International Journal of Scientific & Engineering Research Volume 3, Issue 7, July-2012 1
ISSN 2229-5518

4G Mobile Communication system

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ABSTRACT

The fourth generation of mobile networks will truly turn the current mobile phone networks, in to end to end IP based networks, couple this with the arrival of IPv6, every device in the world will have a unique IP address, which will allow full IP based communications from a mobile device, right to the core of the internet, and back out again. If 4G is implemented correctly, it will truly harmonize global roaming, super high speed connectivity, and transparent end user performance on every mobile communications device in the world.

4G is set to deliver 100mbps to a roaming mobile device globally, and up to 1gbps to a stationary device. With this in mind, it allows for video conferencing, streaming picture perfect video and much more. It won't be just the phone networks that need to evolve, the increased traffic load on the internet as a whole (imagine having 1 billion 100mb nodes attached to a network over night) will need to expand, with faster backbones and oceanic links requiring major upgrade. 4G won't happen overnight, it is estimated that it will be implemented by 2012, and if done correctly, should take off rather quickly.

4G networks i.e. Next Generation Networks (NGNs) are becoming fast and very cost-effective solutions for those wanting an IP built high-speed data capacities in the mobile network. Some possible standards for the 4G system are 802.20, WiMAX (802.16), HSDPA, TDD UMTS, UMTS and future versions of UMTS.

The design is that 4G will be based on OFDM (Orthogonal Frequency Division Multiplexing), which is the key enabler of 4G technology. Other technological aspects of 4G are adaptive processing and smart antennas, both of which will be used in 3G networks and enhance rates when used in with OFDM. Currently 3G networks still send their data digitally over a single channel; OFDM is designed to send data over hundreds of parallel streams, thus increasing the amount of information that can be sent at a time over traditional CDMA networks.

1. INTRODUCTION

4G (also known as Beyond 3G), an abbreviation for Fourth-Generation, is a term used to describe the next complete evolution in *wireless communications*. A 4G system will be able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given trousers on an "Anytime, Anywhere" basis, and at higher data rates than previous generations.

The approaching 4G (fourth generation) mobile communication systems are projected to solve still-remaining problems of 3G (third generation) systems and to provide a wide variety of new services, from high-quality voice to high-definition video to high-data-rate wireless channels. The term 4G is used broadly to include several types of broadband wireless access communication systems, not only cellular telephone systems. One of the terms used to describe

4G is MAGIC-Mobile multimedia, anytime anywhere, Global mobility support, integrated-wireless solution, and customized personal service.

As a promise for the future, 4G systems, that is, cellular broadband wireless access systems have been attracting much interest in the mobile communication arena. The 4G systems not only will support the next generation of mobile service, but also will support the fixed wireless networks. Researchers and vendors are expressing a growing interest in 4G wireless networks that support global roaming across multiple wireless and mobile networks—for example, from a

cellular network to a satellite-based network to a high-bandwidth wireless LAN. With this feature, users will have access to different services, increased coverage, the convenience of a single device, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks. 4G networks will also feature IP interoperability for seamless mobile Internet access and bit rates of 50 Mbps or more.

2. HISTORY

1G or first Generation

At the end of the 1940's, the first radio telephone service was introduced, and was designed to users in cars to the public land-line based telephone network. Then, in the sixties, a system launched by Bell Systems, called IMTS, or, "Improve d Mobile Telephone Service", brought quite a few improvements such as direct dialing and more bandwidth. The very first analog systems were based upon IMTS and were created in the late 60s and early 70s. The systems were called "cellular" because large coverage areas were split into smaller areas or "cells", each cell is served by a low power transmitter and receiver. The 1G or First Generation was an analog system, and was developed in the seventies, 1G had two major improvements, this was the invention of the microprocessor, and the digital transform of the control link between the phone and the cell site. Advance mobile phone system (AMPS) was first launched by the US and is a 1G mobile system. Based on FDMA, it allows users to make

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voice calls in 1 country.

2G or Second Generation

2G first appeared around the end of the 1980's, the 2G system digitized the voice signal, as well as the control link. This new digital system gave a lot better quality and much more capacity (i.e. more people could use their phones at the same time), all at a lower cost to the end consumer. Based on TDMA, the first commercial network for use by the public was the Global system for mobile communication (GSM).

3G or Third Generation

3G systems promise faster communications services, entailing voice, fax and Internet data transfer capabilities, the aim of 3G are to provide these services anytime, anywhere throughout the globe, with seamless roaming between standards. ITU's IMT-2000 is a global standard for 3G and has opened new doors to enabling innovative services and application for instance, multimedia entertainment, and location-based services, as well as a whole lot more .In 2001,Japan saw the first 3G network launched.3G technology supports around 144 Kbps, with high speed movement and 384Kbps locally, and up to 2Mbps for fixed stations, i.e. in a building.

Technology	1G	2G	2.5G	3G	4G
Design Began	1970	1980	1985	1990	2000
Implementation	1984	1991	1999	2002	2010?
Service	Analog voice, synchronous data to 9.6 kbps	Digital voice, short messages	Higher capacity, packetized data	Higher capacity, broadband data up to 2 Mbps	Higher capacity, completely IP oriented, multimedia, data to hundreds of megabits
Standards	AMPS, TACS, NMT, etc.	TDMA, CDMA, GSM, PDC	GPRS, EDGE, 1xRTT	WCDMA, CDMA2000	Single standard
Data Bandwidth	1.9 kbps	14.4 kbps	384 kbps	2 Mbps	200 Mbps
Multiplexing	FDMA	TDMA, CDMA	TDMA, CDMA	CDMA	CDMA?
Core Network	PSTN	PSTN	PSTN, packet network	Packet network	Internet

Legend:

1xRTT = 2.5G CDMA data service up to 384 kbps
AMPS = advanced mobile phone service
CDMA = code division multiple access
EDGE = enhanced data for global evolution
FDMA = frequency division multiple access
GPRS = general packet radio system
GSM = global system for mobile
NMT = Nordic mobile telephone
PDC = personal digital cellular
PSTN = public switched telephone network
TACS = total access communications system
TDMA = time division multiple access
WCDMA = wideband CDMA

Fig 1: - History of Mobile Networks

3. What is 4G?

Fourth generation (4G) wireless was originally conceived by the Defense Advanced Research Projects Agency (DARPA), the same organization that developed the wired Internet. It is not surprising, then, that DARPA chose the same distributed architecture for the wireless Internet that had proven so successful in the wired Internet.

Although experts and policymakers have yet to agree on all the aspects of 4G wireless, two characteristics have emerged as all but certain components of 4G: end-to-end Internet Protocol (IP), and peer-to-peer networking. An all IP network makes sense because consumers will want to use the same data applications they are used to in wired networks.

A peer-to-peer network, where every device is both a transceiver and a router/repeater for other devices in the network, eliminates this spoke-and-hub weakness of cellular architectures, because the elimination of a single node does not disable the network. The final definition of “4G” will have to include something as simple as this: if a consumer can do it at home or in the office while wired to the Internet, that consumer must be able to do it wirelessly in a fully mobile environment.

Let’s define “4G” as “wireless *ad hoc* peer-to-peer networking.” 4G technology is significant because users joining the network add mobile routers to the network infrastructure. Because users carry much of the network with them, network capacity and coverage is dynamically shifted to accommodate changing user patterns.

As people congregate and create pockets of high demand, they also create additional routes for each other, thus enabling additional access to network capacity. Users will automatically hop away from congested routes to less congested routes.

