phone

0G which is known as Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are sometimes retroactively referred to as pre cellular systems. Technologies used in pre cellular systems included the Push to talk or mobile telephone system.

1G refers the first generation of wireless telephone technology. These are the analog telecommunication standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The basic difference between 1G and 2G is that the radio signal used by 1G networks are analog, while 2G networks are digital. 2G cellular telecom networks (second generation) were commercially launched on the GSM standard in Finland in 1991. The benefit of 2G over 1G is that it provides services such as text messages, picture messages and MMS. 3G is the third generation of mobile telecommunications technology. 3G finds applications in wireless voice telephony, mobile internet access, fixed wireless internet access, video calls and mobile TV. 3.5G is a grouping of disparate mobile telephony and data technologies designed to provide better performance than 3G system the technology includes: high-speed Downlink Packet Access, Evolved HSPA, 3GPP Long Term Evolution, precursor of LTE Advanced. 4G provides, in addition to the usual voice and other services of 3G, mobile broadband internet access. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television and cloud computing. 4.5G is a grouping of disparate mobile telephony and data technologies designed to provide better performance than 4G systems. The technology includes: LTE Advanced and MIMO. 5G denotes the next major phase of mobile telecommunications standards beyond the current 4G/IMT-Advanced standards. Next generation mobile network alliance defines 5G networks requirements as: data rates of several tens of Mb/s should be supported foe tens of thousands of users. 1Gbits/s is offered, simultaneously to tens of workers on the same office floor. Several hundreds of thousands simultaneous connections are supported for massive sensor deployments. Spectral efficiency should be significantly enhanced compared to 4G. Latency should be significantly reduced compared to LTE.

**Comparison**

| Technology / Features | 1G | 2/2.5G | 3G | 4G | 5G |
|---|---|---|---|---|---|
| Start/ Deployment | 1970/ 1984 | 1980/ 1999 | 1990/ 2002 | 2000/ 2010 | 2010/ 2015 |
| Data Bandwidth | 2 kbps | 14.4-64 kbps | 2 Mbps | 200 Mbps to 1 Gbps for low mobility | 1 Gbps and higher |
| Standards | AMPS | 2G: TDMA, CDMA, GSM 2.5G: GPRS, EDGE,1xRTT | WCDMA, CDMA-2000 | Single unified standard | Single unified standard |
| Technology | Analog cellular technology | Digital cellular technology | Broad bandwidth CDMA, IP technology | Unified IP and seamless combination of broadband, LAN/WAN/ | Unified IP and seamless combination of broadband, |

## III.Heterogeneous Networks

Heterogeneous network is a network connecting computers and the other devices with different operating system or protocols. For example LAN that connects Microsoft windows and LINUX based personal computers with Apple MAC INTOSH computers are heterogeneous. The heterogeneous networks in wireless communication are that network which provide a service through Wireless LAN and is able to maintain the service when switching to a cellular network.

### A. Small Cells

One of the solutions available to operate when the demand for higher data rates increases is to reduce the size of the cell. By doing so, we can increase area, spectral efficiency through higher frequency use while transmit power can be reduced such that the power lost through propagation will be lower. By deploying, small cells indoors where reception may not be good, coverage can be improved. In the recent years with the advancement in hardware miniaturization and corresponding reduction in cost this solution has been made possible.

Additionally, changes to the functional architecture of the access network allowed data and control signals to tunnel through the internet, enabling small cell to be deployed anywhere with internet connectivity. Small cell can have different flavors with low powered femtocells which is typically used in residential and enterprise deployments. Higher powered picocells are used for wider outdoor coverage.

### B. New Carrier Type

One of the key concepts underpinning the operation of enhanced small cell is the separation of the control plane and user plan. The connectivity and mobility is provided by the control plane while the data transportation is provided by the user plane. The user equipment will maintain connection with two different base stations that is a macro and small cell simultaneously. The macrocells will maintain connectivity and mobility using lower frequency band, while the small cells provides high throughput data transport using higher frequency bands. This can be illustrated through Fig. 1.

