

Chapter 2

The 3G Mobile Communications

2.1 The Vision for Third Generation (3G) Mobile Communication Systems:

The vision for the emerging mobile and personal communication services for the new century is to enable communication with a person, at any time, at any place, and in any form, with a paradigm shift from current focus on voice and low speed data services to high speed data and multimedia services. The current second generation digital mobile and personal communication systems are based on national or regional standards that are optimized for region or country specific regulatory and operating environments. They are incompatible with each other and can provide mobility only within their radio environments.

Efforts are therefore under way at the international as well as regional/national levels to define the third generation mobile telecommunication system that will meet the future requirements of telecommunications subscribers. International or global standards are needed for seamless global mobility and integration of wire line and wireless networks for providing transparent telecommunications services to the users.

The International Telecommunication Union (ITU) responsible for global telecommunications standards has been working since 1986 towards developing an international standard for wireless access to worldwide telecommunication infrastructure. This standard is known as IMT-2000, for International Mobile Telecommunications 2000. IMT-2000 is intended to form the basis for third – generation wireless systems, which will consolidate today's diverse and incompatible mobile environments into a seamless radio and network infrastructure capable of offering a wide range of telecommunications services on a global scale.

The vision for IMT-2000 is as follows:

- Common spectrum worldwide(1.8-2.2 GHz band)
- Multiple radio environments(Cellular, Cordless, Satellite, LANs)
- Wide range of telecommunications services(Voice, Data, Multimedia, Internet)
- Flexible radio bearers for increased spectrum efficiency
- Data rates up to 2 Mbps for indoor environments

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- Global seamless roaming
- Enhanced security and performance
- Integration of satellite and terrestrial systems

Whereas the vision for IMT-2000 implies significant departures from the second generation systems in terms of range of environments and services, as well as seamless global mobility ,it is expected that IMT-2000 will evolve from existing wireless and wire line systems and it will be a family of systems rather than a single, monolithic network.

The European Telecommunications Standards institute ,ETSI ,has been working on the Universal Mobile Telecommunication System (UMTS) which will be the European standard for third generation mobile systems. UMTS will represent one of the family member groups within IMT-2000 family of systems.

2.2 Existing Wireless Networks: Existing networks are mostly digital cellular systems .However ,if we look at evolution of wireless networks, they are often divided into first, second and third generation networks.

2.2.1 First Generation Wireless Networks

The first generation of wireless mobile communications was based on analog signalling. Analog systems, implemented in North America, were known as Analog Mobile Phone Systems (AMPS), while systems implemented in Europe and the rest of the world were typically identified as a variation of Total Access Communication Systems (TACS). Analog systems were primarily based on circuit-switched technology and designed for voice, not for data.

2.2.2 Second Generation Wireless Networks

The second generation (2G) of the wireless mobile network was based on low-band digital data signalling. The most popular 2G wireless technology is known as Global System for Mobile Communications (GSM). GSM systems, first implemented in 1991, are now operating in about 140 countries and territories around the world. An estimated 248 million users now operate over GSM systems. GSM technology is a combination of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA). The first GSM

systems used a 25 MHz frequency spectrum in the 900 MHz band. FDMA is used to divide the available 25 MHz of bandwidth into 124 carrier frequencies of 200 kHz each. Each frequency is then divided using a TDMA scheme into eight timeslots. The use of separate timeslots for transmission and reception simplifies the electronics in the mobile units. Today, GSM systems operate in the 900 MHz and 1.8 GHz bands throughout the world with the exception of the Americas where they operate in the 1.9 GHz band.

In addition to GSM, a similar technology, called Personal Digital Cellular (PDC), using TDMA-based technology, emerged in Japan. Since then, several other TDMA-based systems have been deployed worldwide and serve an estimated 89 million people worldwide. While GSM technology was developed in Europe, Code Division Multiple Access (CDMA) technology was developed in North America. CDMA uses spread spectrum technology to break up speech into small, digitized segments and encodes them to identify each call. CDMA systems have been implemented worldwide in about 30 countries and serve an estimated 44 million subscribers.