This permits the network to dynamically and automatically self-balance capacity, and increase network utilization. What may not be obvious is that when user devices act as routers, these devices are actually part of the network infrastructure. So instead of carriers subsidizing the cost of user devices (e.g., handsets, PDAs, of laptop computers), consumers actually subsidize and help deploy the network for the carrier. With a cellular infrastructure, users contribute nothing to the network. They are just consumers competing for resources. But in wireless *ad hoc* peer-to-peer networks, users cooperate – rather than compete – for network resources.

Thus, as the service gains popularity and the number of user increases, service likewise improves for all users. And there is also the 80/20 rule. With traditional wireless networks, about 80% of the cost is for site acquisition and installation, and just 20% is for the technology. Rising land and labor costs means installation costs tend to rise over time, subjecting the service providers’ business models to some challenging issues in the out years. With wireless peer-to-peer networking, however, about 80% of the cost is the technology and only 20% is the installation.

Because technology costs tend to decline over time, a current viable business model should only become more profitable over time. The devices will get cheaper, and service providers will reach economies of scale sooner because they will be able to pass on the infrastructure savings to consumers, which will further increase the rate of penetration. This new generation of wireless is intended to complement and replace the 3G systems, perhaps in 5 to 10 years. Accessing information anywhere, anytime, with a seamless connection to a wide range of information and services, and receiving a large volume of information, data, pictures, video, and so on, are the keys of the 4G infrastructures.

The future 4G infrastructures will consist of a set of various networks using IP (Internet protocol) as a common protocol so that users are in control because they will be able to choose every application and environment. Based on the developing trends of mobile communication, 4G will have broader bandwidth, higher data rate, and smoother and quicker handoff and will focus on ensuring seamless service across a multitude of wireless systems and networks.

The key concept is integrating the 4G capabilities with all of the existing mobile technologies through advanced technologies. Application adaptability and being highly dynamic are the main features of 4G services of interest to users. These features mean services can be delivered and be available to the personal preference of different users and support the users' traffic, air interfaces, radio environment, and quality of service. Connection with the network applications can be transferred into various forms and levels correctly and efficiently.

The dominant methods of access to this pool of information will be the mobile telephone, PDA, and laptop to seamlessly access the voice communication, high-speed information services, and entertainment broadcast services. Figure 1 illustrates elements and techniques to support the adaptability of the 4G domain. The fourth generation will encompass all systems from various

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networks, public to private; operator-driven broadband networks to personal areas; and ad hoc networks. The 4G systems will interoperate networks, public to private; operator-driven broadband networks to personal areas; and ad hoc networks. The 4G systems will interoperate with 2G and 3G systems, as well as with digital (broadband) broadcasting systems. In addition, 4G systems will be fully IP-based wireless Internet. This all-encompassing integrated perspective shows the broad range of systems that the fourth generation intends to integrate, from satellite broadband to high altitude platform to cellular 3G and 3G systems to WLL (wireless local loop) and FWA(fixed wireless access) to WLAN (wireless

local area network) and PAN (personal area network), all with IP as the integrating mechanism. With 4G, a range of new services and models will be available. These services and models need to be further examined for their interface with the design of 4G systems.

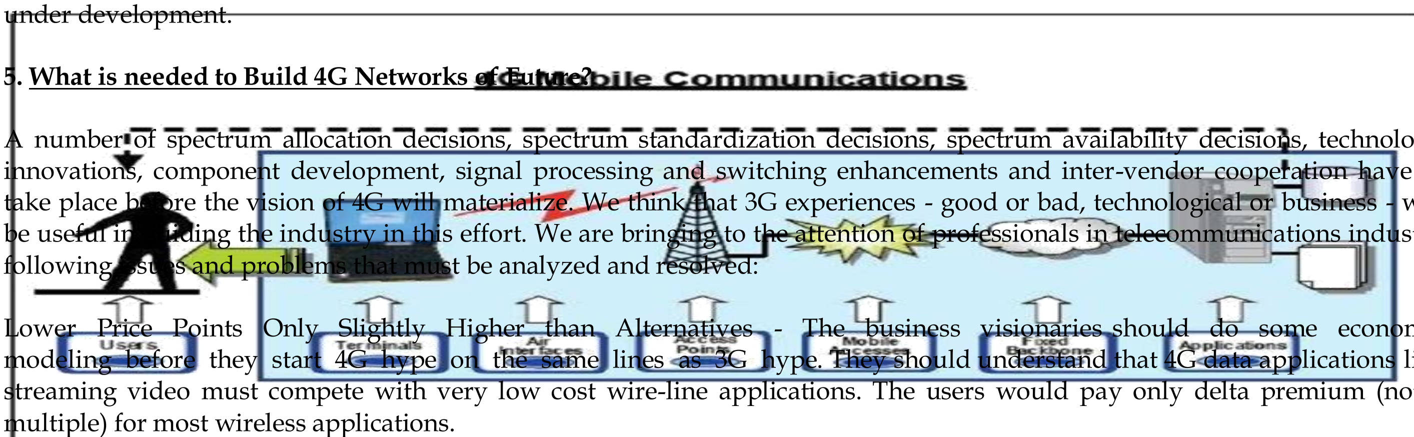

Fig 2: - <u>4G Mobile Communication</u>

4. FEATURES

- Support for interactive multimedia, voice, streaming video, Internet, and Other broadband services.
- IP based mobile system
- High speed, high capacity, and low cost-per-bit
- Global access, service portability, and scalable mobile services
- Seamless switching, and a variety of Quality of Service-driven services
- Better scheduling and call-admission-control techniques
- Ad-hoc and multi-hop networks (the strict delay requirements of voice make Multi-hop network service a difficult problem)
- Better spectral efficiency
- Seamless network of multiple protocols and air interfaces (since 4G will be All-IP, look for 4G systems to be compatible with all common network Technologies, including 802.11, WCDMA, Bluetooth, and Hyper LAN).
- An infrastructure to handle pre-existing 3G systems along with other wireless technologies, some of which are currently under development.

5. What is needed to Build 4G Networks of Future?

A number of spectrum allocation decisions, spectrum standardization decisions, spectrum availability decisions, technology innovations, component development, signal processing and switching enhancements and inter-vendor cooperation have to take place before the vision of 4G will materialize. We think that 3G experiences - good or bad, technological or business - will be useful in guiding the industry in this effort. We are bringing to the attention of professionals in telecommunications industry following issues and problems that must be analyzed and resolved:

Lower Price Points Only Slightly Higher than Alternatives - The business visionaries should do some economic modeling before they start 4G hype on the same lines as 3G hype. They should understand that 4G data applications like streaming video must compete with very low cost wire-line applications. The users would pay only delta premium (not a multiple) for most wireless applications.

More Coordination among Spectrum Regulators around the World- Spectrum regulation bodies must get involved in guiding the researchers by indicating which frequency band might be used for 4G. FCC in USA must cooperate more actively with International bodies like ITU and perhaps modify its hands-off policy in guiding the industry. When public interest, national security interest and economic interest (inter-industry ala TV versus Telecommunications) are at stake, leadership must come from regulators. At appropriate time, industry builds its own self-regulation mechanisms.

More Academic Research: Universities must spend more effort in solving fundamental problems in radio communications (especially multiband and wideband radios, intelligent antennas and signal processing.

Standardization of wireless networks in terms of modulation techniques, switching schemes and roaming is an absolute necessity for 4G.

A Voice-independent Business Justification Thinking: Business development and technology executives should not bias their business models by using voice channels as economic determinant for data applications. Voice has a built-in demand limit - data applications do not.

Integration Across Different Network Topologies: Network architects must base their architecture on hybrid network concepts that integrates wireless wide area networks, wireless LANS (IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.15 and IEEE 802.16, Bluetooth with fiber-based Internet backbone. Broadband wireless networks must be a part of this integrated network architecture.

