A PROJECT REPORT

ON

FOURTH GENERATION WIRELESS TECHNOLOGY (4G)

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1. INTRODUCTION TO WIRELESS SYSTEM

Wireless telecommunication history can be classified into different generations of network. Each generation has been a giant stride which revolutionized the field of mobile communication:

- ➔ First generation **(1G)** in 1980 where all the systems where based on analog radio signal technology. Voice was considered to be the main traffic, Various 1G standards defined were Advance Mobile Phone System(AMPS), Nordic Mobile Telephone (NMT), Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA).
- ➔ Second generation **(2G)** wireless communications systems, In 1990, 1G was replaced by 2G which provided rich set of services such as high voice quality and global mobility based on the digital radio signal technology. Here also voice was considered to be the main traffic, 2G includes standards such as Global System For Mobile Communications (GSM), General Packet Radio System (GPRS). Both 1G and 2G are based on circuit switched technology for data communication at low speed.2G was a huge success.
- ➔ **(2.5G)** which is an intermittent between 2G and 3G. It is based on both circuit switched and packet switched technologies providing high data rate with low power consumption. It uses the infrastructure of Global System for Mobile communications (GSM) and Code division multiple access (CDMA) to provide its making their appearance in late 2002 and in 2003, are designed for voice and paging services, as well as interactive media use such as teleconferencing, Internet access, and other services.
- ➔ Third generation **(3G)** In the present generation which includes standards from 2.5G to 3G and also some other technologies such as WiMAX (Worldwide Interoperability for Microwave Access). It is totally based on the packet switching technology providing broad range of high quality services to the end user to meet the demand of high data rate and increasing rate of network users. The problem with 3G wireless systems is bandwidth-these systems provide only WAN coverage ranging from 144 kbps (for vehicle mobility applications) to 2 Mbps (for indoor static applications).

➔ Segue to **4G** *(* Fourth generation of communication) the "next dimension " of wireless communication. The 4G wireless uses Orthogonal Frequency Division Multiplexing (OFDM), Ultra Wide Radio Band (UWB), and Millimeter wireless and smart antenna. Data rate of 20mbps is employed. Mobile speed will be up to 200km/hr. Frequency band is 2 - 8 GHz. it gives the ability for world wide roaming to access cell anywhere This idea was beyond the imagination of ordinary mobile user promising *"connect anytime, anyhow, anywhere"* .This ubiquitous network access will be achieved by seamlessly integrating the available and new networks using a core IP based network layer. This vision is called as the" **Magic Technology**"

Technology	1 G	2 G	3 G	4 G
Design began Implementation	1970 1984	1980 1991	1990 2002	2000 2010?
Service	Analog voice, Synchronous data to 9.6 Kbps.	Digital voice, short messages	Higher capacity, broad band data upto 2 Mbps.	Higher capacity, completely IP oriented, multimedia, data to hundreds of megabits
Data bandwidth	1.0 Kbps.	14.4 Kbps.	2 Mbps.	100 Mbps.
Multiplexing	FDMA	TDMA	CDMA	MC-(CDMA),MC-(TDMA) , OFDM

Figure (1): comparison between **(1G,2G,3G,4G)**

Generation	Standard	Multiple Access	Frequency Band	Throughput
2	GSM	TDMA/FDMA	890-960(MHz) 1710-1880(MHz)	9.6 Kbps
2.5	GPRS	TDMA/FDMA	890-960(MHz) 1710-1880(MHz)	171 Kbps
2.75	EDGE	TDMA/FDMA	890-960(MHz) 1710-1880(MHz)	384 Kbps
3	UMTS	WCDMA	1185-2025(MHz) 2110-2200(MHz)	2 Mbps
4	LTE	OFDMA/SC-FDMA	1920-1980(MHz) 2110-2170(MHz)	100 Mbps

Figure (2): different types of standards with frequency bands

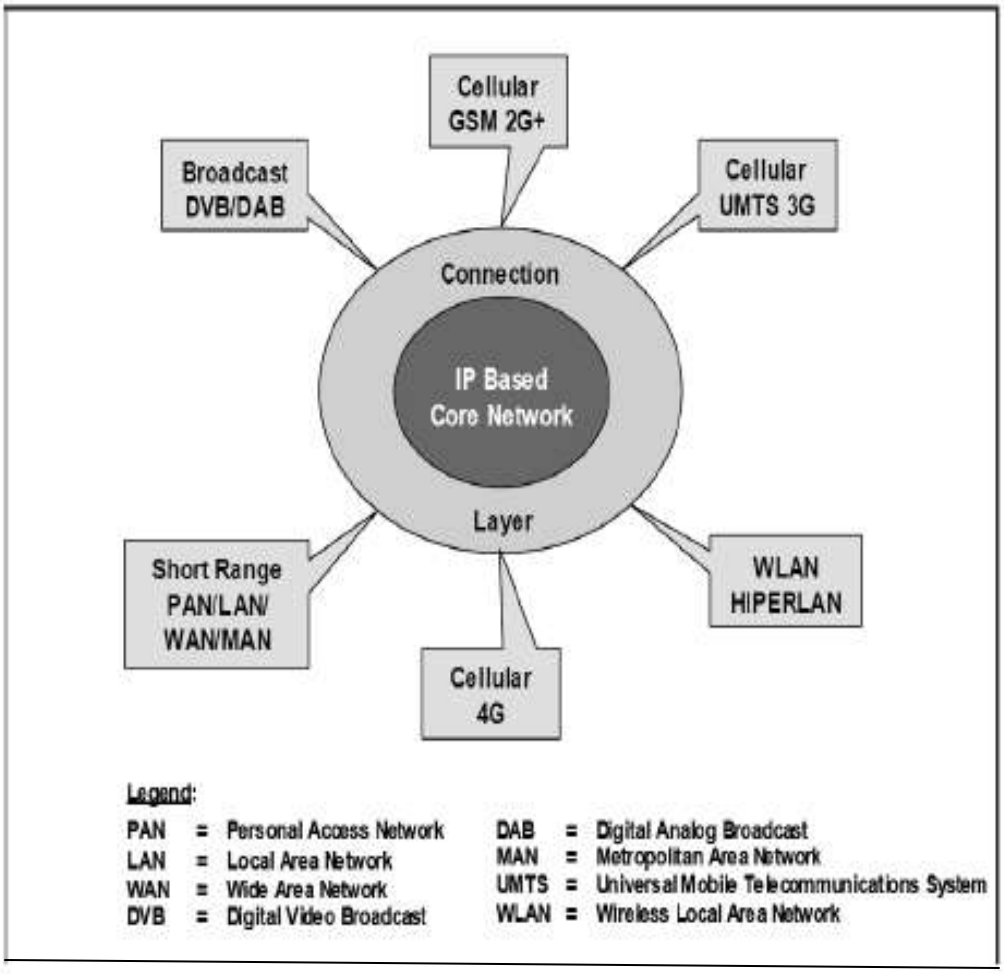
2. 4G EVOLUTION :