While GSM and other TDMA-based systems have become the dominant 2G wireless technologies, CDMA technology is recognized as providing clearer voice quality with less background noise, fewer dropped calls, enhanced security, greater reliability and greater network capacity. The Second Generation (2G) wireless networks mentioned above are also mostly based on circuit-switched technology. 2G wireless networks are digital and expand the range of applications to more advanced voice services, such as Caller Line Identification. 2G wireless technology can handle some data capabilities such as fax and short message service at the data rate of up to 9.6 kbps, but it is not suitable for web browsing and multimedia applications.

2.3 Next Generation Wireless Networks: The next generation networks are evolving from existing networks. We divide them into 2G+ and 3G networks.

2.3.1 Second Generation plus (2G+) Wireless Networks :

The virtual explosion of Internet usage has had a tremendous impact on the demand for advanced wireless data communication

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services. However, the effective data rate of 2G circuit-switched wireless systems is relatively slow -- too slow for today's Internet. As a result, GSM, PDC and other TDMA-based mobile system providers and carriers have developed 2G+ technology that is packet-based and increases the data communication speeds to as high as 384kbps. These 2G+ systems are based on the following technologies: High Speed Circuit-Switched Data (HSCSD), General Packet Radio Service (GPRS) and Enhanced Data Rates for Global Evolution (EDGE) technologies.

HSCSD is one step towards 3G wideband mobile data networks. This circuit-switched technology improves the data rates up to 57.6 kbps by introducing 14.4 kbps data coding and by aggregating 4 radio channels timeslots of 14.4 kbps.

GPRS is an intermediate step that is designed to allow the GSM world to implement a full range of Internet services without waiting for the deployment of full-scale 3G wireless systems. GPRS technology is packet-based and designed to work in parallel with the 2G GSM, PDC and TDMA systems that are used for voice communications and for table look-up to obtain GPRS user profiles in the Location Register databases. GPRS uses a multiple of the 1 to 8 radio channel timeslots in the 200kHz-frequency band allocated for a carrier frequency to enable data speeds of up to 115 kbps. The data is packetized and transported over Public Land Mobile Networks (PLMN) using an IP backbone so that mobile users can access services on the Internet, such as e-mail, ftp and HTTP-based Web services.

EDGE technology is a standard that has been specified to enhance the throughput per timeslot for both HSCSD and GPRS. The enhancement of HSCSD is called ECSD, whereas the enhancement of GPRS is called EGPRS. In ECSD, the maximum data rate will not increase from 64 kbps due to the restrictions in the A interface, but the data rate per timeslot will triple. Similarly, in EGPRS, the data rate per timeslot will triple and the peak throughput, including all eight timeslots in the radio interface, will exceed 384 kbps.

GPRS networks consist of an IP-based Public Land Mobile

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Network (PLMN), Base Station Subsystem (BSS), Mobile handsets (MS), and Mobile Switching Centers (MSC) for circuit-switched network access and databases. The Serving GPRS Support Nodes (SGSN) and Gateway GPRS Support Nodes (GGSN) make up the PLMN. Roaming is accommodated through multiple PLMNs. SGSN and GGSN interface with the Home Location Register (HLR) to retrieve the mobile user's profiles to facilitate call completion. GGSN provides the connection to external Packet Data Network (PDN), e.g. an Internet backbone or an X.25 network. The BSS consists of Base Transceiver Stations and Base Station Controllers. The Base Transceiver Station (BTS) receives and transmits over the air interfaces (CDMA, TDMA), providing wireless voice and data connectivity to the mobile handsets. Base Station Controllers (BSC) route the data calls to the packet-switched PLMN over a Frame Relay (FR) link and the voice calls to the Mobile Switching Center (MSC). MSC switches the voice calls to circuit-switched network such as PSTN and ISDN. MSC accommodates the Visitor Location Register (VLR) to store the roaming subscriber information. The reverse process happens at the destination PLMN and the destination BSS. On the data side, the BSC routes the data calls to the SGSN, and then the data is switched to the external PDN through the GGSN or to another mobile subscriber. Figure 2.1 shows a GPRS network

