CHAPTER II: WIRELESS AND MOBILE NETWORK ARCHITECTURE

2.1. Introduction

A **wireless network** is communication without wires as transmission medium or without a physical Channel. It allows homes, telecommunications networks and businesses to avoid the costly process of introducing cables into a building or between equipment locations. The wireless communication revolution is bringing fundamental changes to data networking, telecommunication, and is making integrated networks a reality. By freeing the user from the cord, personal communications networks, wireless LAN's, mobile radio networks and cellular systems, harbor the promise of fully distributed mobile computing and communications, anytime, anywhere.

2.2. Wireless network components

Wireless local area networks (WLANs) use the same basic structure of components as the traditional Ethernet-wired networks. However, instead of cables, WLANs use infrared or radio frequency technology to transmit data around the network.

Businesses typically use wireless networks within a single building, or as a building-to-building connection, often as an extension to a wired network.

The physical **WLAN architecture** is fairly simple. Basic components of WLAN are typically:

- wireless access points
- network interface cards (NICs) or client adaptors

You can use other components, such as wireless bridges and repeaters, to extend the reach of your network.

2.2.1. Wireless access points

A **central access point** is basically the wireless equivalent of a LAN hub. It is a small box (with one or more aerials) that uses a connector to attach it to the rest of your wired LAN.

Access points receive and transmit data from and to all the wireless devices in their area. They can handle many different connections between different devices all talking to each other at once, but the more devices you have working with an access point, the slower they will operate.

You may need more than one access point to cover a building, depending on its range and the composition of any walls or floors between the access point and the wireless network card.

Wireless Access Point

2.2.2. Wireless network interface card (NIC)

The **network interface card** acts as the radio receiver and transmitter for a specific computer and connects it into the WLAN. It is coupled with the device operating system using a software driver. Many modern laptops or tablets have this Wi-Fi capability built-in, but with older desktop PCs you may need to install one.

Most wireless network cards connect to an access point. However, some NICs can enable a **peer-to-peer connection** - ie they can talk to other compatible network cards that are within its range. This may be useful for small roaming workgroups of devices that do not require access to the LAN backbone.

2.3.Wireless range extenders

Wireless repeaters can improve or extend coverage of your network. They work by receiving your existing Wi-Fi signal and relaying your requests and responses back and forwards between your device and your main Wi-Fi router/access point. With a repeater, you can effectively double the range of your WLAN.

Most WLANs are installed using access points that have **omnidirectional aerials** or antennae. These transmit wireless signals in all directions, as opposed to directional antennae, which produce a more concentrated signal, focused on a narrower area. Depending on the type of signal you need, replacing the antenna of your wireless access point may give you a better range.

2.4.Wireless formats

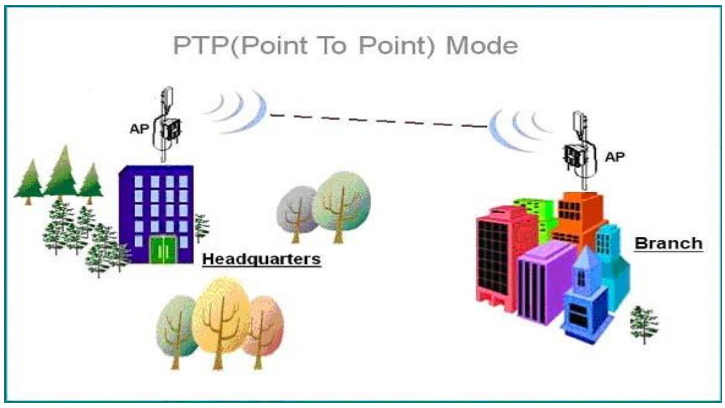
The domain of wireless technologies covers several facets, which we have grouped into: fixed, moveable and nomadic (moving). In addition, they may be simplex, dual-simplex, and full duplex in form.

2.4.1. Point-to-point links

Point-to-point wireless systems are typified by the parabolic antenna of a microwave link, that is, one unit communicates to one, and only one, other unit. It's a form of wireless cable. The node can communicate reliably as long as the two end points are close enough to one another (to see each other) and escape the effects RF interference (RFI) and attenuation.

If unable to achieve a reliable connection initially, sometimes relocating the antennas or boosting the transmit power can achieve the desired reliability. When the end points are farther apart than a single hop (i.e one transmitter and one receiver) can support, for example, greater than about 30miles, or have obstacles in the way, repeating units can make the links work.

Fixed wireless can operate in a regulated part of the radio frequency spectrum or it may use unregulated spectrum and/or spread-spectrum technology. In addition, it can use above-radio-frequency optical spectrum. While the standard point-to- point microwave systems have a range up to 30 miles.



