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A survey on multiple access technologies beyond fourth generation wireless communication system

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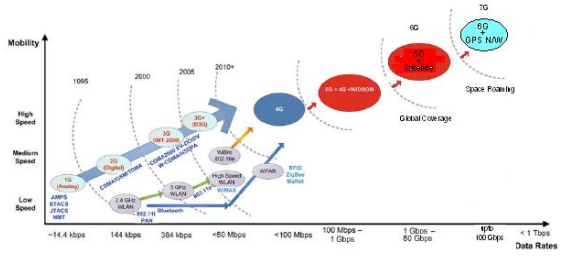
Abstract
The future of mobile wireless communication networks will include existing 3rd generation, 4th generation 5th generation,6th generation (with very high data rates Quality of Service (QoS) and service applications) and 7th generation (with space roaming). Mobile and wireless networks have made tremendous growth in the last fifteen years. The rapid improvement of the mobile generations was for the purpose of supporting as many mobile devices as possible that could benefit the users at anytime and anywhere in terms of common practical applications such as internet access, video-on-demand, video conferencing system and many more applications. This paper is focused on the specifications of future generations and latest technologies to be used in future wireless mobile communication networks like MIMO, OFDM, OFDMA, Massive MIMO, LTE, LTE-A.

Keywords: *TDMA, FDMA, TDD, FDD, MIMO, MU MIMO, Massive MIMO, LTE, LTE-A*

I. Introduction

Wireless mobile communication networks have been experienced four generations of change. In this research work,we present the detail survey of the different generations of the mobile communication networks. First Generation (1G) mobile phone networks were the earliest cellular systems to develop, and they relied on a network of distributed transceivers to communicate with the mobile phones. Second Generation (2G) mobile telephone networks were the logical next stage in the development of wireless systems after 1G, and they introduced for the first time a mobile phone system that used purely digital technology. Third Generation (3G) mobile telephone networks are the latest stage in the development of wireless communications technology. Significant features of3G systems are that they support much higher data transmission rates and offer increased capacity, which makesthem suitable for high-speed data applications as well as for the traditional voice calls. Fourth Generation (4G) is known as beyond 3G, stands as an acronym for Fourth-Generation Communications System. It is used to describe the next step in wireless communications. A 4G system will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an anytime, anywhere" basis, and at higher data rates than previous generations. Mobile devices together with the intelligence that will be embedded in human environments - home, office, public places - will create a new platform that enables ubiquitous sensing, computing, storage and communication. Core requirements for this kind of ubiquitous ambient intelligence are that the devices are autonomous and robust. They can be deployed easily and require little maintenance. Mobile device will be the gateways to personally access ambient intelligence and needed information. Mobile also implies limited size and restrictions on the power consumption. Seamless connectivity with other devices and fixed networks is a crucial enabler for ambient intelligence system - this leads to requirements for increased data-rates of the wireless links. Intelligence, sensing, context awareness and increased data-rates require more memory and computing power, which together with the size limitations leads to severe challenges in thermal management. All the above requirements can be addressed satisfactorily with the application of OFDM, CDMA-2000, WCDMA/UMTS, TD-SCDMA, Wi-Fi (i.e. Wireless LAN) networks with fixed internet to support wireless mobile internet as the same quality of service as fixed internet, which is an evolution not only to move beyond the limitations and problems of 3G, but also to enhance the quality of services, to increase the bandwidth and to reduce the cost of the resource, 5G based on cognitive radio, 6G (to integrate satellites for getting global coverage) andnanotechnology [1]. 4G mobile systems will mainly be characterized by a horizontal communication model, where such different access technologies as cellular, cordless, wireless LAN type systems, short-range wireless connectivity, and wired systems will be combined on a common platform to complement each other in the best

possible way for different service requirements and radio environments [2]. The 5th wireless mobile multimedia internet networks can be completed wireless communication without limitation, which bring us perfect real world wireless – World Wide Wireless Web (WWWW). 5G is based on 4G technologies, which is to be revolution to 5G. During this processing, there are two kind of problems need to be solved. The first is wider coverage and the second is freedom of movement from one technology to another. The 6th generation (6G) wireless mobile communication networks shall integrate satellites to get global coverage. The global coverage systems have been developed by four courtiers. The global position system (GPS) is developed by USA. The COMPASS system is developed by China. The Galileo system is developed by EU, and the GLONASS system is developed by Russia [3]. These independent systems are difficulty for space roaming. The task of 7th generation (7G) wireless mobile communication networks are going to unite the four systems to get space roaming.