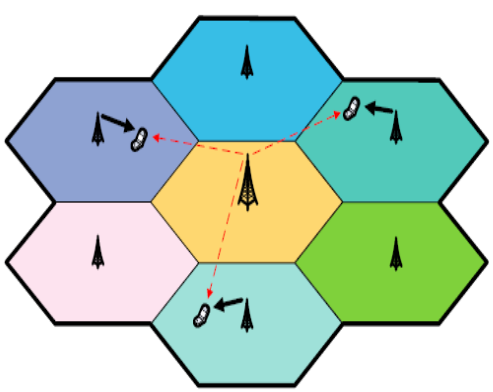

Fig.1 Separation of control planes and user planes

Splitting of uplink and downlink across different classes of base station is an alternative version. In the current 3GPP standard, cell specific reference signals are always transmitted regardless of whether there is data to transmit or not, and the transmitter cannot be switched off even when there is no data to transmit.

### C. Multiple Radio Access Technologies

Although the 3GPP define heterogeneous networks as the concurrent operation of different classes of base stations, we consider that heterogeneous networks in 5G will be a mixture of different radio access technologies as well. This will include future Wireless Local Area Network (WLAN) technologies which can offer seamless handovers to and from the cellular infrastructure, and device to device communications. This will lighten the burden on cellular networks and shift load away from the treasured licensed bands. At the same time, it can also concurrently provide higher throughput to users. This can already be implemented in part using the 3GPP Access Network Discovery and Selection Function (ANDSF).

### D. Device to Device Communication

Another solution for the highly dense network problem will be through device to device communication. Where, each terminal is able to communicate directly with other terminals in order to either share their radio access connection, or to exchange information. Coupled with power control, D2D communications can reduce interference, especially in non-licensed frequency bands.

In 4G cellular communications, there are no provisions made for devices to communicate directly with nearby devices. All communications will have to be routed through the base station, and the gateway. In scenarios such as machine to machine (M2M) communications, where the number of devices involved can potentially be very large, it would be more sensible if devices can communicate directly with each other when necessary.

## IV. Software Defined Cellular Networks

Software Defined Networking (SDN) has gathered momentum in the networking industry in the past few years. The concept of SDN originates from Stanford University's Open Flow system, which enables abstraction of low level networking functionality into virtual services. In this way, the network control plane can be decoupled from the network data plane, which significantly simplifies network management and facilitates the easy introduction of new services or configuration changes into the network. Currently in both academia and industry, a clear definition of SDN is still lacking. Nevertheless, according to standardization body of SDN, Open Networking Foundation (ONF), the SDN architecture (as shown in Figure 2)

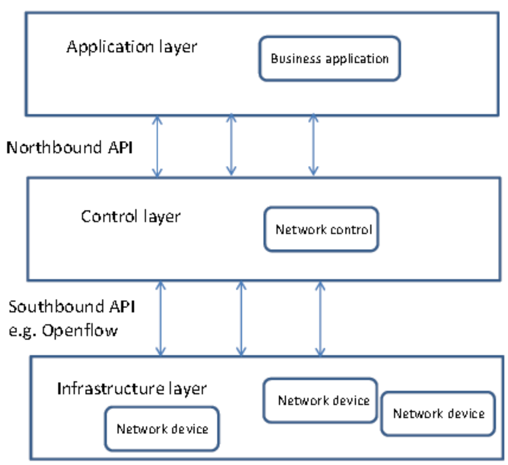


Fig.2 The SDN architecture

SDN has the following features:

• **Directly programmable:** the network control plane is logically centralized and decoupled from the data plane. Network intelligence resides in software-based SDN controllers that maintain a global view of the network.

• **Open:** SDN simplifies network design and operation via open standards-based and vendor-neutral APIs (northbound and southbound).

