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Comparisons in all generations 1g, 2g, 3g, 4g ,4.5G

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Abstract:

In this paper we study the survey or comparison between the evolution of networks i.e. 1G, 2G , 3G, 4G and 4.5G. This paper covers all the terms that can be used in all networks and how new networks can be evolved and also covers the features of new networks and also tell about the demerits and merits of all generations. In other words we can say that we're going to cover off the major differences between the different 'generation' networks and check out some of the technical aspects of the different technologies.

Keyword : 2G; 3G; LTE; LTE-Advanced

Introduction:

Communication is one of the integral parts of science that has always been a focus point for exchanging information among parties at locations physically apart. After its discovery, telephones have replaced the telegrams and letters. Similarly, the term 'mobile' has completely revolutionized the communication by opening up innovative applications that are limited to one's imagination. Today, mobile communication has become the backbone of the society. All the mobile system technologies have improved the way of living. Its main plus point is that it has privileged a common mass of society. In this paper, the evolution as well as the fundamental techniques of the mobile communication is discussed.

1G-Analog:

Introduced in 1987 by Telecom (known today as Telstra), Australia received its first cellular mobile phone network utilising a 1G analog system. The technology behind 1G was the AMPS (Advanced Mobile Phone System) network. Permanently switched off at the end of 1999, AMPS was a voice-only network operating on the 800MHz band. Being a primitive radio technology, AMPS operated in the same manner as a regular radio transmission, much like your UHF radio where the 800MHz band was split up into a number of channels (395 voice, 21 control) via FDMA (Frequency Division Multiple Access).

Problem arise: It is not just a limited number of users .Just like your UHF radio, anyone with a radio scanner capable of receiving/transmitting on the 800MHz band could drop in on your call. Being analog, the 800MHz band was also susceptible to background noise and static caused by nearby electronic devices. However the simplicity of the AMPS design meant it did have one advantage over later 2G networks - coverage. An AMPS user could connect to a cell tower as far as the signal could be transmitted (often >40km depending on terrain).

2G-Digital:

Fast forward to 1993 Telecom, now known as Telstra, introduces the digital network. The introduction came about to overcome many of the issues with the AMPS network highlighted above, with network congestion and security being the most important two motivators. With this new technology came many of the services we now take for granted - text messaging, multimedia messaging, internet access, etc, and also introduced us to the SIM card.

This fancy new digital network is called GSM - Global System for Mobile Communication, and its technological backbone of choice is TDMA (similar to FDMA). The radio frequency band utilised by GSM is the 900MHz spectrum and later introduced on the 1800MHz band.

So how is this network any better than AMPS? The secret lies in TDMA - Time Division Multiple Access. The FDMA component splits the 900MHz (actually 890MHz to 915MHz) band into 124 channels that are 200KHz wide. The 'time' component then comes into play in which each channel is split into eight 0.577us bursts,significantly increasing the maximum number of users at any one time. We don't hear a 'stuttering' of a persons voice thanks to the wonders of digital compression codecs, which we're not going to go into here.

Problem Arise: Unlike its AMPS predecessor, GSM is limited severely in range. The TDMA technology behind the 2G network means that if a mobile phone cannot respond within its given timeslot (0.577us bursts) the phone tower will drop you and begin handling another call. Aside from this, packet data transmission rates on GSM are extremely slow, and if you're on Vodafone/3/Virgin/Optus you've probably had first hand experience on this when you go outside your networks defined 'coverage zone'.

To overcome these two problems we're going to introduce two new networks - CDMA and EDGE.

CDMA

Code Division Multiple Access. This branch of 2G was introduced by Telstra in September 1999 as a replacement for customers who could receive a good signal on AMPS, but were outside GSM's limited range.

EDGE

Enhanced Data Rates for GSM Evolution. GSM introduced a GPRS based packet data network in 2001, with a max speed of around 60-80kbps (downlink), equating to a download speed of 10kB/s - slightly faster than dial-up.

3G - The Mobile Broadband Revolution

Introducing the 2100MHz network. Three Mobile in conjunction with Telstra brought the 3G standard to life in 2005, servicing major metropolitan areas initially and over the following years expanding coverage to 50% of the Australian population.