II. Brief Discussion about 1G,2G and 3G

2.1 first generation (1G)

The first generation wireless mobile communication system is not digital technology, but analog cellular telephonesystem which was used for voice service only during the early 1980s [4]. This Advanced Mobile Phone System (AMPS) was a frequency modulated analog mobile radio system using Frequency Division Multiple Access(FDMA) with 30kHz channels occupying the 824MHz −894MHz frequency band and a first commercial cellularsystem deployed until the early 1990's [5].

2.2 second generation(2G)

2G - Second Generation mobile telephone networks were the logical next stage in the development of wireless systems after 1G, and they introduced for the first time a mobile phone system that used purely digital technology. The demands placed on the networks, particularly in the densely populated areas within cities, meant that increasingly sophisticated methods had to be employed to handle the large number of calls, and so avoid the risks of interference and dropped calls at handoffs. Although many of the principle involved in a 1Gsystem also apply to 2G - they both use the same cell structure - there are also differences in the way that the signals are handled, and the 1G network are not capable of providing the more advanced features of the 2G systems, such as caller identity and text messaging.

2.5G: In term "2.5G" usually describes a 2G cellular system combined with General Packet Radio Services (GPRS), or other services not generally found in 2G or 1G networks. A 2.5G system may make use of 2G system infrastructure, but it implements a packet-switched network domain in addition to a circuit-switched domain. It can support data rate up to 144kbps.GPRS, EDGE, & CDMA 2000 were the focal 2.5G technologies. This does not necessarily give 2.5G an advantage over 2G in terms of network speed, because bundling of timeslots is also used for circuit-switched data services (HSCSD).

2.3 Third generation (3G)

3G - Third Generation mobile telephone networks are the latest stage in the development of wireless communications technology. Significant features of 3G systems are that they support much higher data transmission rates and offer increased capacity, which makes them suitable for high-speed data applications as well as for the traditional voice calls. In fact, 3G systems are designed to process data, and since voice signals are converted to digital data, these results in speech being dealt with in much the same way as any other form of data. ThirdGeneration systems use packet-switching technology, which is more efficient and faster than the traditional circuit-switched systems, but they do require a somewhat different infrastructure to the 2G systems. The benefits of higher data rates and greater bandwidth mean that 3G mobile phones can offer subscribers a wide range of data services, such as mobile Internet access and multimedia applications. Compared to earlier mobile phones a 3G handsetprovides many new features, and the possibilities for new services are almost limitless, including many popularapplications such as TV streaming, multimedia, videoconferencing, Web browsing, e-mail, paging, fax, andnavigational maps. 3G technologies make use of TDMA and CDMA.3G (Third Generation Technology) technologies make use of value added services like mobile television, GPS (global positioning system) and video conferencing. The basic feature of 3G Technology is fast data transfer

rates. 3G technology is much flexible, because it is able to support the 5 major radio technologies. These radio technologies operate under CDMA,TDMA and FDMA.CDMA holds for IMT-DS (direct spread), IMT-MC (multi carrier). TDMA accounts for IMTTC (time code), IMT-SC (single carrier). FDMA has only one radio interface known as IMT-FC or frequency code. Third generation technology is really affordable due to the agreement of industry. This agreement took pace in order to increase its adoption by the users. 3G system is compatible to work with the 2G technologies. The aim of the 3G is to allow for more coverage and growth with minimum investment. There are many 3G technologies as W-CDMA, GSM EDGE, UMTS, DECT, Wi Max and CDMA 2000.Enhanced data rates for GSM evolution or EDGE is termed to as a backward digital technology, because it can operate with older devices. 3G has the following enhancements over 2.5G and previous networks: Enhanced audio and video streaming;

- Several Times higher data speed.
- Video-conferencing support.
- Web and WAP browsing at higher speeds.
- IPTV (TV through the Internet) support.