• **Agile:** Network operators can dynamically configure, manage, and optimize network resources and adjust traffic flows to meet changing needs quickly via dynamic and automated SDN programs.

In present, there is a growing interest in both academia and industry to apply SDN to mobile networks. The main aim behind this is to simplify network management system and enable new services to support the exponential traffic growth envisaged for 5G networks. SDN can separate the network service from the underlying physical infrastructure, thereby moving towards a more open wireless ecosystem and facilitating fast innovation. Similarly, in wired SDN programmable switches are used with programmable base stations and packet gateways. However, we imagine the future possibility in cellular SDN architectures with extensions such as network virtualization on subscriber attributes and flexible adaptation of air interfaces. Now, we believe that wireless or cellular SDN could be a possibility in near future of wireless network.

## V. Massive Mimo And 3D Mimo

Another technology which is being considered is the use of a large array of antenna elements, several orders more than the number in use today, to provide diversity and compensate for path loss is known as Massive Multiple-Input/Multiple-Output (MIMO), it also allows for high resolution beam forming and is especially useful at higher frequencies where antenna elements can be miniaturized.

Massive MIMO can purportedly increase the capacity by several orders and simultaneously improve the radiated energy-efficiency. In addition, it provides large number of degrees of freedom, which can be exploited using beam forming if the channel state information is available. Another advantage of Massive MIMO is its energy efficiency, and each antenna element is expected to use extremely low power

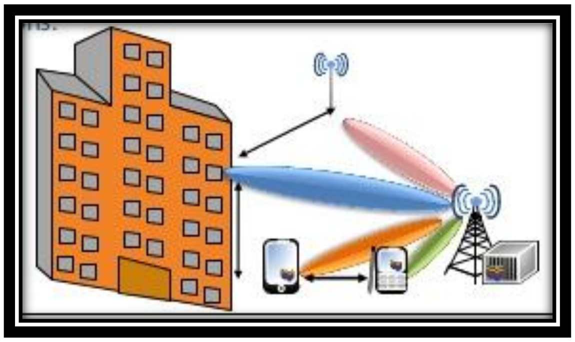

Fig.3 3D MIMO Beam Separations

Another interesting technique currently considered is 3D MIMO, which allows for 3D beam forming. This is sometimes considered as a special type of large scale MIMO which is only concerned with using the antenna elements for beam forming. While normal beam forming methods form beams in two dimensions, 3D MIMO allows beam control in both horizontal and vertical directions. This additional control allows for further sectorization within a cell. An example of sectorization created by 3D MIMO is shown in Figure 3. As with Massive MIMO, 3D MIMO requires new channel models. Currently, 3GPP has started a work item on modeling 3D channels. 3D MIMO will also require additional modifications to the feedback mechanism. Massive MIMO is composed of many inexpensive low power antenna components that are used to increase throughput and channel efficiency. As shown in the figure the 3D MIMO produce separate beams on three dimensions at the same time. It covers the Multiuser MIMO.

## VI. Other Technology

Apart from the above technologies and applications, the following technologies can also potentially impact 5G.

### A. Millimeter Wave

An obvious way of increasing the throughput will be through bandwidth expansion. However, the available bandwidth below 6 GHz is limited, and re-farming analogue TV spectrum will not sufficiently meet the burgeoning demand. Already, there are efforts to look beyond 6 GHz and also at the millimeter wave frequencies to evaluate their feasibility for use in future networks. However, the characteristics of higher frequencies are not well studied, and measurement campaigns and channel modeling for different scenarios and environments will be required before transmission technologies can be designed for them. We believe that millimeter wave frequencies hold the most promise, and there are already on-going efforts to make this a possibility. In millimeter wave frequencies of 28 GHz and 38 GHz are extensively studied to understand their propagation characteristics in different environments, paving the way for their use in future wireless systems.