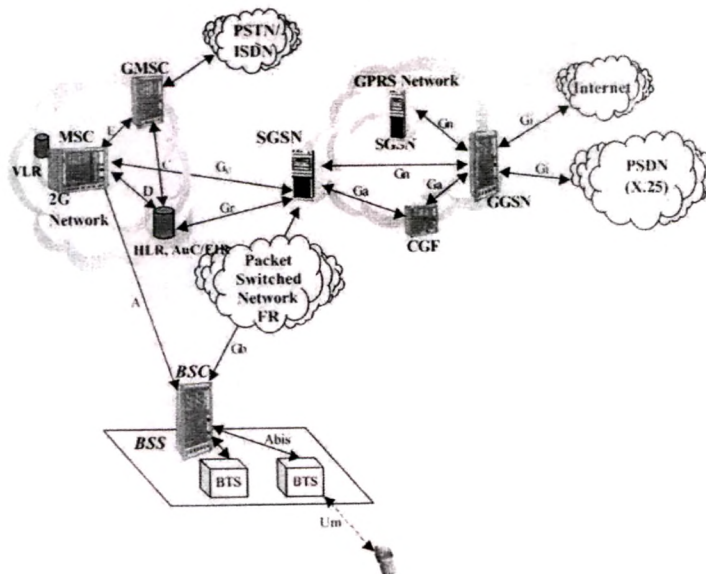


Figure 2.1 GPRS network

2.3.2 Third Generation (3G) Wireless Networks:

3G wireless technology represents the convergence of various 2G wireless telecommunications systems into a single global system that includes both terrestrial and satellite components. One of the most important aspects of 3G wireless technology is its ability to unify existing cellular standards, such as CDMA, GSM, and TDMA, under one umbrella. The following three air interface modes accomplish this result: wideband CDMA, CDMA2000 and the Universal Wireless Communication (UWC-136) interfaces.

Wideband CDMA (W-CDMA) is compatible with the current 2G GSM networks prevalent in Europe and parts of Asia. W-CDMA will require bandwidth of between 5 MHz and 10 MHz, making it a suitable platform for higher capacity applications. It can be overlaid onto existing GSM, TDMA (IS-36) and IS-95 networks. Subscribers are likely to access 3G wireless services initially via dual band terminal devices. W-CDMA networks will be used for high-capacity applications and 2G digital wireless systems will be used for voice calls.

The second radio interface is CDMA2000 which is backward compatible with the second generation CDMA IS-95 standard predominantly used in US. The third radio interface, Universal Wireless Communications – UWC-136, also called IS-136HS, was proposed by the TIA and designed to comply with ANSI-136, the North American TDMA standard.

3G wireless networks consist of a Radio Access Network (RAN) and a core network. The core network consists of a packet-switched domain, which includes 3G SGSNs and GGSNs, which provide the same functionality that they provide in a GPRS system, and a circuit-switched domain, which includes 3G MSC for switching of voice calls. Charging for services and access is done through the Charging Gateway Function (CGF), which is also part of the core network. RAN functionality is independent from the core network functionality. The access network provides a core network technology independent access for mobile terminals to different types of core networks and network services. Either core network domain can access any

appropriate RAN service; e.g. it should be possible to access a “speech” radio access bearer from the packet-switched domain.