Known as Beyond 3G / Fourth Generation Technology

- MAGIC
  - Mobile multimedia
  - Anytime anywhere
  - Global mobility support
  - Integrated wireless solution
  - Customized personal service
- 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.
- 4G : Convergence of High Speed Internet & Mobility
- 3GPP is currently standardizing LTE Advanced as future 4G standard. LTE Advanced will be standardized as part of the Release 10 of the 3GPP specification this year.

3. 4G NETWORK ARCHITECTURE

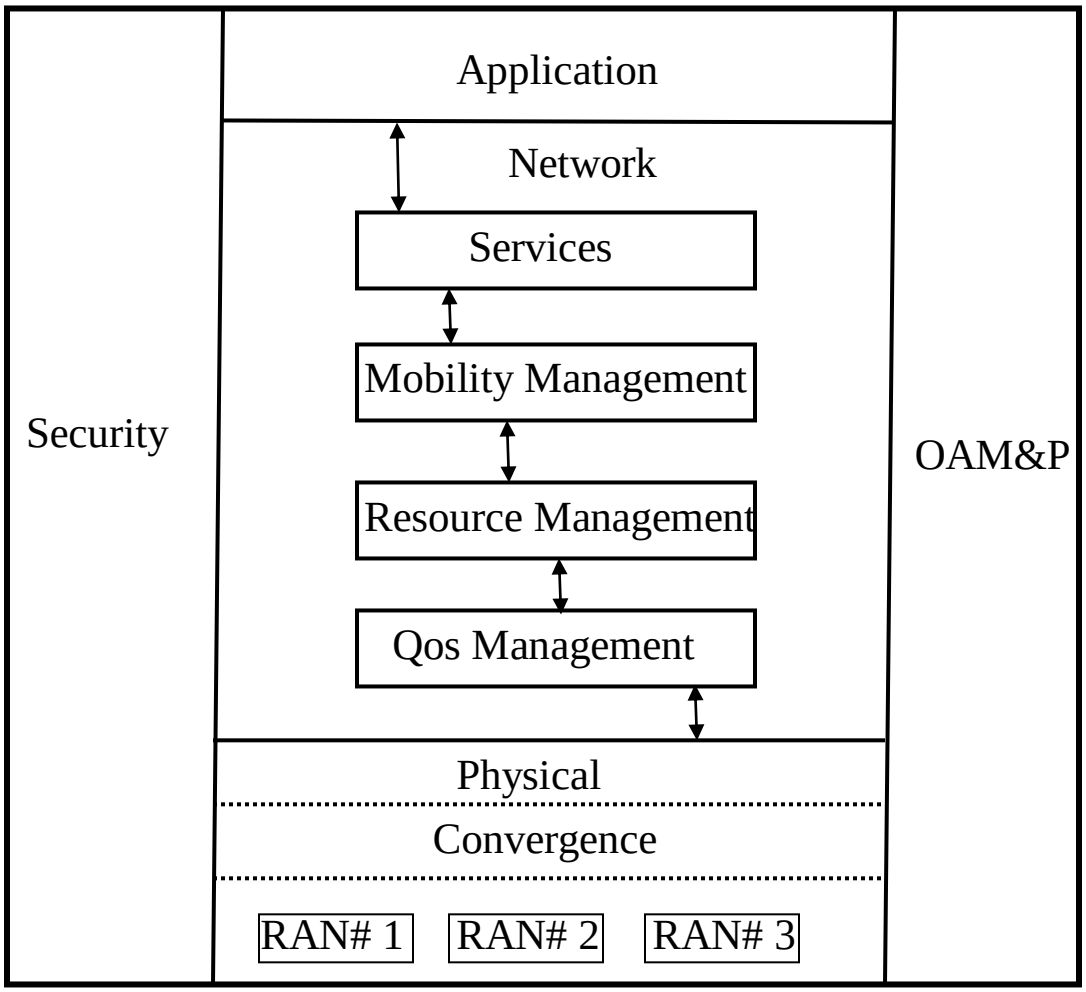
Figure (3) shows the widely accepted 4G network structure with IP as the core network used for communication; integrating the 2G, 3G and 4G technologies using a convergence layer



Figure(3): 4G NETWORK ARCHITECTURE

Figure (4) shows the proposed layered/level Architecture of 4G network elucidated. This architecture fulfills the basic requirement of servicing the standalone and mobile subscribers on an "anytime, anywhere, anyhow" basis in dynamic network conditions. The architecture is based on Internet Protocol version 6 (IPV6) which operates at the transport layer enabling seamless communication across various heterogeneous networks and based on the key factors such as mobility, Quality of Service (QoS) and efficient

resource management schemes. The functionalities provided by each layer and module can be described as follows:



Figure(4): layered/level Architecture of 4G network

Application Layer

This layer is composed of various third party applications which provide value added services to its subscribers.

Network

This layer consists of various sub layers described as follows:

- **Services**

This layer manages the interaction between various value-added services and networks.

- **Mobility Management**

This layer provides quality and uniform services to the mobile/stationary terminal across various heterogeneous networks. It provides features of low handover latency and packet loss during the provision of real-time and non-real time services to the end user moving across different networks. To achieve this, it performs tasks such as binding update (updating the care-off address of the mobile user), location management, common control signaling (signaling required to perform wireless network discovery),address assignment, handover control mechanism and so forth.

- **Resource Management**

This layer incorporates the functionalities of allocation, de-allocation and reallocation of the network resources which are acquired during the communication sessions within the same or different network domains. This activity is performed during or before the communication activity. This layer also performs the task of congestion control, packet scheduling and packet classification.