The 3G standard utilises a new technology called UMTS as its core network architecture - Universal Mobile Telecommunications System. This network combines aspects of the 2G network with some new technology and protocols to deliver a significantly faster data rate.

So how is 3G faster than 2G? UMTS employs a protocol called HSPA - High Speed Packet Access, which is a combination of HSDPA (downlink) and HSUPA (uplink) protocols. The Telstra HSDPA network supports category 10 devices (speeds up to 14.4Mbps down) however most devices are only capable of category 7/8 transmission (7.2Mbps down), and its HSUPA network supports category 6 (5.76Mbps up). These protocols have an improved transport layer by a complex arrangement of physical layer channels (HS-SCCH, HS-DPCCH and HS-PDSCH). The technological implementation of HSPA will not be discussed here but for a basic explanation feel free to watch the below video.

Problem Arise: The only major limitation of the 3G network is, not surprisingly, coverage. As stated earlier the 2100MHz network is available to around 50% of Australia's population and when combined with a 900MHz UMTS network available to about 94%. As expected, the higher 2100MHz component suffers far more attenuation and FSPL and is often considered a 'short range' mobile network which is why a lower 900MHz network is required to service many regional and rural areas.

Next-G - 3G on Steroids

To overcome the coverage limitations of regular 3G, Telstra introduced its Next-G network (considered a '3.5G' network) in late 2006, operating on the 850MHz spectrum. The lower radio frequency coupled with a far greater number of phone towers is responsible for Telstra's Next-G network being over twice the geographical size (around 2.2 million square km) of any other network, and servicing 99% of Australian residences.

4G - LTE-Advanced

Initially available in major cities, airports and selected regional areas in October 2011, Telstra's 4G network offers significantly faster speeds, lower latency, and reduced network congestion.

The 4G network is based on LTE-Advanced - 3GPP Long Term Evolution. LTE is a series of upgrades to existing UMTS technology and will be rolled out on Telstra's existing 1800MHz frequency band. This new network boosts peak downloads speeds up to 100Mbps and 50Mbps upload, latency reduced from around 300ms to less than 100ms, and significantly lower congestion. For more technical details on peak 4G speeds check out our fastest 4G speed guide.

4G bandwidth (ie the width of frequencies we can send and receive on) is critical in supporting high speed and a high number of users. Because in order for your connection not to get confused with someone else's, each user is allocated a small sliver of frequencies that they can transmit on and nobody else can. You'll notice this most during peak usage hours, where as more people start using the tower it will reduce the width of your (and everyone else's) sliver of frequencies, resulting in each person getting a reduced download/upload speed.

Architectures of all Generations:

Architecture of 1G:

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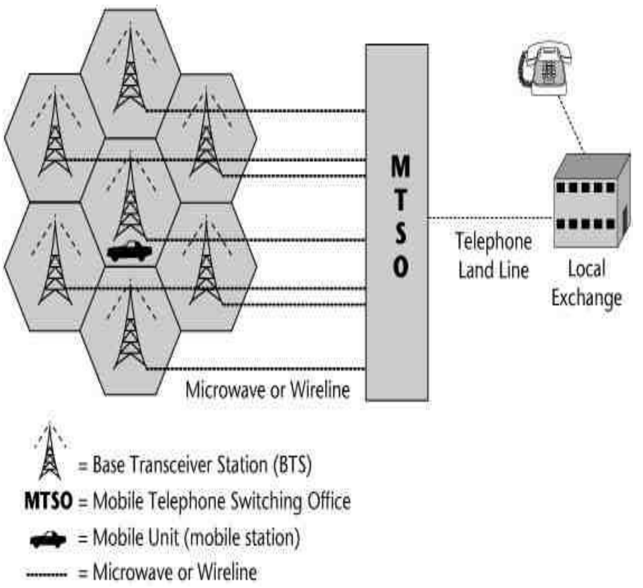
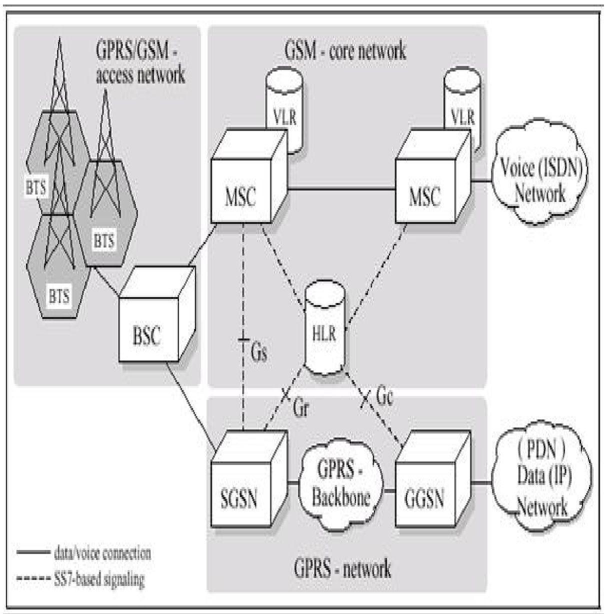