### B. Shared Spectral

Although cognitive radio was often touted as a solution to the problem of frequency spectrum shortage, it is seldom adopted as there are always concerns about the impact on the primary user or license holder of the spectrum. An alternative solution proposed which can potentially solve this dilemma is Authorized Spectrum Access (ASA) also known as Licensed Spectrum Access (LSA) [17]. The concept of LSA is to allow authorized users to access licensed spectrum based on certain conditions set by the licensee of the spectrum. This would allow under-utilized spectrum to be more effectively used and also solve the problem of quality of service for the primary user.

### C. Big Data

Big data will also bring about lots of challenges and opportunities in 5G wireless like in many other market sectors and industries. First of all, cellular networks have to provide efficient infrastructure support for this data deluge. For example, Internet of Things (IOT) applications will generate a vast amount of data. This proves to be a major technical challenge for RANs. Secondly, new network architectures may emerge from the necessity of running big data applications. There is close synergy between cloud computing, software defined networking, and Network Function Virtualization (NFV).

**D. Indoor Positioning**

While indoor positioning itself does not improve throughput or coverage, it has large implications on various applications and the quality of communications. Accurate positioning of user terminals can provide the network with additional information that can help in resource allocation and quality of service improvement. It can also enable a plethora of applications, including position based handover, resource allocation, and location based services.

Currently, 3GPP LTE has several positioning methods, including Cell ID (CID) and Enhanced Cell ID (ECID), as well as Assisted Global Navigational Satellite Systems (A-GNSS). It is also able to position using the Observed Time Difference of Arrival (OTDOA) method. All these are enabled through the Enhanced Serving Mobile Location Centre (E-SMLC) using the LTE Positioning Protocol (LPP) [18]. Accuracy improvements to the currently available methods will certainly open opportunities for more location based applications.

## VII. Challenges

A. Challenges of Heterogeneous Networks

1) Inter-cell Interference

One of the biggest problems for Het Nets is inter-cell interference. This is especially problematic with unplanned deployment of small cells, where the operators have little or no control of the location of the small cell. Additionally, the concurrent operation of small cells and traditional macro cells will produce irregular shaped cell sizes, and hence inter-tier interference, which will require advanced power control and resource allocation to avoid inter-cell interference.

2) Distributed Interference Coordination

In deployment of access points where there are little or no coordination, such as between WLANs, distributed interference avoidance will be required. This will be increasingly crucial as more devices access unlicensed spectrum to complement their throughput.

3) Efficient Medium Control

This is particularly relevant for dense deployment of access points and user terminals where the medium access is distributed, such as that of WLANs. In such situations, the user throughput is low, latency is high, and hotspots will not be able to complement cellular technology to provide a high throughput. Existing medium access control will need to be redesigned for such an environment to optimize the channel usage.

4) Millimeter Wave

In non-network assisted device discovery in D2D communications, there could be issues when there are a large number of devices around. Additionally, setting up and maintain links with more than one party can prove to be difficult, especially when operating in the same frequency.

**B. Challenges of Massive/3D MIMO**

1) Channel Estimation/Feedback

Currently, only time division duplexing scenarios are considered for massive MIMO due to the prohibitive cost of channel estimation and feedback. Even for time division duplexing to work, channel calibration for Massive MIMO can prove to be a feat. New methods of channel estimation and feedback schemes will need to be proposed for massive MIMO to achieve mainstream status.

2) Fast Processing Algorithms

To deal with the massive amount of data from the RF chains, extremely fast algorithms to process these data will be required.

3) Pilot Contamination

Massive MIMO suffers from pilot contamination from other cells. Work around for this will be required for Massive MIMO to deliver its promised performance.

## VIII. Conclusions

In this paper we have discussed some emerging technologies in 5G wireless networks and also discussed some other technologies with their applications. We have also described some research problems which these technologies present.

While there is currently no clear consensus among academics and industrials on what will define 5G wireless networks, we believe that future 5G wireless networks will be a combination of different enabling technologies, and the biggest challenge will be to make them all work together.

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