- **Quality of service (QoS) management**

This layer provides best optimal utilization of the available resources. In scenarios where the network resources are limited it provides an option to the applications to choose between high overall throughput and low end-to-end delay. It provides the best trade-off mechanisms depending on the application's preference. It encompasses several activities such as link utilization control, bandwidth control and so forth.

Physical Layer

This layer consist of the core IPV6 network of 4G and other heterogeneous access networks such as GSM (Global System for Mobile communications), CDMA(Code Division Multiple Access) and WLAN in their physicalview. This layer is composed of two sub-layers namely:

- **Convergence layer**

This layer provides common control signaling mechanism across the core and other heterogeneous networks at the physical level. It also allows different radio access networks to transparently use the independent network services such as mobility management, resource management and QoS management.

- **Different RANS**

This layer consists of several radio access networks communicating with each other at the physical level.

Operation, Administration, Maintenance and Provisioning

This layer spans across all the layers of the network architecture and provides the functionalities of network controlling, network monitoring and fault detection. It also maintains the repudiation between various services and resources of several heterogeneous and core networks.

Security Layer

This layer also branches across all the layers of the 4G network architecture which perform the function of authentication, authorization, encryption, establishment and implementation of service policy agreement between the various vendors . The three layers are mainly:

- **Infrastructure layer**: Consists of the building blocks of the network like routers, switches, Ethernet links, etc.
- **Service layer**: Services provided to the end users like VoIP (Voice over Internet Protocol), Wi-Fi, etc constitutes this layer.
- **Application layer**: Network-based applications accessed by the end-users such as web browsing, email, etc constitute this layer.

Security Planes

The security plane specifies the different types of network activities that need to be protected. The three security planes classified are :

- **User plane** *:* is concerned with information routing and performs several functions such as error correction and flow control. User services such as voice, fax, video, web access, etc can be categorized under the user plane.
- **Control plane**: deals with the short term network operations such as control of communication sessions like call setup, call release, etc. It contains several functions like security(performing authentication) , QoS, mobility, charging, etc
- **Management plane***:* is concerned with the long-term network operations and includes functions like fault, configuration, accounting (pricing and billing),

performance and security (maintaining the authentication system) management.

Security dimensions

Security dimensions specify the different threats and the measures to counter them. The eight security dimensions are:

- **Access control:** Keeps a track on the protection level against the unauthorized use of network resources. For example, password, ACL, firewall.
- **Authentication**: checks whether the user of the network resources has been authenticated. For example, digital signature and certificates.
- **Non-repudiation**: Prevents denial of occurrence of an activity on the network. For example, system logs, digital signatures.
- **Data confidentiality**: ensures that data is made available only to the authorized user using encryption mechanism.
- **Communication security**: Ensures the data flow only between authorized end points.
- **Data integrity**: Counters unauthorized attempts made to modify the data using anti-virus software or encryption mechanisms.
- **Availability**: Ensures that the network resources and services are always available to the authorized users using network redundancy techniques.
- **Privacy**: Prevents revelation of any important information derived from network monitoring activities performed by other malicious users using encryption techniques.

4. TCHNOLOGIES UESD IN 4G SYSTEM

4.4 OFDM (**O**rthogonal **F**requency **D**ivision **M**ultiplexing).

4.5 IPv6 (Internet protocol version 6).

4.6 VoIP (Voice Over IP) and VoLTE.

4.4 Ultra Wide Radio Band (UWB).

4.5 Smart Antennas and Multiple-input and multiple-output (MIMO).

4.6 LTE(Long-Term Evolution), A-LTE(Advance).

4.7 Millimeter Wireless.

4.8 QOS(quality of service).

4.1 OFDM (Orthogonal Frequency Division Multiplexing)

An FDM is the available band width is subdivided into a number of narrower band channels each user is allocated a unique frequency carrier in which to transmit and receive, OFDM reduces the amount of crosstalk in signal transmissions, 803.11a WLAN, 802.16 and WiMAX technologies use OFDM. OFDM technology has been incorporated into LTE because it enables high data bandwidths to be transmitted efficiently while still providing a high degree of resilience to reflections and interference. The access schemes different between the uplink and downlink, OFDMA used in the downlink; while SC-FDMA(Single Carrier - Frequency Division Multiple Access) is used in the uplink. SC-FDMA is used in view of the fact that its peak to average power ratio is small and the more constant power enables high RF power amplifier efficiency in the mobile.

Advantage of OFDM

- High spectrum efficiency.
- Resistance against multipath interference.
- Ease of filtering out noise.
- Combining OFDM technique with other techniques (possible to achieve more advantages e.g. MC-CDMA).

Disadvantage of OFDM

- Suffers from time-variations in the channel : severely degrades performance
- Circuitry must be very linear