BTS: The **Base Transceiver Station** (**BTS**) is a term used to denote a base station in GSM terminology. A **BTS** consists of an antenna and the radio equipment necessary to communicate by radio with a Mobile Station (MS). Each **BTS** covers a **defined** area, known as a cell.

MTSO: The **Mobile Telephone Switching Office** (**MTSO**) is the mobile equivalent to a PSTN Central Office. The **MTSO** contains the switching equipment or Mobile Switching Center (MSC) for routing mobile phone calls. It also contains the equipment for controlling the cell sites that are connected to the MSC.

MU: an establishment on wheels (as an automobile or trailer) equipped for some special service (as a traveling library, an ambulance, an X-ray clinic, or television pickup).

Architecture of 2G:



BTS : Working is same as 1G (**Base Transceiver Station** (**BTS**))

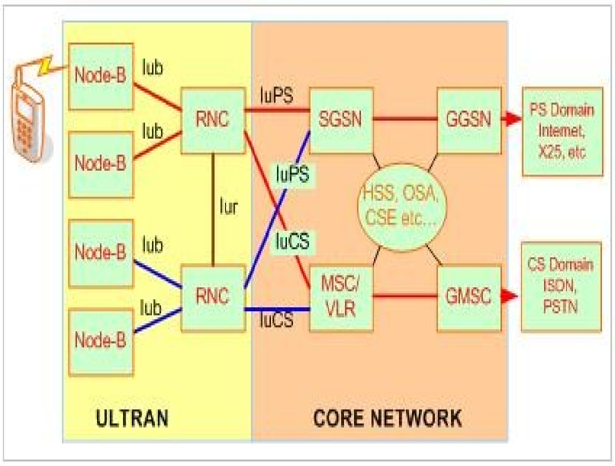
BSC: The **base station controller** (BSC) provides, classically, the intelligence behind the BTSs. Typically a BSC has tens or even hundreds of BTSs under its control. The BSC handles allocation of radio channels, receives measurements from the mobile phones, and controls handovers from BTS to BTS (except in the case of an inter-BSC handover in which case control is in part the responsibility of the anchor MSC**)**

MSC: The **mobile switching centre**, abbreviated as **MSC Server** or **MSS**, is a 2G core network element which controls thenetwork switching subsystem elements.

GPRS Core Network: This is the central part of the general packet radio service (GPRS) which allows 2G , 3G and WCDMA mobile networks to transmit IP packets to external networks such as the Internet . The GPRS system is an integrated part of the GSM network switching subsystem**.**

GSM Core Network: This is component of a GSMsystem that carries out call switching and mobility management functions for mobile phones roaming on the network of base stations. It is owned and deployed by mobile phone operators and allows mobile devices to communicate with each other and telephones in the wider public switched telephone network (PSTN).