The Radio Access Network consists of new network elements, known as Node B and Radio Network Controllers (RNCs). Node B is comparable to the Base Transceiver Station in 2G wireless networks. RNC replaces the Base Station Controller. It provides the radio resource management, handover control and support for the connections to circuit-switched and packet-switched domains. The interconnection of the network elements in RAN and between RAN and core network is over Iub, Iur and Iu interfaces based on ATM as a layer 2 switching technology. Data services run from the terminal device over IP, which in turn uses ATM as a reliable transport with QoS. Voice is embedded into ATM from the edge of the network(Node B) and is transported over ATM out of the RNC. The Iu interface is split into 2 parts: circuit-switched and packet-switched. The Iu interface is based on ATM with voice traffic embedded on virtual circuits using AAL2 technology and IP-over-ATM for data traffic using AAL5 technology. These traffic types are switched independently to either 3G SGSN for data or 3G MSC for voice. Figure 2.2 shows the 3G network architecture.

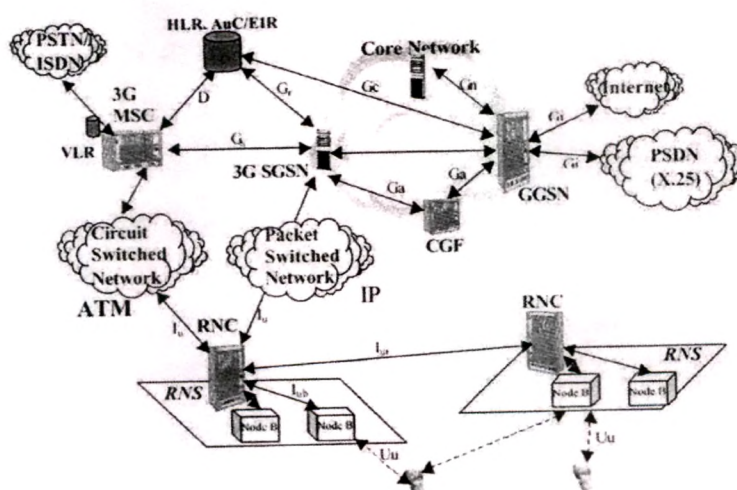


Figure 2.2 3G network architecture

2.4 Evolution to 3G Wireless Technology: The evolution has to be a smooth transition from existing networks to the evolved networks as explained in the following paragraphs.

2.4.1 Initial Coverage : Initially, 3G wireless technology will be deployed as "islands" in business areas where more capacity and advanced services are demanded. A complete evolution to 3G wireless technology was mandated by the end of 2000 in Japan (mostly due to capacity requirements) and by the end of 2001 in Europe. NTT DoCoMo has deployed 3G wireless services in Japan. In contrast, there was no similar mandate in North America and it is more likely that competition will drive the deployment of 3G wireless technology in that region. The implementation of 3G wireless systems raises several critical issues, such as the successful backward compatibility to air interfaces as well as to deployed infrastructures.

2.4.2 Interworking with 2G and 2G+ Wireless Networks: The existence of legacy networks in most regions of the world highlights the challenge that communications equipment manufacturers face when implementing next-generation wireless technology. Compatibility and interworking between the new 3G wireless systems and the old legacy networks must be achieved in order to ensure the acceptance of new 3G wireless technology by service providers and end-users.

The existing core technology used in mobile networks is based on traditional circuit-switched technology for delivery of voice services. However, this traditional technology is inefficient for the delivery of multimedia services. The core switches for next-generation of mobile networks will be based on packet-switched technology which is better suited for data and multimedia services.

Second generation GSM networks consist of BTS, BSC, MSC/VLR and HLR/AuC/EIR network elements. The interfaces between BTS, BSC and MSC/VLR elements are circuit-switched PCM. GPRS technology adds a parallel packet-switched core network. The 2G+ network consists of BSC

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with packet interfaces to SGSN, GGSN, HLR/AuC/EIR. The interfaces between BSC and SGSN network elements are either Frame Relay and/or ATM so as to provide reliable transport with Quality of Service (QoS).