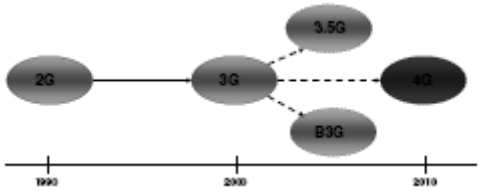
2.4 difference between 2.5G and 3G

Item	**2.5G**	**3G**
Speed	Up to 384 Kbps	Up to 2Mbps
Databases	HLR, VLR, EIR, AuC	Enhanced HLR, VLR, EIR, AuC
Core Network	Circuit and packet switching	Wide-area concept Circuit and packet switching
Technologies	HSCSD GPRS EDGE	WCDM, CDMA2000, TD-SCDMA
Applications	SMS, Internet	Internet, multimedia

2.5 COMPARISION BETWEEN 4 G AND 5G

Items	**4G**	**5G**
Speed	Up to 1 Gbps	Up to 1 Gbps on mobile
Services	Global Roaming	Global Roaming Smoothly
Core Network	Broadband, Entirely IP-based packet switching	Enhanced Broadband Entirely IP-based packet switching
Technologies	OFDM, MC-CDMA, LAS-CDMA, Network-LMPS	LAS-CDMA, OFDM, MC-CDMA, UWB, IPv6 Network-LMDS

III. Fourth generation revalution



- Higher bit rates than 3G and full mobility.
- Higher spectral efficiency and lower cost per bit than 3G
- Air Interface optimized for IP traffic.

Examples: OFDM, MIMO.

3.1 Technical Issues

1. High data rates- OFDM, MC-CDMA, Synchronization
& estimation, Distortion (linear, non-linear).
2. Coding- Iterative decodable codes (Turbo, LDPC)
3. Smart antenna systems
4. MIMO (Multi Input Multi Output) devices
5. Reconfigurable terminals (SW and HW)
6. Cognitive Radio

3.2 Reconfigurable Technology

Reconfigurable refers to the software re-definition and/or adaptation of every element within each layer of the communication chain.

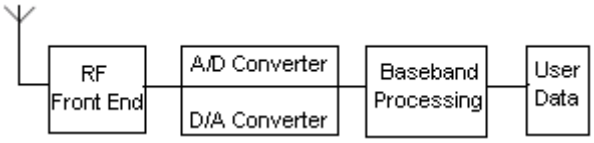


Fig .3 Software Driven Radio

3.3 OFDM

3G systems such as high speed packet access (HSPA) provide up to round 15-20 Mbps downlink and about 5-10 Mbps uplink. 4G systems are being designed to support 5 to 10 times these rates (i.e. downlink above 100 Mbps anduplink above 50 Mbps). OFDMA is based on orthogonal frequency division multiplexing. At first OFDM was usedinto fixed access WIMAX 802.16D to provide high speed internet access either as a replacement for other accesstechnologies like ADSL or cable, or to provide service in regions where the other access technologies where notdeployed.

The widespread interests of OFDM become clear from a glance at OFDM characteristics. In 802.11a, OFDM provides raw data rates up to 54 Mbits / s in a 20-MHz channel. In addition to supporting high data capacity and resisting degradation from various types of radio effects, OFDM makes highly efficient use of the availablespectrum. The latter characteristic will become crucial in coming years as wireless networks are built out.

OFDM Simple Architecture Overcomes - Noise, Signal to Noise Ratio Challenges, Multipath Fading, Adjacent Channel, Interference, Non-Adjacent Channel Interference OFDM also provides a frequency diversity gain, improving the physical layer performance. It is also compatible with other enhancement technologies such as smart antennas and MIMO. OFDM modulation can also be employed as a multiple access technology (OFDMA). In this case, each OFDM symbol can transmit information to/from several users using a different set of sub carriers (sub channels). This not only provides additional flexibility for resource allocation (increasing the capacity), but also enables cross layer optimization of radio link usage.