Architecture of 3G:

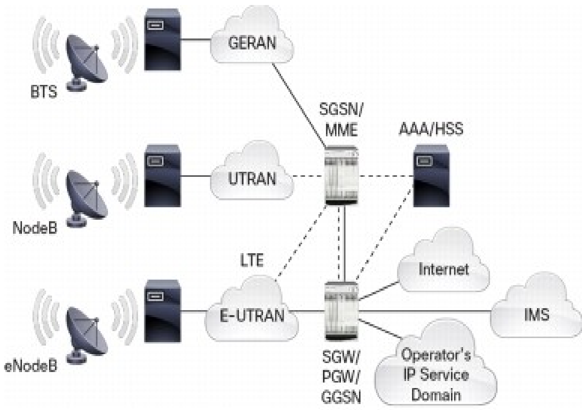


Node B: A **Node B** is a term to denote a base station in UMTS terminology. The**Node B** is responsible for the radio link between the mobile user and the fixed part of the network .

UTRAN: Universal Terrestrial Radio Access Network is a collective term for the network and equipment that connects mobile handsets to the public telephone network or the Internet.

Core Network: The Core Network is divided in circuit switched and packet switched domains. Some of the circuit switched elements are Mobile services Switching Centre (MSC), Visitor location register (VLR) and Gateway MSC. Packet switched elements are Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN). Some network elements, like EIR, HLR, VLR and AUC are shared by both domains.

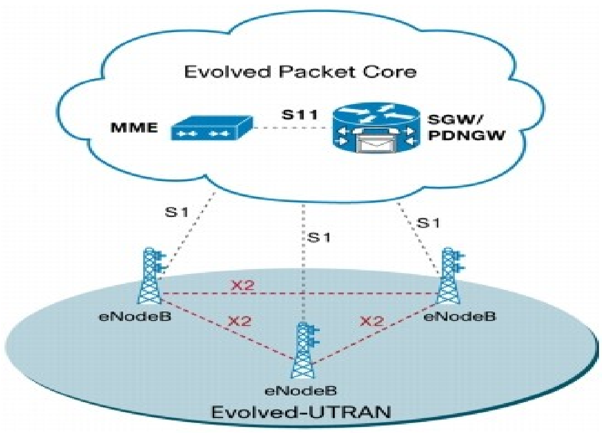
Architecture of 4G (LTE):



E-UTRAN: It is the air interface of 3GPP's Long Term Evolution (LTE) upgrade path for mobile networks.

eNodeB: E-UTRAN Node B, also known as Evolved Node B, (abbreviated as **eNodeB** or eNB) is the element in E-UTRA of LTE that is the evolution of the element Node B in UTRA of UMTS.

Architecture of LTE-Advanced:



Evolved Packet Core: It is a flat architecture that provides a converged voice and data networking framework to connect users on a Long-Term Evolutio (LTE) network.

First level and second level in architecture is same only difference in the technology terms means we provide standard name according to the evolution there is a difference in third level architecture.

Ist Level: BTS (1G)=BTS(2G)=NodeB(3G)=eNodeB(4G).

IINd Level: MTSO(1G)=BSC(2G)=UTRAN(3G)=E-UTRAN(4G).

If we talk about the difference in working in all generations i.e.

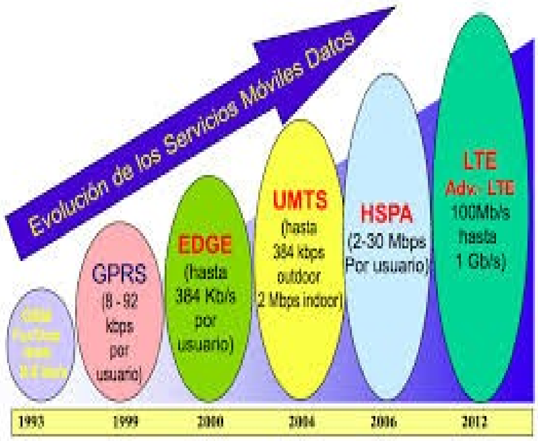
1G(Voice): They used various analog modulation for data transfer. Now when the communication migrated from analog to digital, the foundation of latest communication were led. Hence came 2G.

2G (Voice+SMS/MMS): It marked the start of digital voice communication era. Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of CDMA and GSM. Provided small data service like sms and mms. Note that 2G internet services came after the 3G estabishment.