Non-disruptive Implementation: 4G must allow us to move from 3G to 4G.

6. IMPLEMENTATION USING 4G

The goal of 4G is to replace the current proliferation of core mobile networks with a single worldwide core network standard, based on IP for control, video, packet data, and voice. This will provide uniform video, voice, and data services to the mobile host, based entirely on IP.

The objective is to offer seamless multimedia services to users accessing an all IP-based infrastructure through heterogeneous access technologies. IP is assumed to act as an adhesive for providing global connectivity and mobility among networks.

An all IP-based 4G wireless network has inherent advantages over its predecessors. It is compatible with, and independent of the underlying radio access technology. An IP wireless network replaces the old Signaling

System 7 (SS7) telecommunications protocol, which is considered massively redundant. This is because SS7 signal transmission consumes a larger part of network bandwidth even when there is no signaling traffic for the simple reason that it uses a call setup mechanism to reserve bandwidth, rather time/frequency slots in the radio waves. IP networks, on the other hand, are connectionless and use the slots only when they have data to send. Hence there is optimum usage of the available bandwidth. Today, wireless communications are heavily biased toward voice, even though studies indicate that growth in wireless data traffic is rising exponentially relative to demand for voice traffic. Because an all IP core layer is easily scalable, it is ideally suited to meet this challenge. The goal is a merged data/voice/multimedia network.

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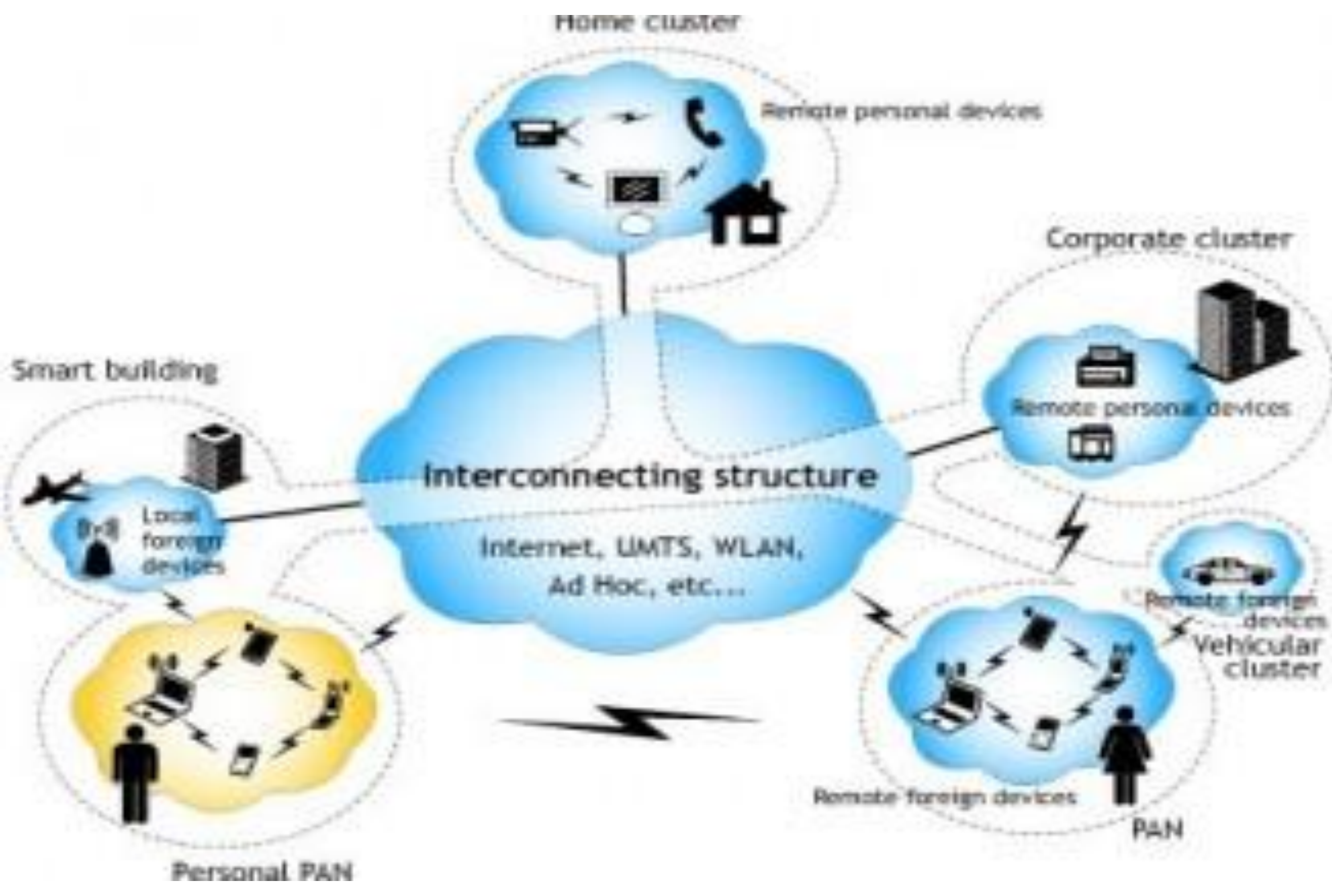