Point-to –point link

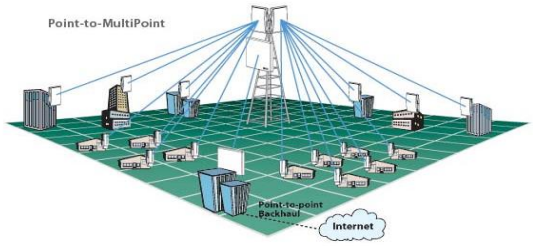
2.4.2. Point-to-multi-points links

In the point-to-multipoint links, there are multiple receiving points connected to a single transmitter. Point-to-multipoint (PMP) communication refers to communication that is accomplished through a distinct and specific form of one-to-many connections, offering several paths from one single location to various locations. Point-to-multipoint is generally abbreviated as PTMP, P2MP or PMP. PMP communication is commonly used in telecommunications.

PMP is usually used for establishing private enterprise connectivity to offices in remote locations, long-range wireless backhaul solutions for various sites, and last-mile broadband access. As such, it is widely used in IP telephony and wireless Internet by means of gigahertz radio frequencies. These PMP networks are employed in distribution amenities, huge corporate campuses, school districts, public safety applications, etc.

The point-to-multipoint topology consists of a central base station that supports several subscriber stations. These offer network access from a single location to multiple locations, permitting them to use the same network resources between them. The bridge located at the central location is known as the base station bridge or root bridge. All data that passes between the wireless bridge clients should initially go via the root bridge.

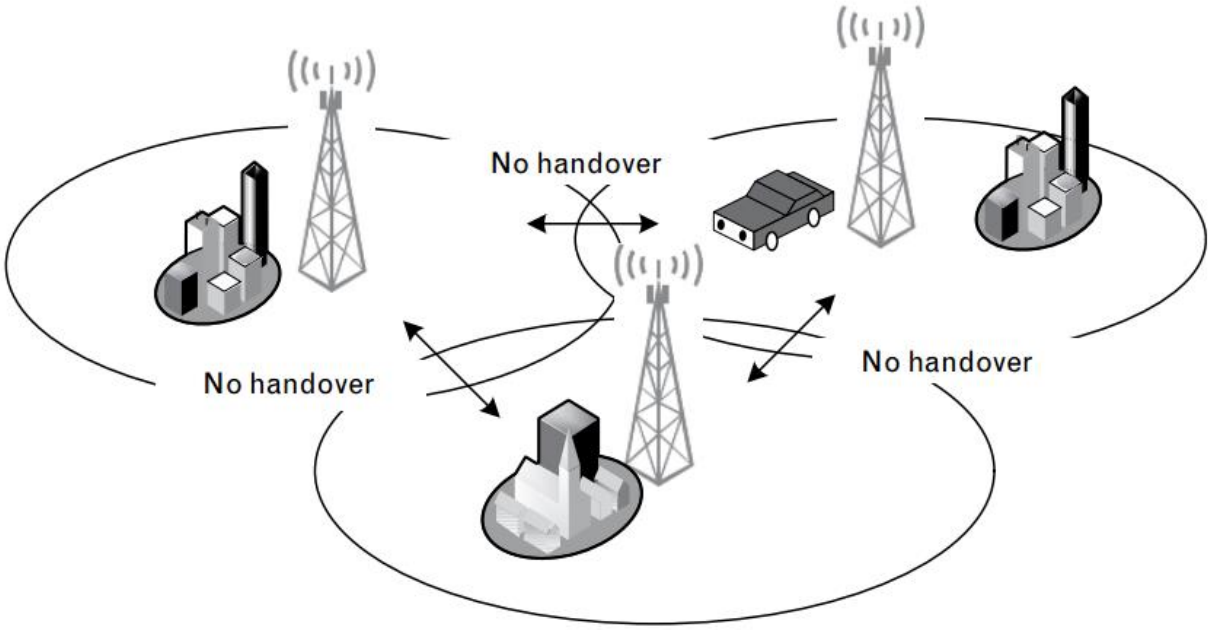
As example of this is satellite communications, where the ground transmitter and orbiting transponder act as single unit but are being received by many dispersed units. Originally, satellite data communications were simplex transmissions but are now half-duplex, or, better stated, dual-simplex as different frequencies are used, creating dual channels for the-to-node and the from-node transmissions. Reliability of these satellites is good, although heavy rain or snow can degrade or interrupt transmission.



Point-to-multipoint links

2.5.First Generation (1G)

Mobile telecommunications actually has quite a long history already. The first generation cellular systems were launched around 1980, but it must be noted that there were already mobile phones in existence long before that. The first mobile phone systems were launched soon after the Second World War, first in the United States and thereafter in various European countries. But these were radio telephones, not cellular systems (see Figure below).



The first generation cellular systems were analog systems (for voice channels, that is; control channels were already digital in most systems). Each frequency carrier could carry only one call.

First generation networks were typically only countrywide. 1G was an analog technology and the phones generally had poor battery life and voice quality was large without much security, and would sometimes experience **dropped calls**. These were the analog telecommunications standards and continued until being replaced by 2G digital telecommunications. The maximum speed of 1G is **2.4 Kbps**. The technology was distinct in different countries, and thus roaming to other networks was not supported.