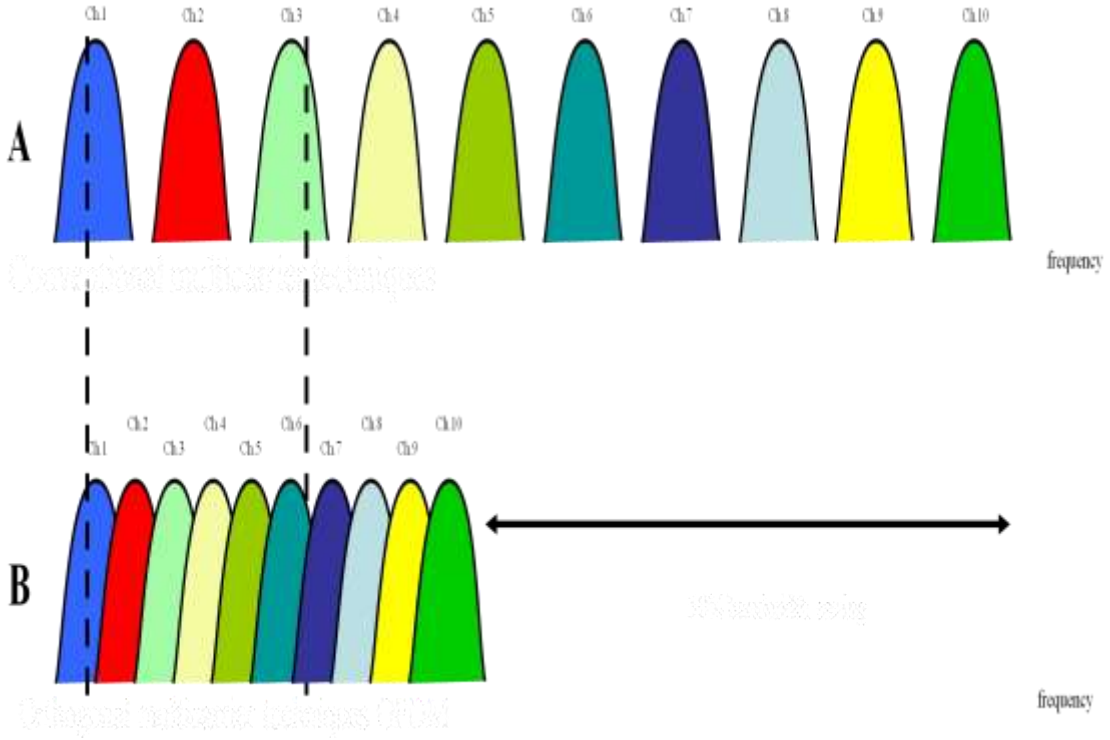


Figure (5) : Orthognal Frequency Division Multiplixing

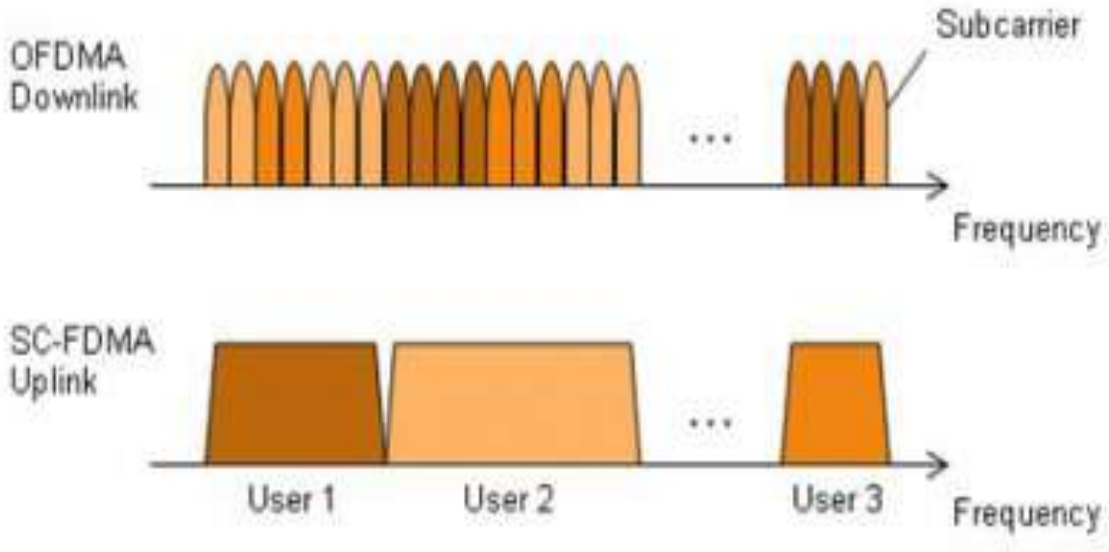


Figure (6) : Downlink and Uplink LTE (Orthognal Frequency Division Multip Acess and SC-FDMA

4.2 IPv6(INTERNET PROTOCOL VERSION 6)

IPv6 support is essential in order to support a large number of wireless-enabled devices.

- ➔ By increasing the number of IP addresses, IPv6 removes the need for Network Address Translation (NAT), a method of sharing a limited number of addresses among a larger group of devices, although NAT will still be required to communicate with devices that are on existing IPv4 networks.
- ➔ In the context of 4G, IPv6 also enables a number of applications with better multicast, security, and route optimization capabilities.
- ➔ With the available address space and number of addressing bits in IPv6, many innovative coding schemes can be developed for 4G devices and applications that could aid deployment of 4G networks and services.
- ➔ Mobile IPv6 have been proposed to reduce the handoff Mobile latency and the number of lost packets.
- ➔ The field "Traffic Class" and "Flow Label" in IPv6 header enables the routers to secure the special QoS for packet series with marked priority.
- ➔ Number of bit= 32bits, 8 octet .

4.3 VoIP AND VoLTE

- VoIP(Voice Over IP) : A methodology and group of technologies for the delivery of voice communication and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. Other terms commonly associated with VoIP are IP telephony, Internet telephony, voice over broadband (VoBB), broadband telephony, IP communications, and broadband phone service.
- VoLTE (Voice Over LTE): This approach is based on the IP Multimedia Subsystem (IMS) network, with specific profiles for control and media planes of voice service on LTE. This approach results in the voice service (control and media planes) being delivered as data flows within the LTE data bearer. This means that there is no dependency on (or ultimately, requirement for) the legacy Circuit Switch voice network to be maintained.

4.4 ULTRA WIDE RADIO BAND (UWB)

- ➔ An advanced transmission hardware technology that can be used in the implementation of a 4G network.
- ➔ It is typically detected as noise.
- ➔ It can use any part of the frequency spectrum, which means that it can use frequencies that are currently in use by other radio frequency devices
- ➔ It uses a frequency of 3.1 to 10.6 Hz.
- ➔ It uses less power , since it transmits pulse instead of continuous signal.
- ➔ Special antennas are needed to tune and aim the signal.

4.5 Smart Antennas and Multiple-input and multiple-output (MIMO)

- ➔ A SMART ANTENNA: is a digital wireless communications antenna system that takes advantage of diversity effect at the source (transmitter), the destination (receiver), or both. Diversity effect involves the transmission and/or reception of multiple radio frequency (RF) waves to increase data speed and reduce the error rate.

There are two types of smart antennas:-

- ❖ switched beam antenna:- It has fixed beams of transmission, and switch from predefined beam to another when the user with the phone moves throughout the sector.
- ❖ Adaptive array antenna :- It represents the most advanced smart antenna approach to data using a variety of new signal It represent the most advanced smart antenna approach to date using a variety of new signal processing algorithms to locate and track the user, minimize interference, and maximize intended signal reception.