The idea of the complementation of IPv6, OFDM, MCCDMA, LAS-CDMA, UWB and Network-LMDS can be arranged in different zone size. IPv6 can be designed for running in the all area because it is basic protocol for address issue. LAS-CDMA can be designed for the global area as zone 1, world cell. OFDM and MC-CDMA can be designed for running in the wide area (Zone 3), called Macro cell. Network-LMDS is in Zone 2, Micro cell, and UWB is in Zone 1, Pico cell. MC-CDMA stands for Multi-Carrier Code Division Multiple Access, which is actually OFDM with a CDMA overlay LAS-CDMA Large Area Synchronized Code Division Multiple Access is developed by Link Air Communication, a patented 4G wireless technology. "LASCDMA enables high-speed data and increases voice capacity and the latest innovative solution.In 4G technologies, UWB *7 radio can help solve the multi-path fading issues by using very short electricalpulses to across all frequencies at once.

The Network-LMDS, Local Multipoint distribution system, is the broadband wireless technology used to carry voice, data, Internet and video services in 25GHz and higher spectrum.

3.4 Multiple-Input Multiple-Output

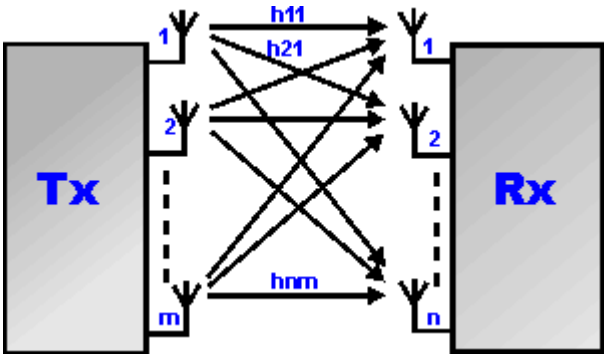
- MIMO: Multiple Input Multiple Output technology is uses multiple antennas to make use of reflected signals to provide gains in channel robustness and throughput.

Multiple-input multiple-output, or MIMO, is a radio communications technology or RF technology that is being mentioned and used in many new technologies these days.

Wi-Fi, LTE; Long Term Evolution, and many other radio, wireless and RF technologies are using the new MIMO wireless technology to provide increased link capacity and spectral efficiency combined with improved link reliability using what were previously seen as interference paths.
Even now many there are many MIMO wireless routers on the market, and as this RF technology is becoming more widespread, more MIMO routers and other items of wireless MIMO equipment will be seen.
As the technology is complex many engineers are asking what is MIMO and how does it work.
A channel may be affected by fading and this will impact the signal to noise ratio. In turn this will impact the error rate, assuming digital data is being transmitted. The principle of diversity is to provide the receiver with multiple versions of the same signal. If these can be made to be affected in different ways by the signal path, the probability that they will all be affected at the same time is considerably reduced. Accordingly, diversity helps to stabilise a link and improves performance, reducing error rate.
Several different diversity modes are available and provide a number of advantages:

- ***Time diversity:*** Using time diversity, a message may be transmitted at different times, e.g. using different timeslots and channel coding.
- ***Frequency diversity:*** This form of diversity uses different frequencies. It may be in the form of using different channels, or technologies such as spread spectrum / OFDM.
- ***Space diversity :*** Space diversity used in the broadest sense of the definition is used as the basis for MIMO. It uses antennas located in different positions to take advantage of the different radio paths that exist in a typical terrestrial environment.

MIMO is effectively a radio antenna technology as it uses multiple antennas at the transmitter and receiver to enable a variety of signal paths to carry the data, choosing separate paths for each antenna to enable multiple signal paths to be used.