Fig 3: - <u>IMPLEMENTATION DAIGRAM OF 4G</u>

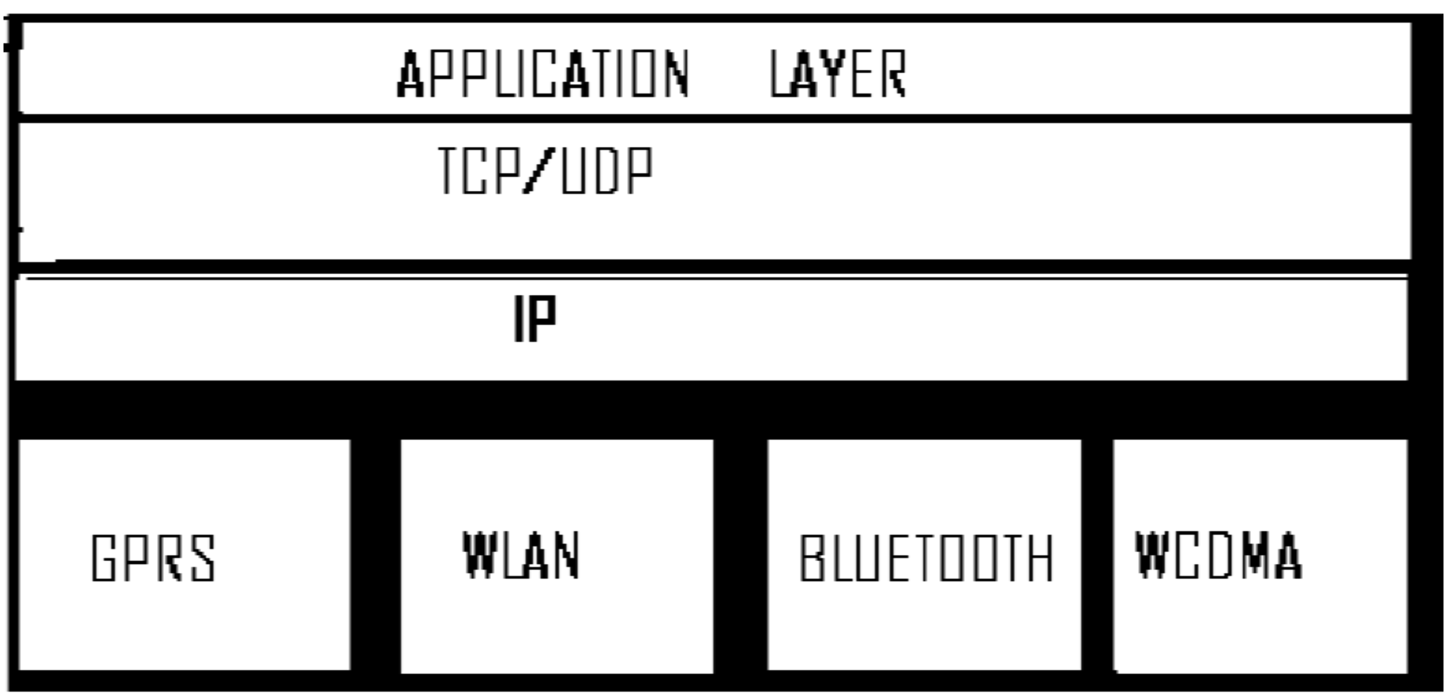

Fig 4: - IMPLEMENTATION BLOCK DIAGRAM OF 4G

7. Architectures in Prospects

7.1 End-to-end Service Architectures for 4G Mobile Systems:-

A characteristic of the transition towards 3G systems and beyond is that highly integrated telecommunications service suppliers fail to provide effective economies of scale. This is primarily due to deterioration of vertical integration scalability with innovation speed up. Thus, the new rule for success in 4G telecommunications markets will be to provide one part of the puzzle and to cooperate with other suppliers to create the complete solutions that end customers require.

A direct consequence of these facts is that a radically new end-to-end service architecture will emerge during the deployment of 3G mobile networks and will became prominent as the operating model of choice for the Fourth Generation (4G) Mobile Telecommunications Networks. This novel end-to-end service architecture is inseparable from an equally radical transformation of the role of the telecommunications network operator role in the new value chain of end service provision.

In fact, 4G systems will be organized not as monolithic structures deployed by a single business entity, but rather as a dynamic confederation of multiple sometimes cooperating and sometimes competing service providers.

End-to-end service architectures should have the following desirable properties:

- Open service and resource allocation model.
- Open capability negotiation and pricing model.
- Trust management. Mechanisms for managing trust relationships among clients and service providers, and between service providers, based on trusted third party monitors.
- Collaborative service constellations.
- Service fault tolerance.

7.2 Middleware Architecture:-

The service middleware is decomposed into three layers; i.e. user support layer, service support layer and network support layer. The criterion for using a layered approach is to reuse the existing subsystems in the traditional middleware. The user support layer has autonomous agent aspects that traditional service middleware lacks. It consists of 4 sub-systems:

'Personalization', 'Adaptation', 'Community' and 'Coordination', to provide mechanisms for context awareness and support for communities and coordination. Introduction of this functional layer enables the reduction of unnecessary user interaction with the system and the provision of user-centric services realized by applying agent concepts, to support analysis of the current context, personalization depending on the user's situation, and negotiation for service usage.

The middle layer, the service support layer, contains most functionality of traditional middleware. The bottom layer, the network layer supports connectivity for all-IP networks. The dynamic service delivery pattern defines a powerful interaction model to negotiate the conditions of service delivery by using three subsystems: 'Discovery & Advertisement', 'Contract Notary' and 'Authentication & Authorization'.

7.3 Cellular Multi-hop Communications: Infrastructure-Based Relay

Network Architecture:-

It is clear that more fundamental enhancements are necessary for the very ambitious throughput and coverage requirements of future networks. Towards that end, in addition to advanced transmission techniques and antenna technologies, some major modifications in the wireless network architecture itself, which will enable effective distribution and collection of signals to and from wireless users, are sought. The integration of "multi-hop" capability into the conventional wireless networks is perhaps the most promising architectural upgrade.

In a Multi-hop network, a signal from a source may reach its destination in multiple hops (whenever necessary) through the use of "relays". Since we are here concerned with infrastructure-based networks, either the source or destination is a common point in the network.

Base station (or, access point, in the context of WLANs).The potential advantage of relaying is that it allows substituting a poor-quality (due to high path loss) single-hop wireless link with a composite, two- or more hop, better-quality link whenever possible. Relaying is not only efficient in eliminating black spots throughout the coverage region, but more importantly, it may extend the high data rate coverage range of a single BS; therefore cost-effective high data rate coverage may be possible through the augmentation of the relaying capability in conventional cellular networks.

Advantages:-

• Property owners can install their own access points.

– Spreads infrastructure cost.

• Reduced network access operational cost.

– Backbone access through wireless.

– Wired access through DSL at aggregation points.

• Ad hoc-like characteristics:

– Access points configure into access network.

– Some access points may be moving (bus, train).

• Multi-hop also could reduce costs in heterogeneous 3G networks.

– 802.11 To GPRS for example.