Multiple-input and multiple-output Antenna (MIMO)

- Signal transmitted from multiple antennas (Multiple In)Signal received by multiple antennas (Multiple Out)
- Receiver combines the received signals and optimally combine energy from MxN channels
- Two main types of (MIMO) :

a) Transmit Diversity (also called Altamonte). **b)** Spatial Multiplexing

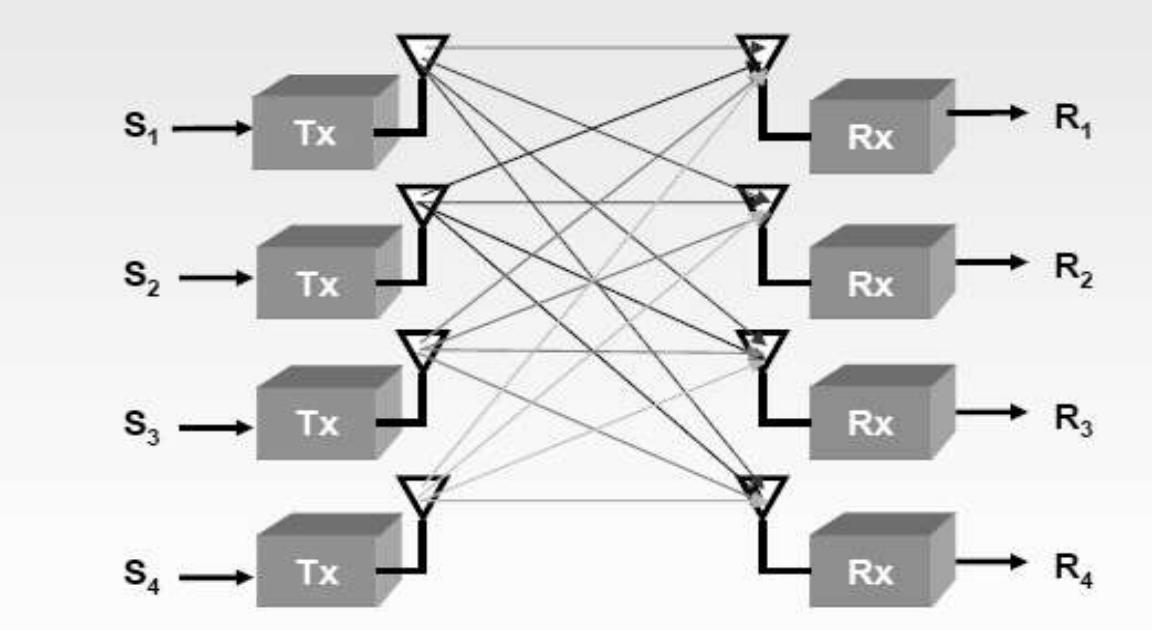


Figure (7): MIMO Antenna

4.6 LTE (LONG -TERM EVOLUTION)

LTE is a standard for wireless data communications technology and an evolution of the GSM/UMTS standard. The main goals of LTE is to increase the capacity and data rates of wireless data networks, improve spectrum efficiency, improve coverage, reduced latency and packet-optimized system that support multiple Radio Access. It can used in 3rd generation and also used LTE-A in 4G . Some advantage to LTE :

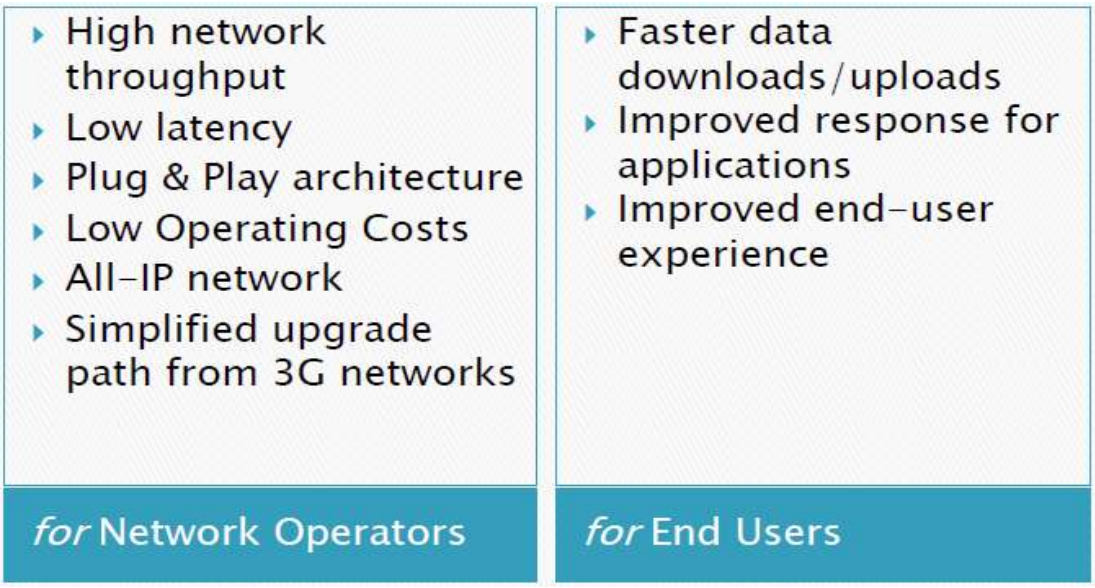


Figure (8): Compression between Network operators and End user in LTE Technology

Main Features LTE :