2.6.Second Generation

2.6.1. Introduction

The second generation was the first one to employ all-digital transmission technology, both for signaling and traffic. This greatly enhanced the capacity of systems and quality of services. In first generation systems, one call required one frequency channel (in full-duplex systems this was actually two frequencies; one for the uplink and one for the downlink), but in second generation systems one frequency channel was divided between several users by means of time-division or code-division techniques, which resulted in increased system capacity. There were also many

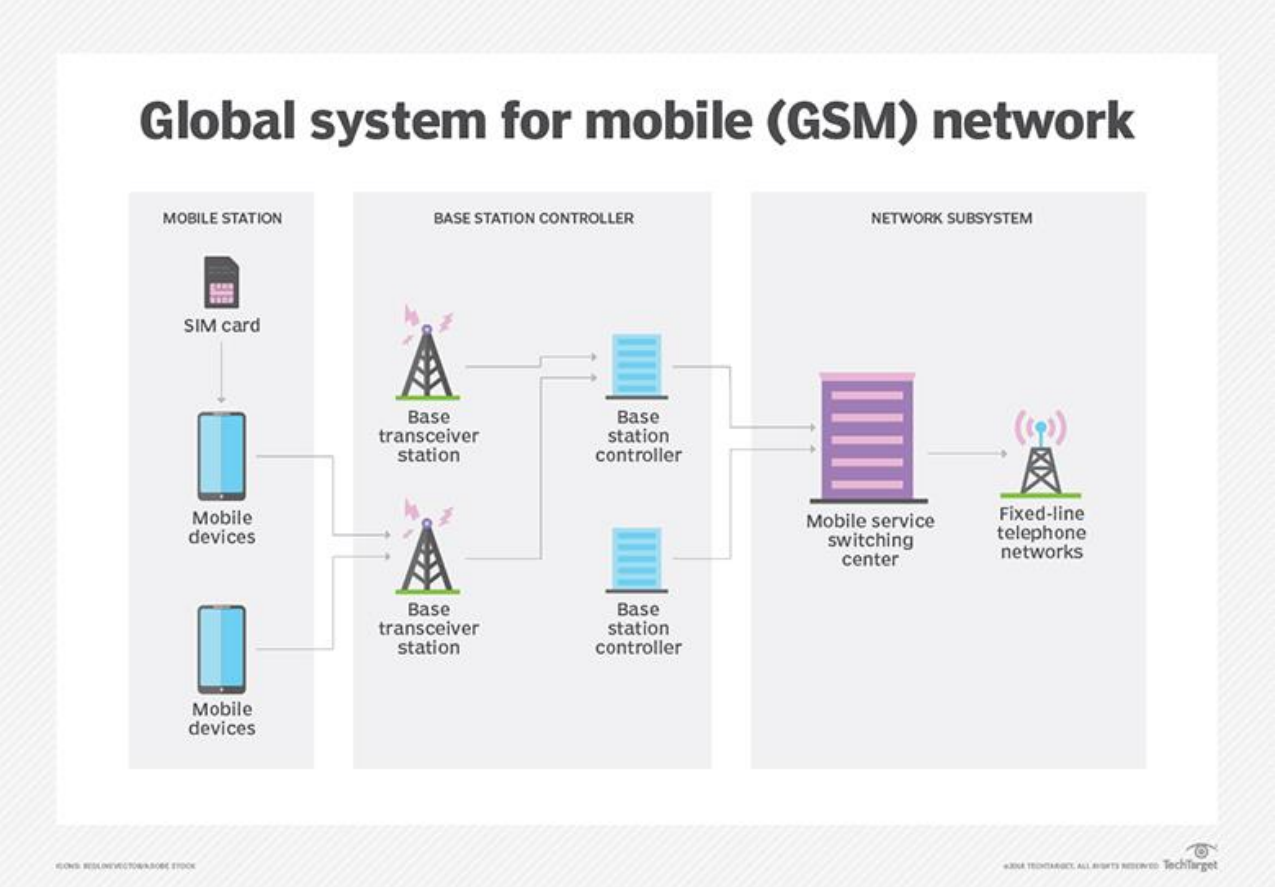
other improvements in 2G that increased the system capacity even further. It is good to note that the development of a major mobile communications standard is a continuous process. Cell phones received their first major **upgrade** when they went from 1G to 2G. The main difference between the two mobile telephone systems (1G and 2G), is that the **radio signals** used by 1G network are analog, while 2G networks are **digital** . Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of **CDMA** and **GSM**. It had provided small data service like sms and mms. 2G capabilities are achieved by allowing multiple users on a single channel via multiplexing. During 2G Cellular phones are used for data also along with voice. The advance in technology from 1G to 2G introduced many of the fundamental services that we still use today, such as SMS, **internal roaming** ***"This type refers to the ability of moving from one region to another region inside national coverage of the mobile operator ("internal roaming")"***, conference calls, call hold and billing based on services e.g. charges based on long distance calls and real time billing. The max speed of 2G with General Packet Radio Service (**GPRS**) is 50 Kbps or 1 Mbps with Enhanced Data Rates for GSM Evolution (**EDGE**). Before making the major leap from 2G to 3G wireless networks, the lesser-known 2.5G and 2.75G was an interim standard that bridged the gap.