One of the core ideas behind MIMO wireless systems space-time signal processing in which time (the natural dimension of digital communication data) is complemented with the spatial dimension inherent in the use of multiple spatially distributed antennas, i.e. the use of multiple antennas located at different points. Accordingly MIMO wireless systems can be viewed as a logical extension to the smart antennas that have been used for many years to improve wireless.
It is found between a transmitter and a receiver, the signal can take many paths. Additionally by moving the antennas even a small distance the paths used will change. The variety of paths available occurs as a result of the number of objects that appear to the side or even in the direct path between the transmitter and receiver. Previously these multiple paths only served to introduce interference. By using MIMO, these additional paths can be used to advantage. They can be used to provide additional robustness to the radio link by improving the signal to noise ratio, or by increasing the link data capacity.
The two main formats for MIMO are given below:

- ***Spatial diversity:*** Spatial diversity used in this narrower sense often refers to transmit and receive diversity. These two methodologies are used to provide improvements in the signal to noise ratio and they are characterised by improving the reliability of the system with respect to the various forms of fading.
- ***Spatial multiplexing :*** This form of MIMO is used to provide additional data capacity by utilising the different paths to carry additional traffic, i.e. increasing the data throughput capability.

As a result of the use multiple antennas, MIMO wireless technology is able to considerably increase the capacity of a given channel while still obeying Shannon's law. By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. This makes MIMO wireless technology one of the most important wireless techniques to be employed in recent years. As spectral bandwidth is becoming an ever more valuable commodity for

radio communications systems, techniques are needed to use the available bandwidth more effectively. MIMO wireless technology is one of these techniques.

4. 5G Based on Cognitive Radio

4.1 5G Concept

The twenty-first century is surely the "century of speed", and achieves a high evolution in all the possible domains,especially in communication: a very large variety of services, software, equipments, possibilities etc. But thishuge and colored offer also brings a complicated lifestyle and waste of time for the human beings, and needs to beintegrated and achievable in a simple manner. Therefore, a new technology started to be delineated, that will provide
all the possible applications, by using only one universal device, and interconnecting the already existing communication infrastructures—that is the fifth generation of the mobile communications standards—5G.

Both the cognitive radio (CR) and the fifth generation of cellular wireless standards (5G) are considered to be thefuture technologies: on one hand, CR offers the possibility to significantly increase the spectrum efficiency, by smart secondary users (CR users) using the free licensed users spectrum holes; on the other hand, the 5G implies thewhole wireless world interconnection (WISDOM— Wireless Innovative System for Dynamic Operating Megacommunications concept), together with very high data rates Quality of Service (QoS) service applications.

Cognitive Radios (CRs) integrate radio technology and networking technology to provide efficient use of radiospectrum, a natural resource, and advanced user services.

The idea of a cognitive radio extends the concepts of a hardware radio and a software defined radio (SDR) from asimple, single function device to a radio that senses and reacts to its operating environment.

A Cognitive Radio incorporates multiple sources of information, determines its current operating settings, andcollaborates with other cognitive radios in a wireless network. The promise of cognitive radios is improved useof spectrum resources, reduced engineering and planning time, and adaptation to current operating conditions. Somefeatures of cognitive radios include:

Sensing the current radio frequency spectrum environment: This includes measuring which frequencies are being used,when they are used, estimating the location of transmittersand receivers, and determining signal modulation. Resultsfrom sensing the environment would be used to determineradio settings.

Policy and configuration databases: Policies specifying how the radio can be operated and physical limitations ofradio operation can be included in the radio or accessed over the network. Policies might specify which frequenciescan be used in which locations. Configuration databases would describe the operating characteristics of the physicalradio. These databases would normally be used to constrain the operation of the radio to stay within regulatory orphysical limits.
Self-configuration: Radios may be assembled from several modules. For example, a radio frequency front-end, adigital signal processor, and a control processor. Each module should be self-describing and the radio shouldautomatically configure itself for operation from the available modules. Some might call this "plug-and-play."