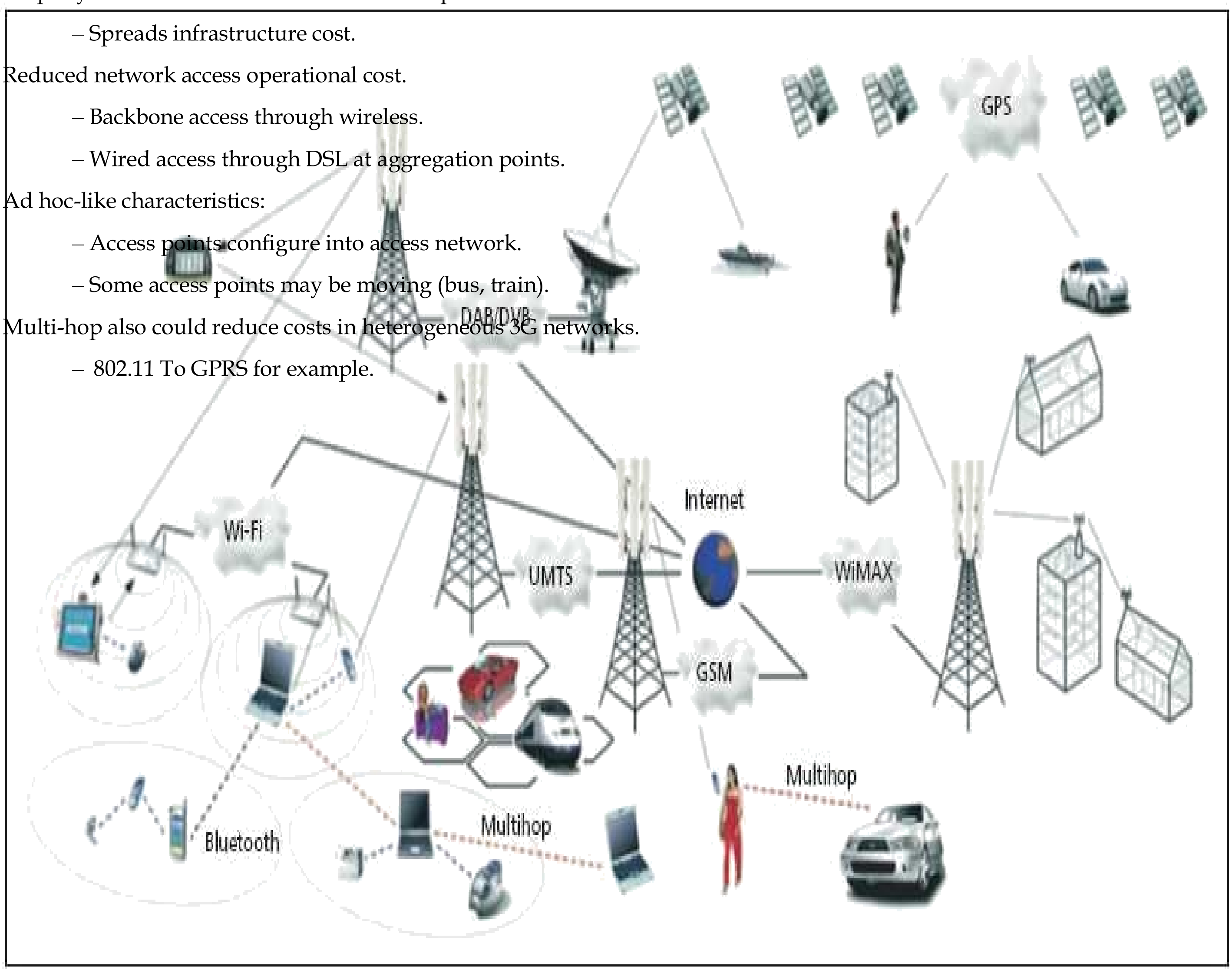

Fig 5: - Example of Heterogeneous Network Multi-hop Architecture

7.4 Overlay network:-

In this architecture, a user accesses an overlay network consisting of several universal access points. These UAPs in turn select a wireless network based on availability, QoS specifications, and user defined choices. A UAP performs protocol and frequency translation, content adaptation, and QoS negotiation-renegotiation on behalf of users. The overlay network, rather than the user or device, performs handoffs as the user moves from one UAP to another. A UAP stores user, network, and device information, capabilities, and preferences. Because UAPs can keep track of the various resources a caller uses, this architecture supports single billing and subscription.

In below Figure possible 4G wireless network architectures.

(a) A multimode device lets the user, device, or network initiate handoff between networks without the need for network modification or interworking devices.

(b) An overlay network—consisting of several universal access points (UAPs) that store user, network, and device information—performs a handoff as the user moves from one UAP to another.

(c) A device capable of automatically switching between networks is possible if wireless networks can support a common protocol to access a satellite-based network and another protocol for terrestrial networks.

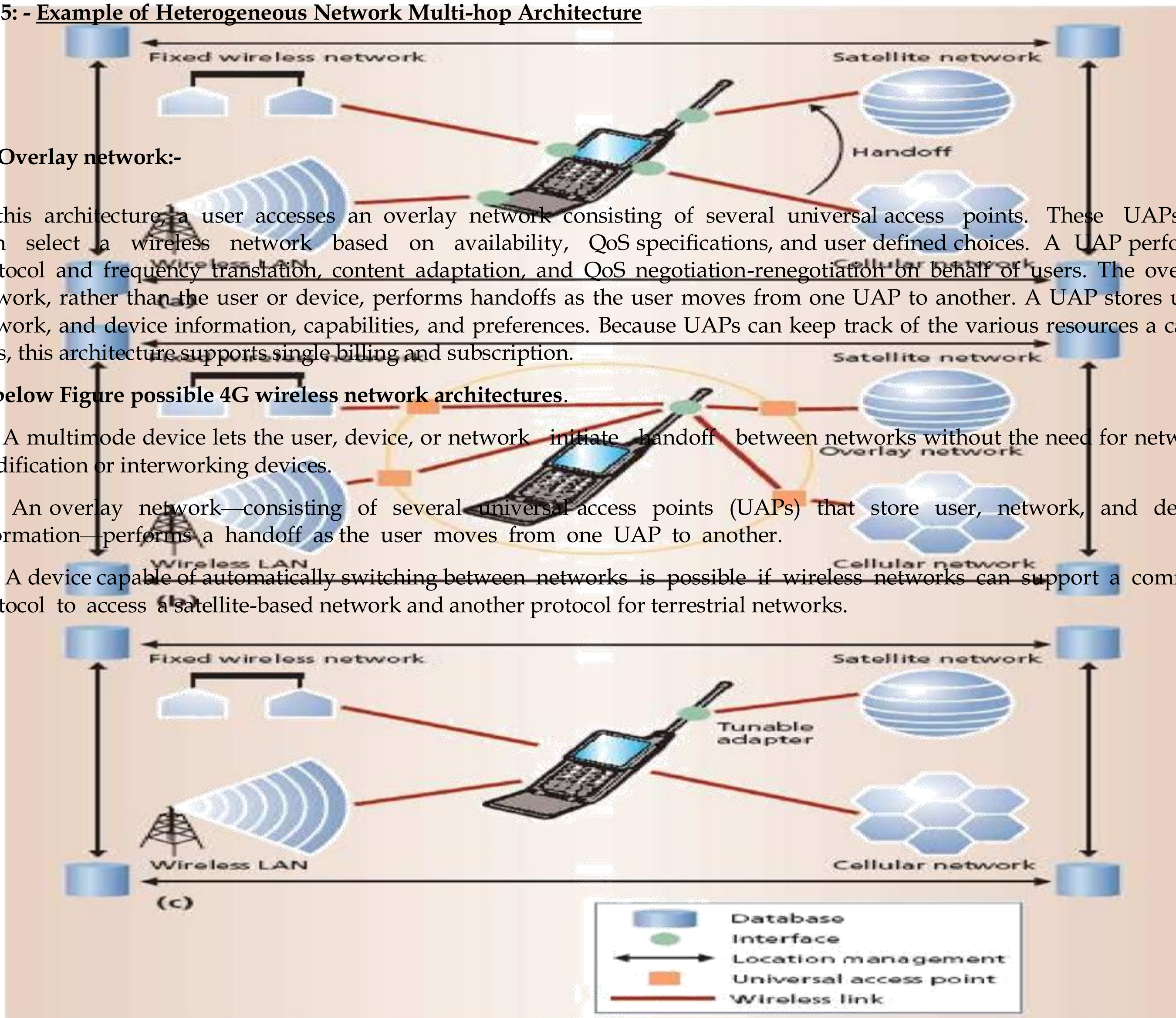

Fig 6:- Overlay Network

8. A Basic Model for 4G Networks

QoS, security and mobility can be viewed as three different, indispensable aspects in 4G networks; however all are related to network nodes involving the controlling or the processing of IP packets for end-to-end flows between an MN and the CN. I show in this section how we view the 4G network infrastructure.

Two Planes: Functional Decomposition

Noting that an IP network element (such as a router) comprises of numerous functional components that cooperate to provide such desired service (such as, mobility, QoS and/or AAA – Authentication, Authorization and Accounting), we identify these components in the SeaSoS architecture into two planes, namely the control plane and the data plane. Fig. 5 illustrates this method of flexible functional composition in 4G networks.

As we are mainly concerned with network elements effectively at the network layer, we do not show a whole end-to-end communication picture through a whole OSI or TCP/IP stack. The control plane performs control related actions such as AAA, MIP registration, QoS signaling, installation/maintenance of traffic selectors and security associations, etc., while the data plane is responsible for data traffic behaviors (such as classification, scheduling and forwarding) for end-to-end traffic flows. Some components located in the control plane interact, through installing and maintaining certain control states for data plane, with data plane components in some network elements, such as access routers (ARs), IntServ nodes or DiffServ edge routers.

However, not all control plane components need to exist in all network elements, and also not all network elements (e.g., AAA server) are involved with data plane functionalities.

I refer these cases as path-decoupled control and other cases as path coupled control. We argue the separation and coordination of control plane and data plane is critical for seamless mobility with QoS and security support in 4G networks, with the reasons as follows. Per-flow or per-user level actions occur much less frequent than per-packet actions, while per-packet actions are part of critical forwarding behavior, which involves very few control actions (which are typically

ISSN 2229-5518

simply to read and enforce according the install state during forwarding data). Actually, this separation concept is not new – routing protocols have the similar abstraction together used with the traditional IP packet delivery, this abstraction is recently being investigated in the IETF for CES working group. However, we emphasize the three critical dimensions of future 4G networks: mobility, QoS and security, as well as other new emerging or replacement components might appear, integrated into a unified framework and allowing more extensibility for 4G networks design.