There are four main 2G systems that have been in widespread use:

- GSM (originally Groupe Special Mobile, later Global System for Mobile communications);
- Digital advanced mobile phone system (D-AMPS);
- Code division multiple access (CDMA);
- Personal digital cellular (PDC).

2.6.2. Global system for Mobile Communication (GSM)

The Global System for Mobile Communications (GSM) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets.



GSM was designed to be the pan-European standard, but later it became very popular and has spread all over the world, with the most notable exception being Japan. The original GSM was using the 900-MHz band because that was the band allocated for the pan-European system. However, later on more bands were allocated for GSM: 850 and 1900 MHz in America, and 1800 MHz in Europe, and existing bands were extended. GSM was also specified for 450 MHz (GSM-450), to replace NMT-450 networks, but this system has not seen commercial deployments. The first GSM network was launched in 1991 in Finland. GSM is a time division multiple access (TDMA) system. ***In TDMA each frequency carrier is divided into timeslots that are allocated for different users dynamically***. In basic GSM there are eight timeslots in a frame (i.e., eight users can have simultaneous calls on the same frequency).

2.6.2.1.GSM Network Architecture

The GSM network architecture provided a simple and yet effective architecture to provide the services needed for a 2G cellular or mobile communications system.

A base station antenna carrying 2G GSM signals

2.6.2.2.GSM network architecture elements

In order that the GSM system operates together as a complete system, the overall network architecture brings together a series of data network identities, each with several elements.

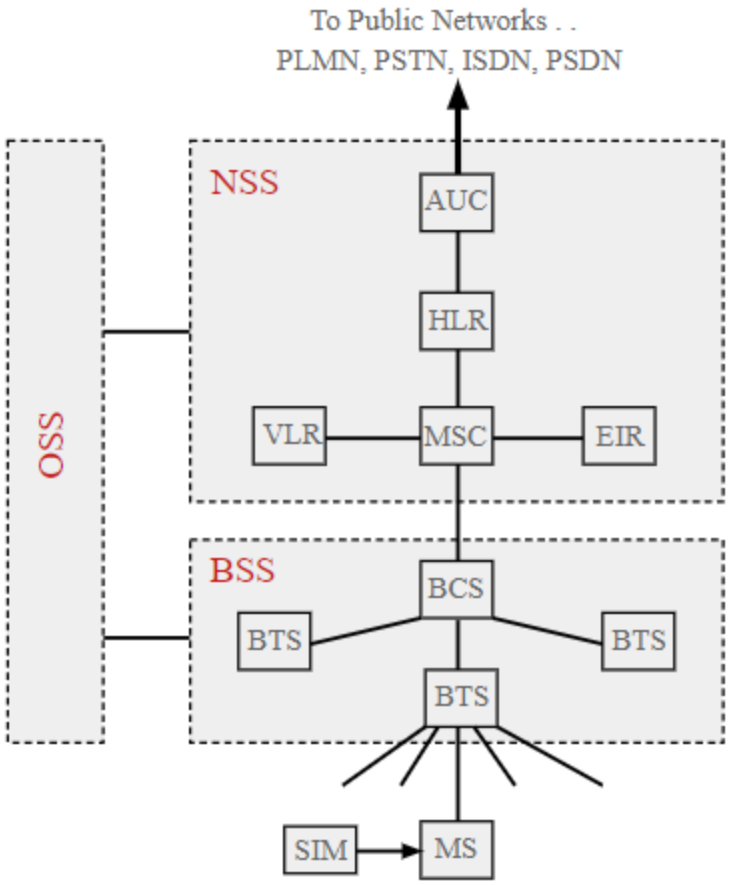
The GSM network architecture is defined in the GSM specifications and it can be grouped into four main areas:

- Network and Switching Subsystem (NSS)
- Base-Station Subsystem (BSS)
- Mobile station (MS)
- Operation and Support Subsystem (OSS)

The different elements of the GSM network operate together and the user is not aware of the different entities within the system.

As the GSM network is defined but the specifications and standards, it enables the system to operate reliably together regardless of the supplier of the different elements.

A basic diagram of the overall system architecture for the 2G GSM mobile communications system includes four major elements which are shown below:



Simplified GSM Network Architecture Diagram

Within this diagram the different network areas can be seen - they are grouped into the four areas that provide different functionality, but all operate to enable reliable mobile communications to be achieved.

The overall network architecture provided to be very successful and was developed further to enable 2G evolution to carry data and then with further evolutions to allow 3G to be established.