- Peak download rates up to 299.6 Mbit/s and upload rates up to 75.4 Mbit/s depending on the user equipment category (with 4x4 antennas using 20 MHz of spectrum). Five different terminal classes have been defined from a voice centric class up to a high end terminal that supports the peak data rates. All terminals will be able to process 20 MHz bandwidth.
- Improved support for mobility, exemplified by support for terminals moving at up to 350 km/h (220 mph) or 500 km/h (310 mph) depending on the frequency band.
- OFDMA for the downlink, SC-OFDM for the uplink to conserve power
- Support for both FDD and TDD communication systems as well as half-duplex FDD with the same radio access technology
- Support for all Frequency band currently used by IMT systems by ITU-R
- Supports at least 200 active data clients in every 5 MHz cell.
- Simplified architecture : The network side of E-UTRAN is composed only of eNode (BTS).
- Packet switch radio interface.
- Support for cell sizes from tens of meters radius (Femto and Pico cell) up to 100 km (62 miles) radius Macro cells. In the lower frequency bands to be used in rural areas, 5 km (3.1 miles) is the optimal cell size, 30 km (19 miles) having reasonable performance, and up to 100 km cell sizes supported with acceptable performance. In city and urban areas, higher frequency bands (such as 2.6 GHz in EU) are used to support high speed mobile broadband. In this case, cell sizes may be 1 km (0.62 miles) or even less.
- Support for MBSFN (Multicast-Broadcast Single Frequency Network). This feature can deliver services such as Mobile TV using the LTE infrastructure.
- Supply Bandwidths from 1.25-20 MHz
- Subcarriers spacing 15kHz.
- Bit rate up to 100Mbps, and by using MIMO the speed should reach 350Mbps.

OFDMA and SC-FDMA

- OFDMA (**OFDMA (Orthogonal Frequency Division Multiple Access)**is used in the downlink .
- **SC-FDMA (Single Carrier - Frequency Division Multiple Access)** is used in the uplink. SC-FDMA is used in view of the fact that its peak-to-average power ratio (PAPR) is small and the more constant power enables high RF power amplifier efficiency in the mobile handsets- an important factor for battery powered equipment is used in the downlink

SC-FDMA (Single Carrier - Frequency Division Multiple Access) is used in the uplink. SC-FDMA is used in view of the fact that its peak-to-average power ratio (PAPR) is small and the more constant power enables high RF power amplifier efficiency in the mobile handsets- an important factor for battery powered equipment

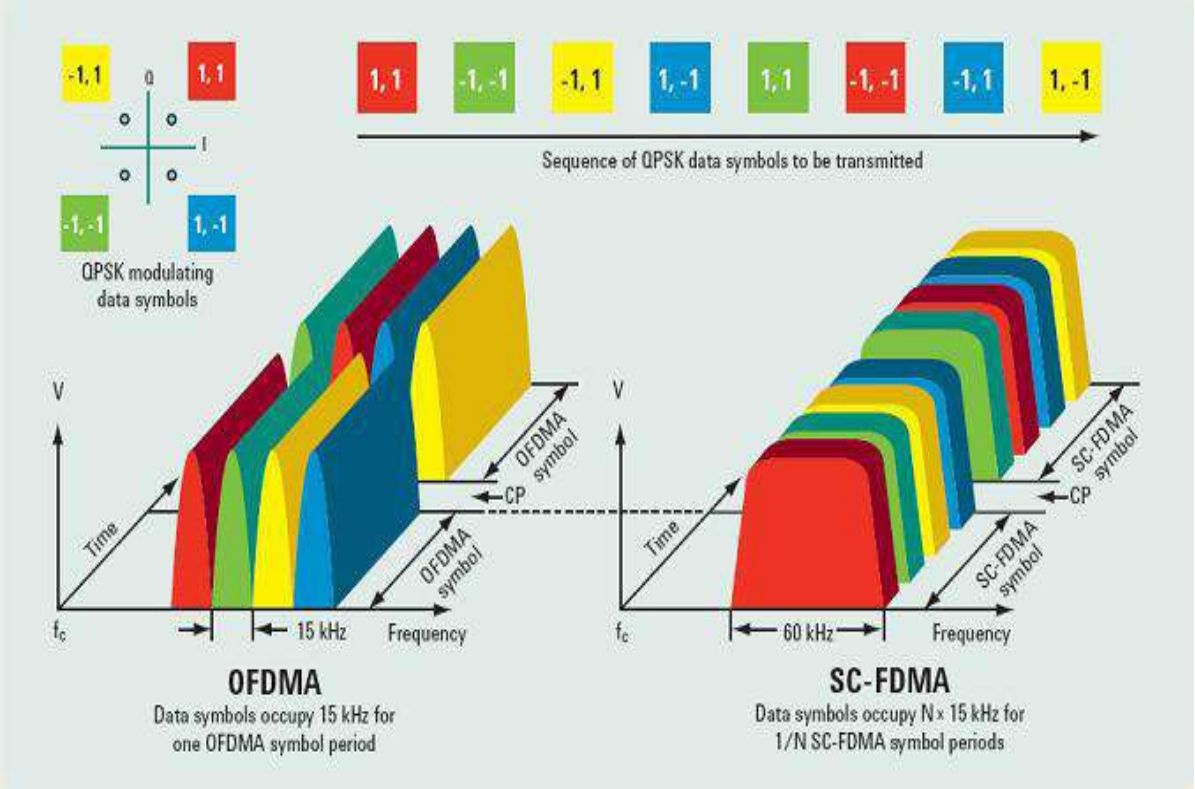


Figure (9): Compression between OFDMA and SC-FDMA

LTE-ADVANCE

- The LTE-Advanced (Release 10) is an evolution of LTE, which is to compliant with the IMT-Advanced requirements and targets.
- It aims to provide peak data rates of up to 1Gbps (for low mobility) and 500 Mbps in DL and UL respectively.
- LTE-Advanced is required to reduce the user- and control-plane latencies as compared to LTE (Release8).
- It targets to achieve peak spectrum efficiency of 30 bps/Hz and 15 bps/Hz in DL and UL respectively.
- LTE-Advanced enhances the cell edge user throughput) in order to achieve a homogeneous user experience in cell.
- It will support the mobility across the cell from 350 km/h to 500 km/h depending on operating frequency band.