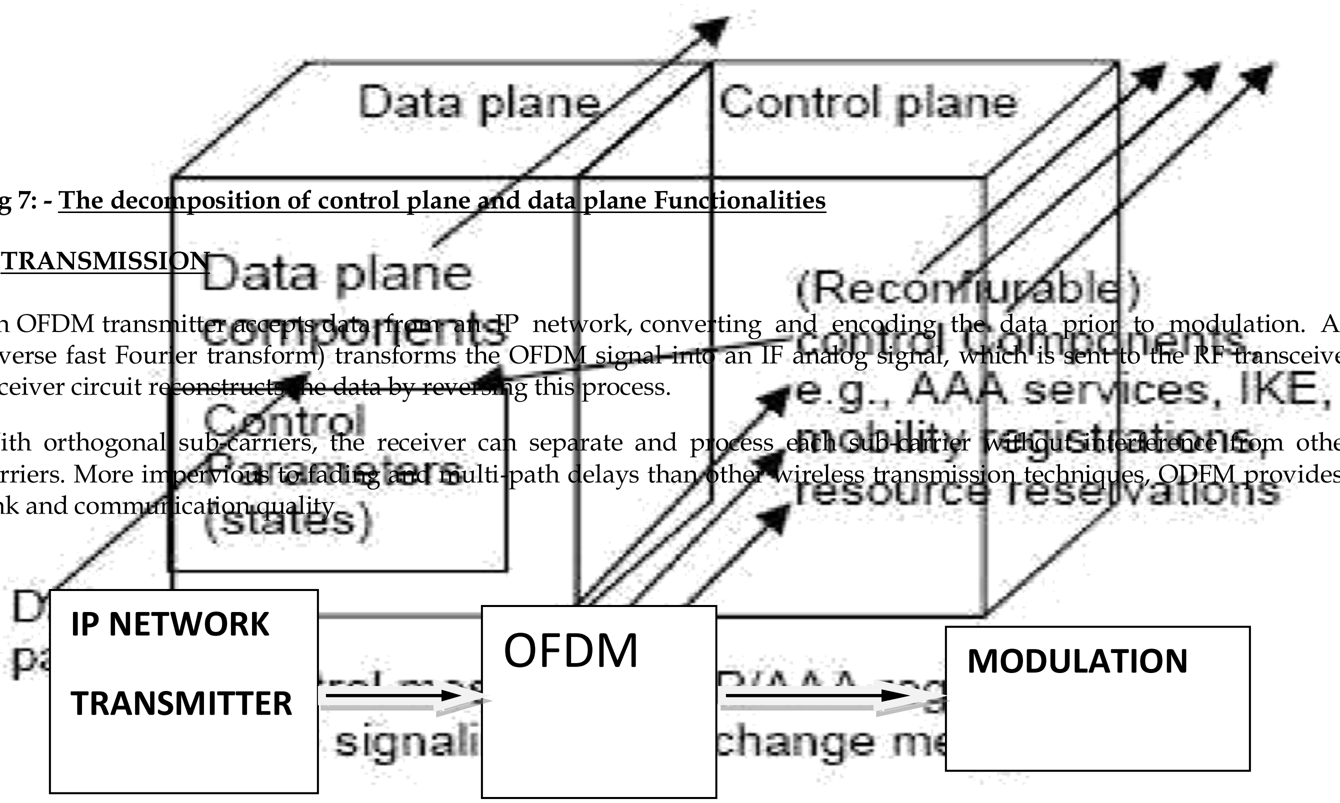

Fig 7: - The decomposition of control plane and data plane Functionalities

9. TRANSMISSION

An OFDM transmitter accepts data from an IP network, converting and encoding the data prior to modulation. An IFFT inverse fast Fourier transform) transforms the OFDM signal into an IF analog signal, which is sent to the RF transceiver. The receiver circuit reconstructs the data by reversing this process.

With orthogonal sub-carriers, the receiver can separate and process each sub-carrier without interference from other sub-carriers. More impervious to fading and multi-path delays than other wireless transmission techniques, ODFM provides better link and communication quality.

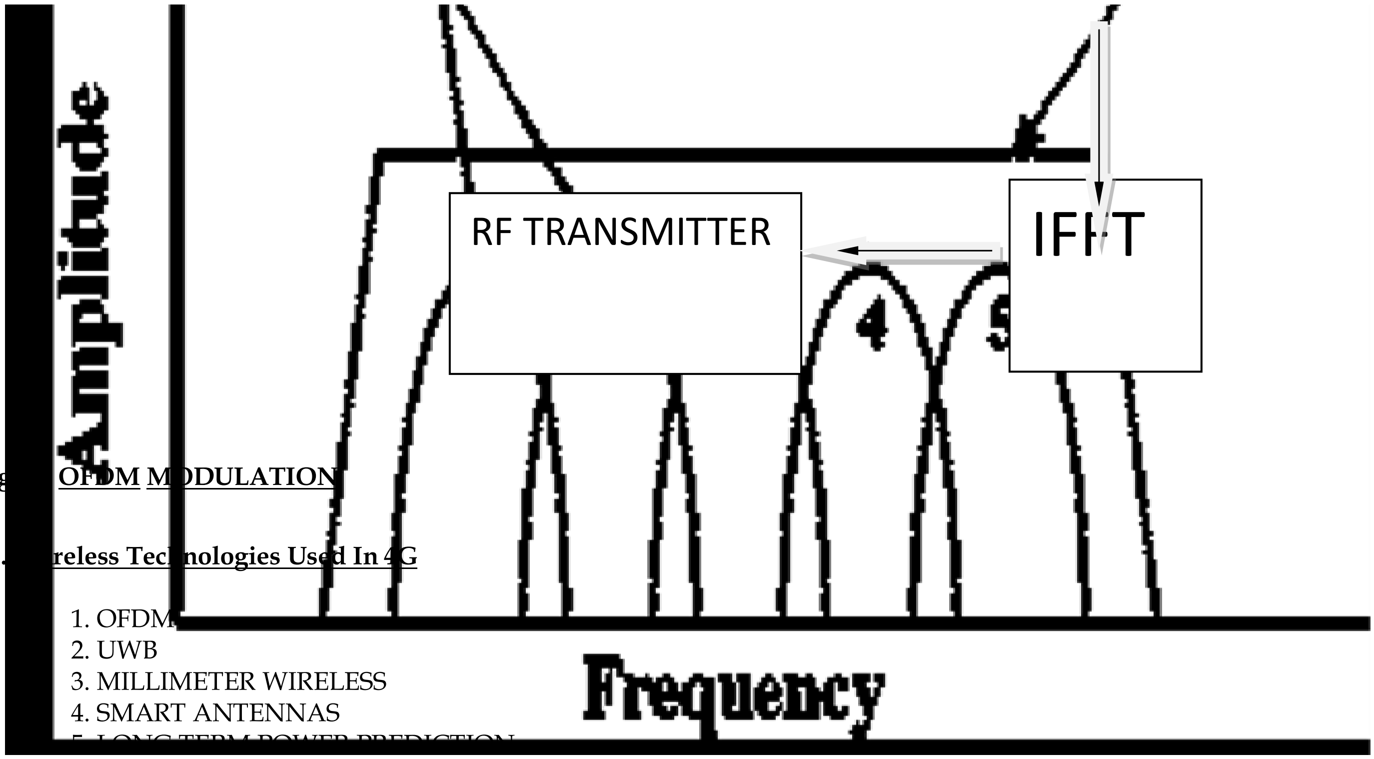

Fig OFDM MODULATION

10. Wireless Technologies Used In 4G

1. OFDM
2. UWB
3. MILLIMETER WIRELESS
4. SMART ANTENNAS
5. LONG TERM POWER PREDICTION
6. SHEDULING AMONG USERS
7. ADAPTIVE MODULATION AND POWER CONTROL

10.1 Orthogonal Frequency Division Multiplexing (OFDM):

OFDM, a form of multi-carrier modulation, works by dividing the data stream for transmission at a bandwidth B into N multiple and parallel bit8 streams, spaced B/N apart (**Figure**). Each of the parallel bit streams has a much lower bit rate than the original bit stream, but their summation can provide very high data rates. N orthogonal sub-carriers modulate the parallel bit streams, which are then summed prior to transmission.