1. Network Switching Subsystem (NSS)

The GSM system architecture contains a variety of different elements, and is often termed the core network. It is essentially a data network with a various entities that provide the main control and interfacing for the whole mobile network. The major elements within the core network include:

- ***Mobile Services Switching Centre (MSC):*** The main element within the core network area of the overall GSM network architecture is the Mobile switching Services Centre (MSC). The MSC acts like a normal switching node within a PSTN or ISDN, but also provides additional functionality to enable the requirements of a mobile user to be supported. These include registration, authentication, call location, inter-MSC handovers and call routing to a mobile subscriber. It also provides an interface to the PSTN so that the mobile communications calls can be routed from the mobile network to a phone connected to a landline. Interfaces to other MSCs are provided to enable calls to be made to mobiles on different networks.
- ***Home Location Register (HLR):*** This database contains all the administrative information about each subscriber along with their last known location. In this way, the GSM network is able to route calls to the relevant base station for the MS. When a user switches on their phone, the phone registers with the network and from this it is possible to determine which BTS it communicates with so that incoming calls can be routed appropriately. Even when the phone is not active (but switched on) it re-registers periodically to ensure that the network (HLR) is aware of its latest position. There is one HLR per network, although it may be distributed across various sub-centres to for operational reasons.
- ***Visitor Location Register (VLR):*** This contains selected information from the HLR that enables the selected services for the individual subscriber to be provided. The VLR can be implemented as a separate entity, but it is commonly realised as an integral part of the MSC, rather than a separate entity. In this way access is made faster and more convenient.
- ***Equipment Identity Register (EIR):*** The EIR is the entity that decides whether a given mobile equipment may be allowed onto the network. Each mobile equipment has a number known as the International Mobile Equipment Identity. This number, as mentioned above, is installed in the equipment and is checked by the network during registration. Dependent upon the information held in the EIR, the mobile may be allocated one of three states - allowed onto the network, barred access, or monitored in case its problems.
- ***Authentication Centre (AuC):*** The AuC is a protected database that contains the secret key also contained in the user's SIM card. It is used for authentication and for ciphering on the radio channel.

2. Base Station Subsystem (BSS)

The Base Station Subsystem (BSS) section of the 2G GSM network architecture that is fundamentally associated with communicating with the mobiles on the network.

It consists of two elements:

- ***Base Transceiver Station (BTS):*** The BTS used in a GSM network comprises the radio transmitter receivers, and their associated antennas that transmit and receive to directly communicate with the mobiles. The BTS is the defining element for each cell. The BTS communicates with the mobiles and the interface between the two is known as the Um interface with its associated protocols.
- ***Base Station Controller (BSC):*** The BSC forms the next stage back into the GSM network. It controls a group of BTSs, and is often co-located with one of the BTSs in its group. It manages the radio resources and controls items such as handover within the group of BTSs, allocates channels and the like. It communicates with the BTSs over what is termed the Abis interface.

The base station subsystem element of the GSM network utilised the radio access technology to enable a number of users to access the system concurrently. Each channel supported up to eight users and by enabling a base station to have several channels, a large number of subscribers could be accommodated by each base station.

Base stations are carefully located by the network provider to enable complete coverage of an area. The area being covered by a base station often being referred to as a cell.

As it is not possible to prevent overlap of the signals into the adjacent cells, channels used in one cell are not used in the next. In this way interference which would reduce call quality is reduced whilst still maintaining sufficient frequency re-use.

It is important to have the different BTSs linked with the BSS and the BSSs linked back to the core network.

3. Mobile station

Mobile stations (MS), mobile equipment (ME) or as they are most widely known, cell or mobile phones are the section of a GSM mobile communications network that the user sees and operates. In recent years their size has fallen dramatically while the level of functionality has greatly increased. A further advantage is that the time between charges has significantly increased.

There are a number of elements to the cell phone, although the two main elements are the main hardware and the SIM.

The hardware itself contains the main elements of the mobile phone including the display, case, battery, and the electronics used to generate the signal, and process the data receiver and to be transmitted.

The mobile station, or ME also contains a number known as the International Mobile Equipment Identity (IMEI). This is installed in the phone at manufacture and "cannot" be changed. It is accessed by the network during registration to check whether the equipment has been reported as stolen. The SIM or Subscriber Identity Module contains the information that provides the identity of the user to the network. It contains a variety of information including a number known as the International Mobile Subscriber Identity (IMSI). As this is included in the SIM, and it means that by moving the SIM card from one mobile to another, the user could easily change mobiles. The ease of changing mobiles whilst keeping the same number meant that people would regularly upgrade, thereby creating a further revenue stream for network providers and helping to increase the overall financial success of GSM.

4. Operation and Support Subsystem (OSS)

The OSS or operation support subsystem is an element within the overall GSM mobile communications network architecture that is connected to components of the NSS and the BSC. It is used to control and monitor the overall GSM network and it is also used to control the traffic load of the BSS. It must be noted that as the number of BS increases with the scaling of the subscriber population some of the maintenance tasks are transferred to the BTS, allowing savings in the cost of ownership of the system.