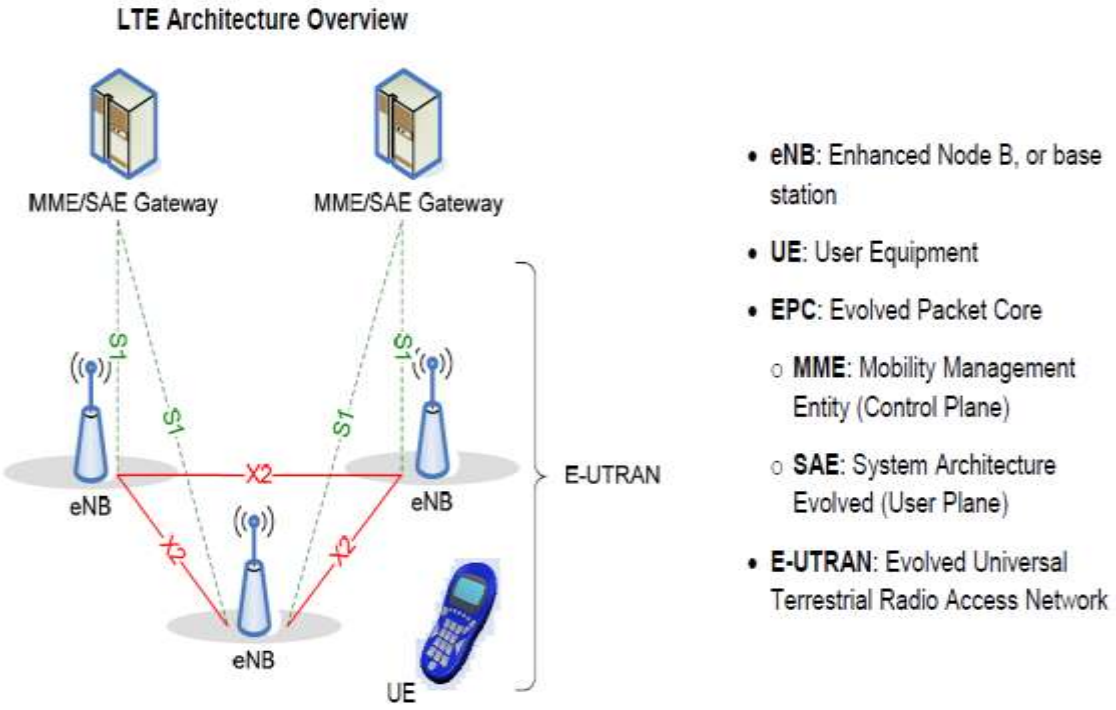


Figure (10): LTE Architecture Overview

Technology	LTE	LTE--A
Peak data rate Down Link (DL)	150 Mbps	1 Gbps
Peak data rate Up Link (UL)	75 Mbps	500 Mbps
Transmission bandwidth DL	20MHz	100 MHz
Transmission bandwidth UL	20MHz	40 MHz (requirements as defined by ITU)
Mobility	Optimized for low speeds(<15 km/hr) High Performance At speeds up to 120 km/hr Maintain Links at speeds up to 350 km/hr	Same as that in LTE
Coverage	Full performance up to 5 km	a) Same as LTE requirement b) Should be optimized or deployment in local areas/micro cell environments.
Scalable Band Widths	1.3,3, 5, 10, and 20 MHz	Up to 20–100 MHz
Capacity	200 active users per cell in 5 MHz.	3 times higher than that in LTE

Figure (11): Compression between LTE and LTE-A

4.7 MILLIMETER WIRELESS

- In a 4G system, millimeter wireless would constitute only one of several frequency bands, with the 5GHz band most likely dominant.

4.8 QOS(QUALITY OF SERVICE)

- In wireless networks, Quality of Service (QOS) refers to the measure of the performance for a system reflecting its transmission quality and service availability.
- 4G is expected to have at least a reliability of 99.99%.

In 4G QOS may be divided in following ways: -

- Transaction-level QOS describes both the time it takes to complete a transaction and the packet loss rate.
- Circuit-level QOS includes call blocking for new as well as existing calls .
- User-level QOS depends on user mobility and application type .

5. OFDM WITH (CDMA)

- **CDMA (code division multiple access):** all users share the same radio frequency at the same time but different codeword, OFDM are different technologies with different capabilities:
- CDMA2000 offers high-performance mobile broadband and voice services today and will continue to be enhanced to provide greater broadband speeds and voice capacity
- OFDM leverages wider-bandwidths up to 20 MHz to provide greater speed and capacity

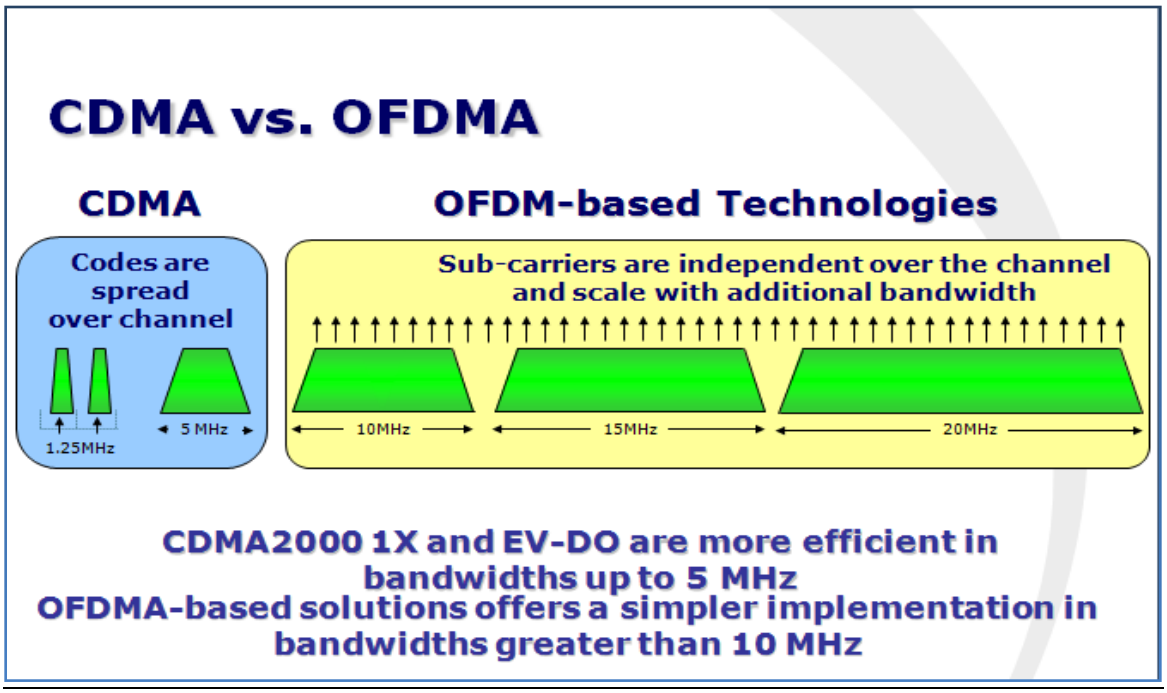


Figure (12): Compression between CDMA and OFDMA

6. WiMAX TECHNOLOGY

WiMAX : Worldwide Interoperability for Microwave Access – should be capable of around 40 megabits per second with a range of 30 miles. It is one of the closest technologies to meet the standards of true 4G and as it develop should surpass the 100MB/second which is the 4G standard. Mobile WiMAX allows the use of high speed data transfers and is the main competition for the 4G LTE services provided by cellular carriers.