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Fig 9: - Orthogonal Frequency Division Multiplexing

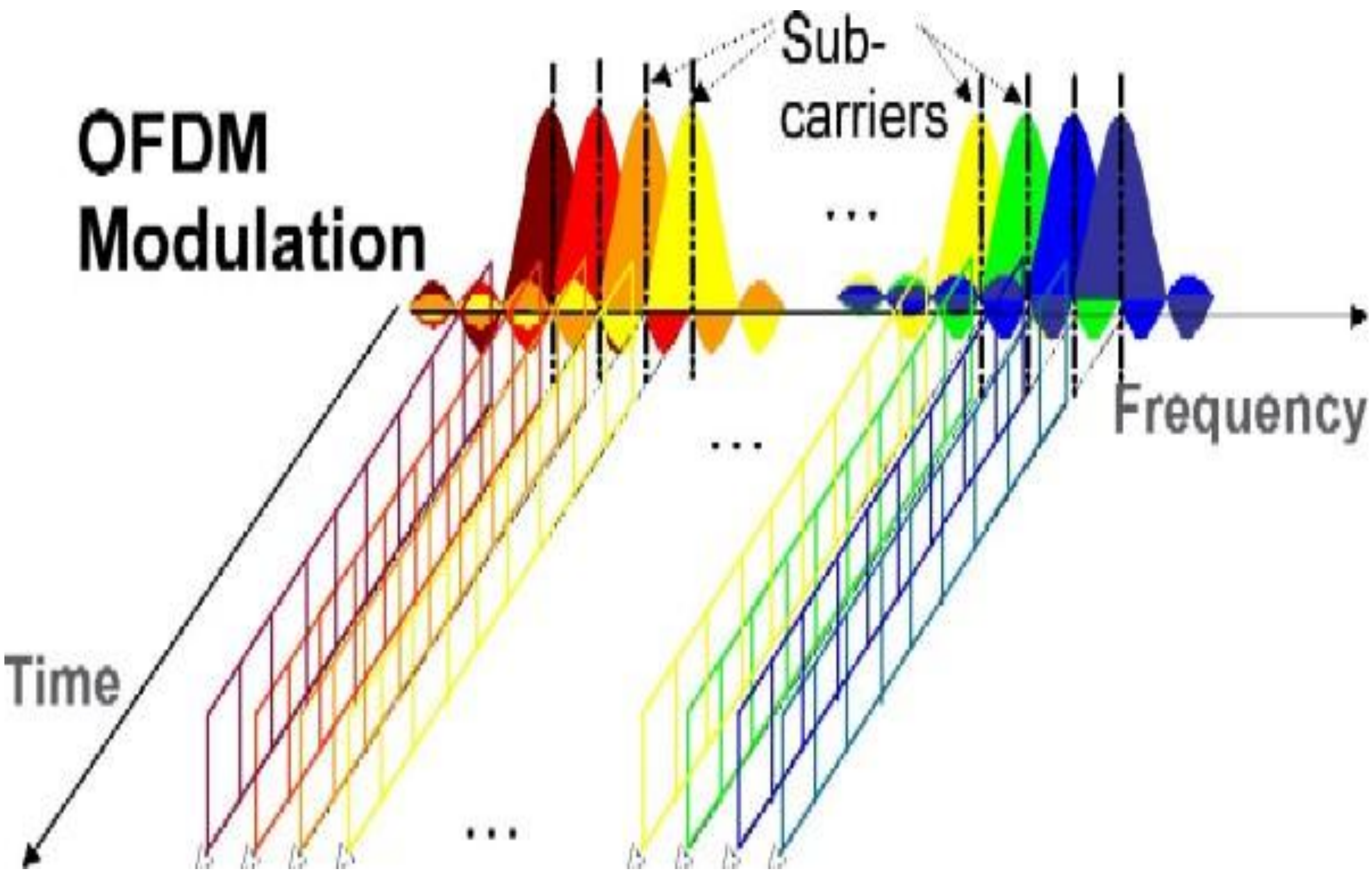

Fig 10: - OFDM BANDWIDTH DIVISION

10.1.1Error Correcting:

4G's error-correction will most likely use some type of concatenated coding and will provide multiple Quality of Service (QoS) levels. Forward error-correction (FEC) coding adds redundancy to a transmitted message through encoding prior to transmission. The advantages of concatenated coding (Viterbi/Reed-Solomon) over convolution coding (Viterbi) are enhanced system performance through the combining of two or more constituent codes (such as a Reed-Solomon and a convolutional code) into one concatenated code. The combination can improve error correction or combine error correction with error detection (useful, for example, for implementing an Automatic Repeat Request if an error is found). FEC using concatenated coding allows a communications system to send larger block sizes while reducing bit-error rates.

10.2 Ultra Wide Band (UWB) :

A UWB transmitter spreads its signal over a wide portion of the RF spectrum, generally 1 GHz wide or more, above 3.1GHz. The FCC has chosen UWB frequencies to minimize interference to other commonly used equipment, such as televisions and radios. This frequency range also puts UWB equipment above the 2.4 GHz range of microwave ovens and modern cordless phones, but below 802.11a wireless Ethernet, which operates at 5 GHz.

UWB equipment transmits very narrow RF pulses—low power and short pulse period means the signal, although of wide bandwidth, falls below the threshold detection of most RF receivers. Traditional RF equipment uses an RF carrier to transmit a modulated signal in the frequency domain, moving the signal from a base band to the carrier frequency the transmitter uses. UWB is "carrier-free", since the technology works by modulating a pulse, on the order of tens of microwatts, resulting in a waveform occupying a very wide frequency domain. The wide bandwidth of a UWB signal is a two-edged sword.

The signal is relatively secure against interference and has the potential for very high-rate wireless broadband access and speed. On the other hand, the signal also has the potential to interfere with other wireless transmissions. In addition, the low-power constraints placed on UWB by the FCC, due to its potential interference with other RF signals, significantly limits the range of UWB equipment (but still makes it a viable LAN technology).

One distinct advantage of UWB is its immunity to multi-path distortion and interference. Multi-path propagation occurs when a transmitted signal takes different paths when propagating from source to destination. The various paths are caused by the signal bouncing off objects between the transmitter and receiver—for example, furniture and walls in a house, or trees and buildings in an outdoor environment.

One part of the signal may go directly to the receiver while another; deflected part will encounter delay and take longer to reach the receiver. Multi-path delay causes the information symbols in the signal to overlap, confusing the receiver—this is known as inter-symbol interference (ISI). Because the signal's shape conveys transmitted information, the receiver will make mistakes when demodulating the information in the signal.

For long-enough delays, bit Errors in the packet will occur since the receiver can't distinguish the symbols and correctly interpret the corresponding bits. The short time-span of UWB waveforms—typically hundreds of picoseconds to a few nanoseconds—means that delays caused by the transmitted signal bouncing off objects are much longer than the width of the original UWB pulse, virtually eliminating ISI from overlapping signals. This makes UWB technology particularly useful for intra-structure and mobile communications applications, minimizing S/N reduction and bit errors.