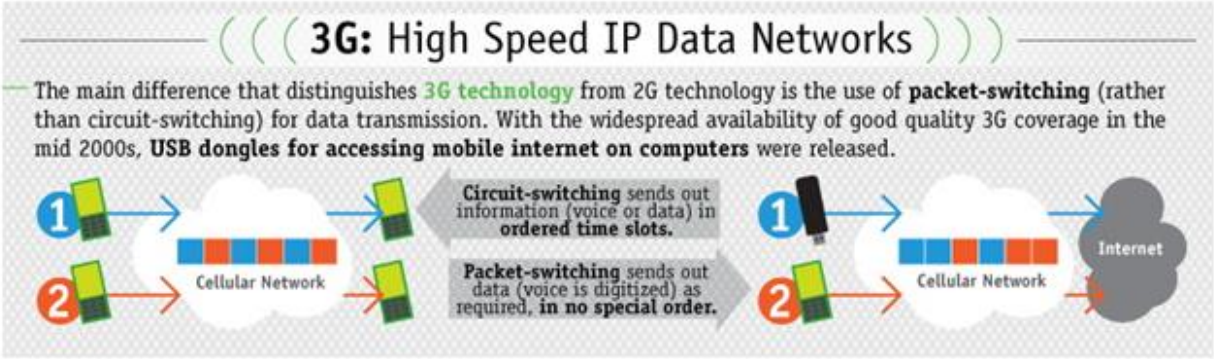
The 2G GSM network architecture follows a logical method of operation. It is far simpler than current mobile phone network architectures which use software defined entities to enable very flexible operation. However the 2G GSM architecture does show the voice and operational basic functions that are needed and how they fit together. As the GSM system was all digital, the network was a data network.

2.7.3G - Third Generation

This generation set the standards for most of the wireless technology we have come to know and love. Web browsing, email, video downloading, picture sharing and other **Smartphone technology** were introduced in the third generation. Introduced commercially in 2001, the goals set out for third generation mobile communication were to facilitate greater voice and data capacity, support a wider range of applications, and increase data transmission at a **lower cost** .

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. Based on a set of standards used for mobile devices and mobile telecommunications use services and networks that comply with the International Mobile Telecommunications-2000 (**IMT-2000**) specifications by the International Telecommunication Union. One of requirements set by IMT-2000 was that speed should be at least 200Kbps to call it as 3G service.

3G increased the efficiency of frequency spectrum by improving how audio is **compressed** during a call, so more simultaneous calls can happen in the same frequency range. The UN's International Telecommunications Union **IMT-2000** standard requires stationary speeds of 2Mbps and mobile speeds of 384kbps for a "true" 3G. Like 2G, 3G evolved into 3.5G and 3.75G as more features were introduced in order to bring about



2.8. 4G - Fourth Generation

4G is a very different technology as compared to **3G** and was made possible practically only because of the advancements in the technology in the last 10 years. Its purpose is to provide **high speed**, high quality and high capacity to users while improving security and lower the cost of voice and data services, multimedia and internet over IP. Potential and current applications include amended mobile web access, **IP telephony**, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

The key technologies that have made this possible are **MIMO** (Multiple Input Multiple Output) and **OFDM** (Orthogonal Frequency Division Multiplexing). The two important 4G standards are WiMAX "***WiMAX (Worldwide Interoperability for Microwave Access) is a family of wireless broadband communication standards based on the IEEE 802.16 set of standards, which provide multiple physical layer (PHY) and Media Access Control (MAC) options"*** (has now fizzled out) and **LTE** ***"In telecommunications, Long-Term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA technologies"*** (has seen widespread deployment). The max speed of a 4G network when the device is moving is 100 Mbps or **1 Gbps** for low mobility communication like when stationary or walking, latency reduced from around 300ms to less than 100ms, and significantly lower congestion. When 4G first became available, it was simply a little faster than 3G. 4G is not the same as **4G LTE** which is very close to meeting the criteria of the standards. To download a new game or stream a TV show in HD, you can do it **without buffering**.

Newer generations of phones are usually designed to be **backward-compatible** , so a 4G phone can communicate through a 3G or even 2G network. All carriers seem to agree that **OFDM** is one of the chief indicators that a service can be legitimately marketed as being 4G. OFDM is a type of digital modulation in which a signal is split into several narrowband channels at different frequencies. There are a significant amount of infrastructure changes needed to be implemented by service providers in order to supply because voice calls in **GSM**, **UMTS** and **CDMA2000** are circuit switched ***(sends out information in ordered time slot)***, so with the adoption of LTE, carriers will have to re-engineer their voice call network.

2.9.5G - Fifth Generation

5G is a generation currently **under development**, that's intended to improve on 4G. **5G** promises significantly faster data rates, higher connection density, much lower latency, among other improvements. Some of the plans for 5G include **device-to-device** communication, better battery consumption, and improved overall wireless coverage. The max speed of 5G is aimed at being as fast as **35.46 Gbps**, which is over 35 times faster than 4G.