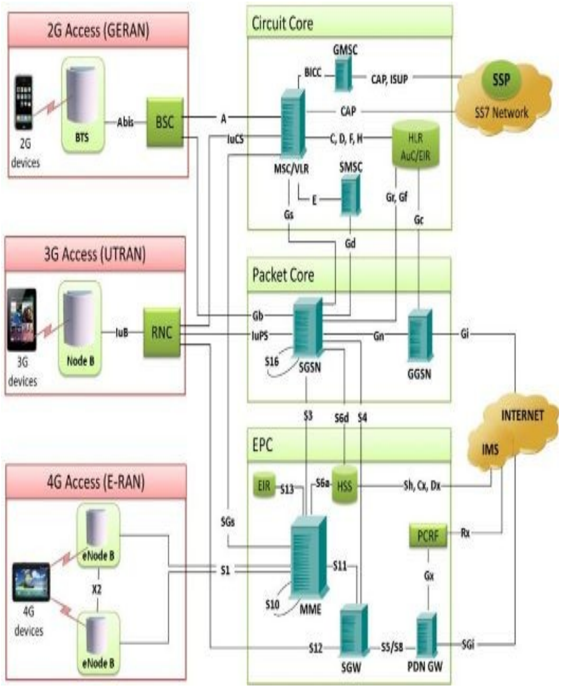
3G (Voice + Data): Then came the time of some decent speed internet connection and awesome voice channel. They exploited area of Wideband-CDMA(W-CDMA), provided better bandwidth and better connectivity even during motion(like in vehicle, train). There was some technical shift towards HSPA for better data communication and to maintain 4G compatibility.

4G (Only DATA and Voice over data): Era of broadband wireless. This in the making and have been successfully deployed in only some part of the world. Best aspect of 4G is the use of data services for everything. Internet is the back bone and even voice call is done over internet. There is no separate voice channel. This allows usage of wider bandwidth in the communication channel for data.

Evolution from 1G to LTE-Advance



Overall Architecture and show the difference in one Figure:



Below figure shows the difference in speed of downloading the data in different generations:

WIRELESS GENERATION	Download NewYork Times home page (1.4MB)	Download 3-minute MP3 file (4MB)	Download 3-minute web video (10MB)
2G Average speed 125 kbps	90 seconds	2 minutes, 16 seconds	10 minutes, 40 seconds
3G Average speed 800 kbps	14 seconds	40 seconds	1 minute, 40 seconds
4G Average speed 1.5 mbps	7 seconds	21 seconds	53 seconds

Below figure also shows the comparision of speeds in different generations:

Comparison between 1G,2G,3G & 4G

Generation	Time Period	Definition	Characteristics	Speed
I (1G)	1980-1990	Analog	Voice only	14.4 Kbps (peak)
II (2G)	1990-2006	Digital narrow band circuit data/packet data	Data along voice, MMS, web browsing.	56Kbps to 115 kbps
III (3G)	2006-2011	Digital broadband packet data.	Universal access, portability, Video calling	5.8 Mbps to 14.4 Mbps
IV (4G)	Now (Upcoming)	Digital broadband packet very high throughput	HD streaming, portability increased to Worldwide roaming.	100 Mbps to 1 Gbps

Conclusion:

As mentioned above, the last decade stood witness to an astounding growth in the network communication industry. Attempts have been made to reduce a number of technologies to a single global standard or The ever-increasing demands of users triggered research and led to development of various generations of technologies, which recently lead to a comprehensive manifestation of upcoming 4.5G system(LTE-Advanced). As the history of mobile communications shows, attempts have been made to reduce numerous technologies to a single global standard. 1G had fulfilled the need for a basic mobile voice, the 2G had introduced capacity and coverage, followed by 3G, which had a quest for data at higher speeds to open the gates for truly a mobile broadband experience, which was further realized by the 4G. LTE-Advanced promises to bring higher data transfer speeds (reaching up to few gigabits per sec) and various other high quality services. 3G came into India only recently, and the cost for the same is still high. 4G is expected to come to India by the end of 2014, and there is no doubt that it will be embraced by all telecom users, seeing yet another monumental shift in Wireless Connectivity Technology or in other words we can say that the upcomping 4.5G System offer this promise of a standard. So 4G or 4.5G (LTE or LTE-advanced) will be the best as compared with its predecessors.

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