Mission-oriented configuration: Software defined radios can meet a wide set of operational requirements.
Configuring a SDR to meet a given set of mission requirements is called mission oriented configuration. Typical mission requirements might include operation within buildings, substantial capacity, operation over longdistances, and operation while moving at high speed. Mission-oriented configuration involves selecting a set ofradio software modules from a library of modules and connecting them into an operational radio.

Adaptive algorithms: During radio operation, the cognitive radio is sensing its environment, adhering to policy andconfiguration constraints, and negotiating with peers to best utilize the radio spectrum and meet user demands.

Distributed collaboration: Cognitive radios will exchange current information on their local environment, userdemand, and radio performance between themselves on regular bases. Radios will use their local information andpeer information to determine their operating settings.
Security: Radios will join and leave wireless networks.

V. Benefit of Nanotechnology

Mobility also implies limited size and restriction on the power consumption. Seamless connectivity with otherdevices and fixed networks is a crucial enabler for ambient intelligence systems- this leads to requirements forincreased data rates of the wireless links. Intelligence, sensing, context awareness, and increased data rates requiremore memory and computing power, which together with the size limitations leads to severe challenges in thermalmanagement. [10], [11]All these requirements combined lead to a situation which can not be resolved with current technologies. Nanotechnology could provide solutions for sensing, actuation, radio, embedding intelligence into theenvironment, power efficient computing, memory, energy sources, human-machine interaction, materials, mechanics, manufacturing, and environmental issues [6].

VI. Hierarchical System

The vision of the "third generation" cellular system incorporates micro &pico cells for pedestrians use, withmacro cells for roaming mobiles. In order to increase the growing capacity demands of cellular mobilecommunication systems cell splitting will be applied and/or small pico cell will be established .Since bothmeasures can increase spectral efficiency. Hierarchical cellular networks have been suggested previously to overcome the inherent disadvantage of an increased no of handoffs, which both cell splitting and small pico cells,bring about. A critical question with respect to hierarchical cellular networks is how to divide the available radioresources (i.e. frequency, channels) among the macro and micro cells layers in a optimal way. Another importantaspect is the optimal choice of a threshold velocity above which users are assigned to the macro cell layer. Mostresearch in this area so far has dealt with those issues is a static way, assuming fixed traffic and mobility parameters.

First time in the year 2000, two adaptive algorithms are described, which control the threshold velocity as well asthe division of the resources among these layers, dynamically. The performance of those algorithms is evaluated by means of computer simulations [7].

6.1 Macro Cell

A conventional base station with 20W power and range is about 20 km to 30 km.

6.2 Micro Cell

A conventional base station with 5W power and range is about 1km to 5 km.

6.3 Pico Cell

The Pico cells are small versions of base stations, ranging in size from a laptop computer to a suitcase. Besidesplugging coverage holes, Pico cells are frequently used to add voice and data capacity, something that repeater anddistributed antenna can not do.Adding capacity in dense area, splitting cells are expensive, time consuming and occasionally impossible in denseurban environment where room for a full size base station often is expensive or unviable. Compact size Pico cellsmakes them a good fit for the places needing enhanced capacity, they can get.Picocells are designed to serve very small area such as part of a building, a street corner, malls, railway station etc.

These are used to extend coverage to indoor area where outdoor signals do not reach well or to add network capacity in areas with very dense uses.

VII. Conclusion

In this paper the survey of 1G to 4G, 5G and CR technologies have been presented & discussed. The important technologies required for achieving desired specifications were also discussed and finally roadmap for probable 5G, 6G and 7G networks have been proposed. 5G obtains the tool technology to interconnect and integrate all the wireless network types and thus gains the needed network infrastructure (CR network).

6G will integrate all wireless mobile networks with satellites to get global coverage. 7G wireless mobile networks are going to unite the four GPS systems available in space to get space roaming in addition to 6G systems.

However our complete attention is to enhance the quality of services, to increase the bandwidth and to reduce the

cost of the resource [8] along with reduction of RF pollution and power consumption.

The modified networks for 2G and 2.5G systems have been proposed to get the desired results. The addition of smart antenna in the system alone can increase spectral efficiency and quality of services manifold.

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