2.10. Mobility Management

Mobility management is a functionality that facilitates mobile device operations in Universal Mobile Telecommunications System (UMTS) or Global System for Mobile Communications (GSM) networks. Mobility management is used to trace physical user and subscriber locations to provide mobile phone services, like calls and Short Message Service (SMS). With the convergence of the Internet and wireless mobile communications and with the rapid growth in the number of mobile subscribers, mobility management emerges as one of the most important and challenging problems for wireless mobile communication over the Internet. Mobility management enables the serving networks to locate a mobile subscriber’s point of attachment for delivering data packets (i.e. location management), and maintain a mobile subscriber’s connection as it continues to change its point of attachment (i.e. handoff management).

2.10.1. Location management

Location management enables the networks to track the locations of mobile nodes. Location management has two major sub-tasks: (i) location registration, and (ii) call delivery or paging. In location registration procedure, the mobile node periodically sends specific signals to inform the

network of its current location so that the location database is kept updated. The call delivery procedure is invoked after the completion of the location registration. Based on the information that has been registered in the network during the location registration, the call delivery procedure queries the network about the exact location of the mobile device so that a call may be delivered successfully. The design of a location management scheme must address the following issues: (i) minimization of signaling overhead and latency in the service delivery, (ii) meeting the guaranteed quality of service (QoS) of applications, and (iii) in a fully overlapping area where several wireless networks co-exist, an efficient and robust algorithm must be designed so as to select the network through which a mobile device should perform registration, deciding on where and how frequently the location information should be stored, and how to determine the exact location of a mobile device within a specific time frame.

2.10.2. Handoff management

Handoff management is the process by which a mobile node keeps its connection active when it moves from one access point to another. There are three stages in a handoff process. First, the initiation of handoff is triggered by either the mobile device, or a network agent, or the changing network conditions. The second stage is for a new connection generation, where the network must find new resources for the handoff connection and perform any additional routing operations. Finally, data-flow control needs to maintain the delivery of the data from the old connection path to the new connection path according to the agreed-upon QoS guarantees.

2.11. PDA - Personal Digital Assistant

P*ersonal* ***D****igital* ***A****ssistant*, is a handheld device that combines computing, telephone/fax, Internet and networking features. A typical PDA can function as a cellular phone, fax sender, Web browser and personal organizer. PDAs may also be referred to as a palmtop, hand-held computer or pocket computer.

Smartphones and Tablets Render PDAs Obsolete

As technology changed the world of mobile devices, the PDA has become obsolete as devices like touch-screen smartphones and tablets grow in popularity. Many of the original manufacturers of PDAs eventually entered the smartphone and tablet market, or were bought out

by larger companies. For example, Palm was purchased by HP and the operating system used in a line of early HP TouchPads.

The difference between a Cell Phone, Smartphone and PDA

Falling under the category of mobile devices, today's consumer electronics serve multiple purposes. Years ago, cellular phones, also called cellphone or mobile phone, served one purpose only: They let you send and receive voice communications. Today, mobile phones and similar devices are equipped with customized software, Internet access, digital cameras, portable music players, GPS functions and many more options.

Once again technological advancements make common terminology such as mobile phone, smartphone, PDA and PDA phone difficult to decipher as each type of device changes constantly and features traditionally belonging to one type of device are now found on others. Here we will explore the popular category of mobile communication devices, the similarities and differences between some of the popular products.

What Is a Mobile Phone?

A mobile phone is more frequently called a cellular phone or cellphone. These communication devices connect to a wireless communications network through radio waves or satellite transmissions. Most mobile phones provide voice communications, Short Message Service (SMS), Multimedia Message Service (MMS), and newer phones may also provide Internet services such as Web browsing, instant messaging capabilities and e-mail.

What Is a PDA?

Short for personal digital assistant, this is the name given to small handheld devices that combine computing, telephone/fax, Internet and networking features. A typical PDA can function as a cellular phone, fax sender, Web browser and personal organizer. These devices are usually pen-based, which requires the use of a stylus rather than a keyboard for input. PDAs today are available in either a stylus or keyboard version. Traditionally, PDAs have not had phone or fax services.

What Is a Smartphone?

A smartphone is considered to be the combination of the traditional PDA and cellular phone,

with a bigger focus on the cellular phone part. These hand held devices integrates mobile phone capabilities with the more common features of a handheld computer or PDA. Smartphones allow users to store information, e-mail, install programs, along with using a mobile phone in one device. A smartphone's features is usually more oriented towards mobile phone options than the PDA-like features. There is no industry standard for what defines a smartphone, so any mobile device that has more than basic cellphone capabilities can actually be filed under the smartphone category of devices.

What Is a PDA Phone?