Application of WiMAX

- Wimax Backhaul.
- Nomadic Broadband
- Broadband for Developing Countries.
- Private Networks.

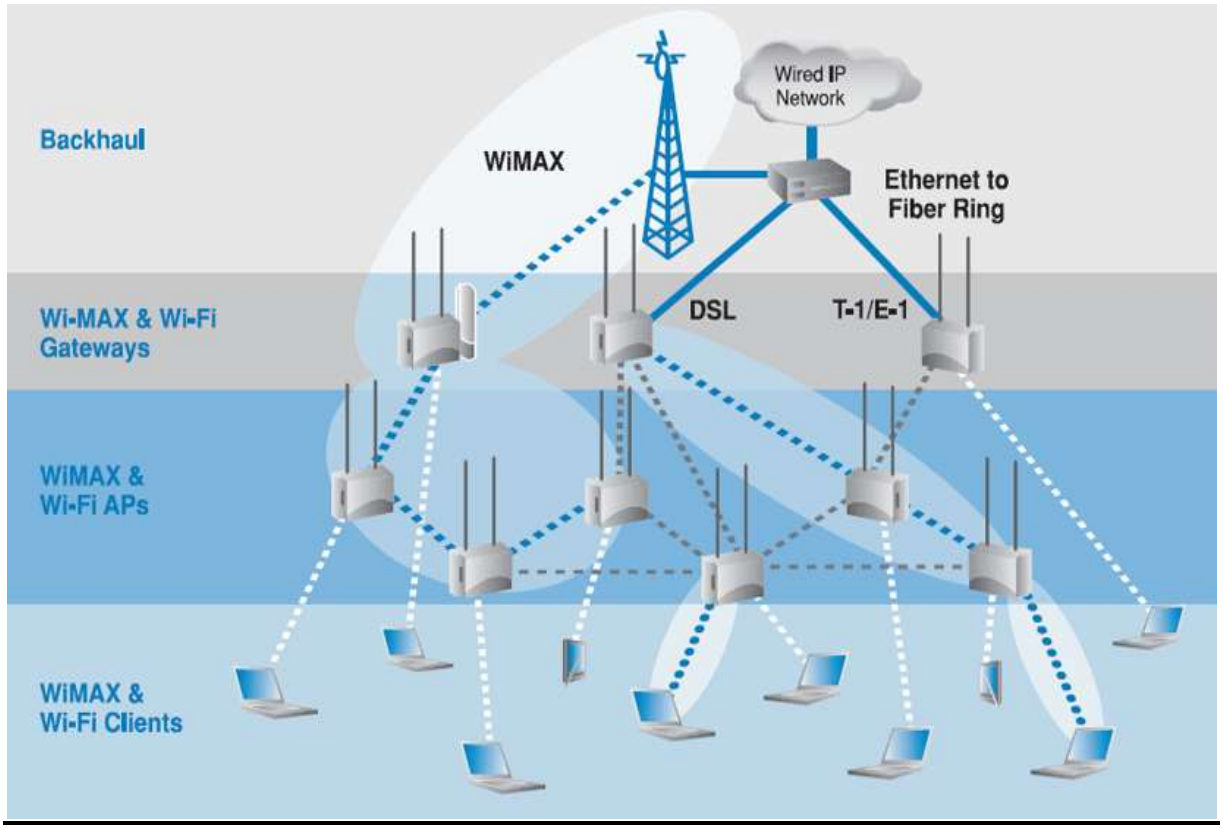


Figure (13): WiMAX Architecture

7. FEATURES AND ADVANTGE OF 4G TECHNOLOGY

- Support for multimedia services like teleconferencing and wireless internet.
- Wider bandwidths and higher bit rates.
- Entirely packet-switched network.
- Global mobility and service portability.
- Support for previous wireless technologies.
- High internet speed.
- tight network security.
- Better response time. 10 times better than 3G.
- Less time to build 4G because it uses the same tower and fiber cable as 3G- they only have to upgrade the tower with 4G
- Provide high flexibility as compared to already existing technologies.

8. DISADVANTGE OF 4G TECHNOLOGY

- ☞ New technology which make is more expensive than 3G
- ☞ Better usage is more
- ☞ Need complicated hardware
- ☞ Not compatible with already existing 2G and 2.5 G handset.

9. APPLICATION OF 4G TECHNOLOGY

- 4G Car : With the hype of 3G wireless in the rear view mirror, but the reality of truly mobile broadband data seemingly too far in the future to be visible yet on the information super highway, it may seem premature to offer a test drive 4G.
- public safety.
- Sensors in public vehicle.
- Cameras in traffic light .
- First responder route selection.
- Traffic control during disasters.

10. CONCLUSION

The advent of 4G is sure to revolutionize the field of telecommunication domain bringing the wireless experience to a completely new level. It would provide wealth of features and services making the world a smaller place to live. Thus, 4G seems to have the capability to realize. But 4G should also take lesson from the 3G's failure to capture the imagination of the end-users. Technology should not be developed for technology's sake rather it should target the end user. Thus, user-centric approach towards 4G's development is the key to its success. Common consensus on the standards and the technologies for 4G needs to be reached to fasten 4G's deployment which would be a gradual process. Lot of research work is required to investigate the open issues like design for SDR, QoS parameters and so forth. The threat analysis model provided by ITU is very apt for the complete analysis and planning for security of 4G. It can be used as a reference framework for future research. But still comprehensive research work is required in the field of network security to tackle potential security threats because a ubiquitous "secured" heterogeneous network will appeal more to the today's consumers.

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