10.3 Millimeter Wireless:

Using the millimeter-wave band (above 20 GHz) for wireless service is particularly interesting, due to the availability in this region of bandwidth resources committed by the governments of some countries to unlicensed cellular and other wireless applications. If deployed in a 4G system, millimeter wireless would constitute only one of several frequency bands, with the 5 GHz band most likely dominant.

Fig 10: - MILLI-METER WIRELESS ANTENNA

10.4 Smart Antennas:

A smart antenna system comprises multiple antenna elements with signal processing to automatically optimize the antennas' radiation (transmitter) and/or reception (receiver) patterns in response to the signal environment. One smart-antenna variation in particular, MIMO, shows promise in 4G systems, particularly since the antenna systems at both transmitter and receiver are usually a limiting factor when attempting to support increased data rates.

MIMO (Multi-Input Multi-Output) is a smart antenna system where 'smartness' is considered at both transmitter and the receiver. MIMO represents space-division multiplexing (SDM)—information signals are multiplexed on spatially separated N multiple antennas and received on MIMO antennas. **Figure shows** a general block diagram of a MIMO system. Some systems may not employ the signal-processing block on the transmitter side.

Multiple antennas at both the transmitter and the receiver provide essentially multiple parallel channels that operate simultaneously on the same frequency band and at the same time. This results in high spectral efficiencies in a rich scattering environment (high multi-path), since you can transmit multiple data streams or signals over the channel simultaneously. Field experiments by several organizations have shown that a MIMO system, combined with adaptive coding and modulation, interference cancellation, and beam-forming technologies, can boost useful channel capacity by at least an order of magnitude.

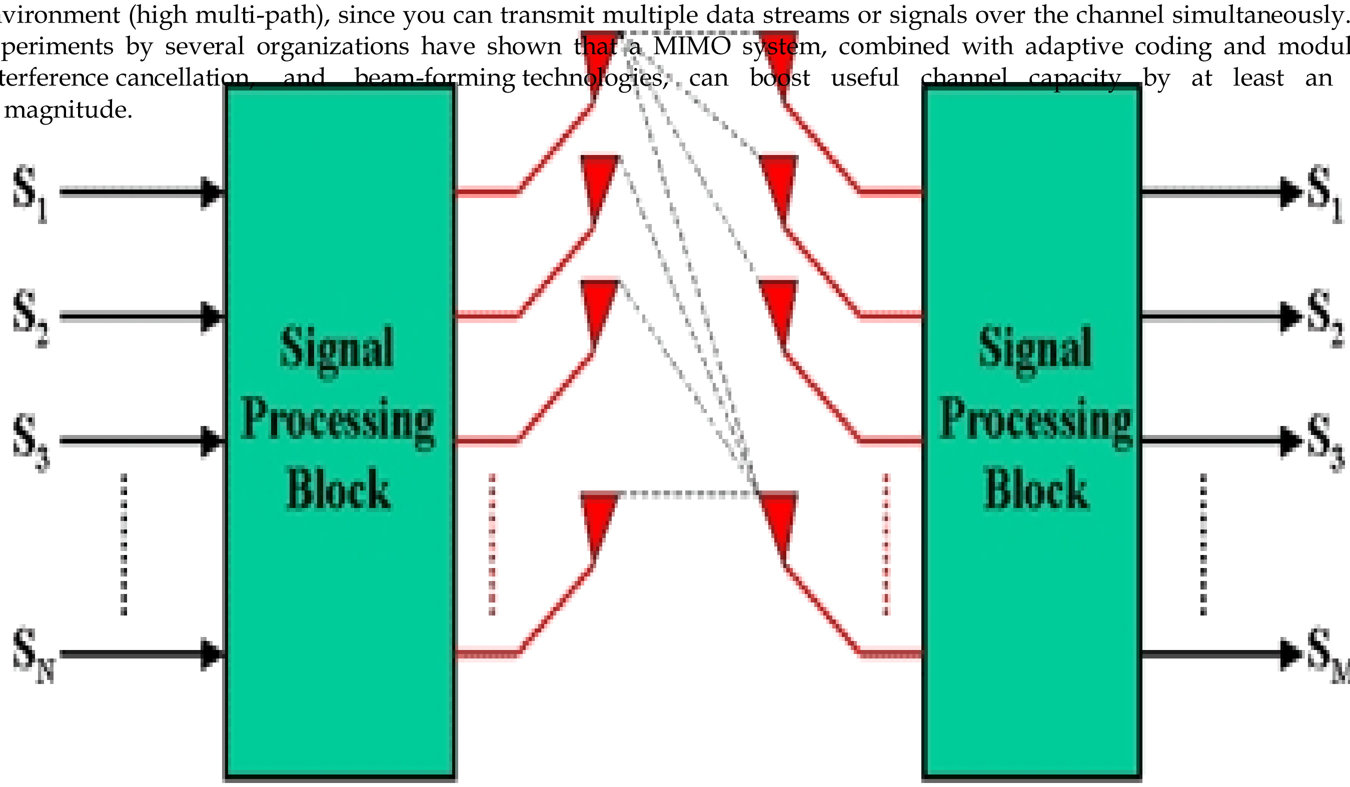

Fig 11:- Multiple Input Multiple Outputs

10.5 Long Term Power Prediction:

Channels to different mobile users will fade independently. If the channel properties of all users in a cell can be predicted a number of milliseconds ahead, then it would be possible to distribute the transmission load among the users in an optimal way while fulfilling certain specified constraints on throughput and delays. The channel time-frequency pattern will depend on the scattering environment and on the velocity of the moving terminal.

In order to take the advantage the channel variability, we use OFDM system with spacing between sub-carriers such that no inter channel interface occurs for the worst case channel scenario (Low coherence bandwidth).A time-frequency grid constituting of regions of one time slot and several subcarriers is used such that the channel is fairly constant over each region. These time-frequency regions are then allocated to the different users by a scheduling algorithm according to some criterion.

10.6 Scheduling among Users:

To optimize the system throughput, under specified QoS requirements and delay constraints, scheduling will be used on different levels:

10.6.1 Among sectors:-

In order to cope with co-channel interference among neighboring sectors in adjacent cells, time slots are allocated according to the traffic load in each sector .Information on the traffic load is exchanged infrequently via an inquiry procedure. In this way the interference can be minimized and higher capacity be obtained.

After an inquiry to adjacent cells, the involved base stations determine the allocation of slots to be used by each base station in each sector. The inquiry process can also include synchronization information to align the transmission of packets at different base stations to further enhance performance.

10.6.2 Among users:-

Based on the time slot allocation obtained from inquiry process, the user scheduler will distribute time-frequency regions among the users of each sector based on their current channel predictions. Here different degrees of sophistication can be used to achieve different transmission goals.

10.7 Adaptive modulation and power control:

In a fading environment and for a highly loaded system there will almost exist users with good channel conditions. Regardless of the choice of criterion, which could be either maximization of system throughput or equalization to user satisfaction, the modulation format for the scheduled selected according to the predicted signal to noise and interference ratio user is by using sufficiently small time-frequency bins the channel can be made approximately constant within bins. We can thus use a flat fading AWGN channel assumption.

Furthermore since we have already determined the time slot allocation, via the inquiry process among adjacent cells described above we may use an aggressive power control scheme, while keeping the interference on an acceptable level.

For every timeslot, the time-frequency bins in the grid represent separate channels. For such channels the optimum rate and power allocation for maximizing the throughput can be calculated under a total average power constraint. The optimum strategy is to let one user, the one with best channel, transmit in each of the parallel channels.