It's definitely a lack of standardization that makes the category of mobile devices so confusing to the consumer. As technology changes, so do the functions that these different devices perform. Years ago, many people differentiated PDA and smartphone simply by looking for touch-screen capabilities. If it had a touch screen it was a PDA, if it didn't, it was a smartphone. The Sony Ericsson Smartphone, for example, offers users both a touch screen and a full QWERTY keyboard. Despite the fact that the manufacturer calls this product a smartphone, the generic term for a PDA oriented device with cellular phone capabilities is called a PDA phone.

2.12. Mobile Operating Systems (Mobile OS)

Much like the Linux or Windows operating system controls your desktop or laptop computer, a mobile operating system is the software platform on top of which other programs can run on mobile devices.

A mobile operating system, also called a *mobile OS*, is an operating system that is specifically designed to run on mobile devices such as mobile phones, smartphones, PDAs, tablet computers and other handheld devices.

The operating system is responsible for determining the functions and features available on your device, such as thumb wheel, keyboards, WAP, synchronization with applications, email, text messaging and more. The mobile OS will also determine which third-party applications (mobile apps) can be used on your device.

2.12.1. Types of Mobile Operating Systems

When you purchase a mobile device the manufacturer will have chosen the operating system for that specific device. Often, you will want to learn about the mobile operating system before you

purchase a device to ensure compatibility and support for the mobile applications you want to use. Nine popular Mobile Operating Systems are described here below:

1. Android OS (Google Inc.)

The Android mobile operating system is Google's open and free software stack that includes an operating system, middleware and also key applications for use on mobile devices, including smartphones. Updates for the open source Android mobile operating system have been developed under "dessert-inspired" version names (Cupcake, Donut, Eclair, Gingerbread, Honeycomb, Ice Cream Sandwich) with each new version arriving in alphabetical order with new enhancements and improvements.

2. Bada (Samsung Electronics)

Bada is a proprietary Samsung mobile OS that was first launched in 2010. The Samsung Wave was the first smartphone to use this mobile OS. Bada provides mobile features such as multipoint-touch, 3D graphics and of course, application downloads and installation.

3. BlackBerry OS (Research In Motion)

The BlackBerry OS is a proprietary mobile operating system developed by Research In Motion for use on the company's popular BlackBerry hand held devices. The BlackBerry platform is popular with corporate users as it offers synchronization with Microsoft Exchange, Lotus Domino, Novell GroupWise email and other business software, when used with the BlackBerry Enterprise Server.

4. iPhone OS / iOS (Apple)

Apple's iPhone OS was originally developed for use on its iPhone devices. Now, the mobile operating system is referred to as iOS and is supported on a number of Apple devices including the iPhone, iPad, iPad 2 and iPod Touch. The iOS mobile operating system is available only on Apple's own manufactured devices as the company does not license the OS for third-party hardware. Apple iOS is derived from Apple's Mac OS X operating system.

5. MeeGo OS (Nokia and Intel)

A joint open source mobile operating system which is the result of merging two products based on open source technologies: Maemo (Nokia) and Moblin (Intel). MeeGo is a mobile OS designed to work on a number of devices including smartphones, netbooks, tablets, in-vehicle information systems and various devices using Intel Atom.

6. Palm OS (Garnet OS)

The Palm OS is a proprietary mobile operating system (PDA operating system) that was originally released in 1996 on the Pilot 1000 handheld. Newer versions of the Palm OS have added support for expansion ports, new processors, external memory cards, improved security and support for ARM processors and smartphones. Palm OS 5 was extended to provide support for a broad range of screen resolutions, wireless connections and enhanced multimedia capabilities and is called Garnet OS.

7. Symbian OS (Nokia)

Symbian is a mobile operating system (OS) targeted at mobile phones that offers a high-level of integration with communication and personal information management (PIM) functionality. Symbian OS combines middleware with wireless communications through an integrated mailbox and the integration of Java and PIM functionality (agenda and contacts). Nokia has made the Symbian platform available under an alternative, open and direct model, to work with some OEMs and the small community of platform development collaborators. Nokia does not maintain Symbian as an open source development project.

8. web OS (Palm/HP)

Web OS is a mobile operating system that runs on the Linux kernel. Web OS was initially developed by Palm as the successor to its Palm OS mobile operating system. It is a proprietary Mobile OS which was eventually acquired by HP and now referred to as web OS (lower-case w) in HP literature. HP uses web OS in a number of devices including several smartphones and HP TouchPads. HP has pushed its web OS into the enterprise mobile market by focusing on improving security features and management with the release of web OS 3.x. HP has also announced plans for a version of webOS to run within the Microsoft Windows operating system and to be installed on all HP desktop and notebook computers in 2012.

9. Windows Mobile (Windows Phone)

Windows Mobile is Microsoft's mobile operating system used in smartphones and mobile devices – with or without touchscreens. The Mobile OS is based on the Windows CE 5.2 kernel. In 2010 Microsoft announced a new smartphone platform called Windows Phone 7.