3G wireless technology introduces new Radio Access Network (RAN) consisting of Node B and RNC network elements. The 3G Core Network consists of the same entities as GSM and GPRS: 3G MSC/VLR, GMSC, HLR/AuC/EIR, 3G-SGSN, and GGSN. IP technology is used for end-to-end multimedia applications and ATM technology is used to provide reliable transport with QoS.

3G wireless solutions allow for the possibility of having an integrated network for circuit-switched and packet-switched services by utilizing ATM technology. The BSC may evolve into an RNC by using add-on cards or additional hardware that is co-located. The carrier frequency and the bands are different for 3G wireless technology compared to 2G/2G+ wireless technology. Evolution of BSC to RNC requires support for new protocols such as PDCP, RRC, RANAP, RNSAP and NBAP. Therefore, BTS's evolution into Node B may prove to be difficult and may represent significant capital expenditure on the part of network operators.

MSC evolution depends on the selection of a fixed network to carry the requested services. If an ATM network is chosen, then ATM protocols will have to be supported in 3G MSC along with interworking between ATM and existing PSTN/ISDN networks.

The evolution of SGSN and GGSN to 3G nodes is relatively easier. Enhancements to GTP protocol and support for new RANAP protocol are necessary to support 3G wireless systems. ATM protocols need to be incorporated to transport the services. The HLR databases evolve into 3G- HLR by adding 3G wireless user profiles. The VLR database must also be updated accordingly. The EIR database needs to change to accommodate new equipment that will be deployed for 3G wireless systems. Finally, global roaming requires compatibility to existing deployment and graceful fallback to an available level when requested services are not available in the region. Towards this end, the Operator

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Harmonization Group (OHG) is working closely with 3G Partnership Projects (3GPP and 3GPP2) to come up with global standards for 3G wireless protocols.

2.5 Comparison of 2G and 3G Mobile Networks: Although there are many similarities between 2G and 3G networks and many of the 2G and 3G components are shared or connected through inter working functions, there are also many differences between the two technologies. Table 2.1 compares the differences between the core network, the radio portion and other areas of two networks.

Feature	2G	3G
Core Network	MSC/VLR,GMSC,HLR/AuC/EIR MM,CM,BSSAP,SCCP,ISUP, TCAP,MAP, MTP 3,MTP 2,MTP1 TDM transport	3G MSC/VLR(with added interworking and transcoding) GMSC,HLR/AuC/EIR,3G-SGSN,GGSN,CGF GMM/SM,MM,CM,BSSAP,RANAP,GTP, SCCP,MTP3B,M3UA,SCTP,TCAP,MAP, ISUP,MTP3,MTP2,MTP1,Q.2140 ATM,IP transport
Radio Access	BTS,BSC,MS FDMA,TDMA,CDMA MM,CM,RR,LAPDm,LAPD,BSS AP,SCCP, MTP 3,MTP 2,MTP 1	Node B,RNC,MS W-CDMA,CDMA2000,IWC-136 GMM/SM,MAC,RLC,PDCP,RRR,Q.2630.1 NBAP,RNSAP,RANAP,SCCP,MTP3B,M3 UA,SCTP,GTPU,Q.2140,Q.2130,SSCOP, CIP
Handsets	Voice only terminals	New type of terminal, Multiple modes, Voice, data and video terminals, WAP,Multimedia management
Databases	HLR, VLR ,EIR , AuC	Enhanced HLR, VLR , EIR, AuC
Data rates	Up to 9.6 Kbps	Up to 2 Mbps
Applications	Voice, SMS	Internet, Multimedia
Roaming	Restricted, Not global	Global
Compatibility	Not Compatible to 3G	Compatible to 2G,2G+ and Bluetooth

Table 2.1 Comparison of 2G and 3G Mobile networks

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2.6 Summary : This chapter has presented an overview of current trends in wireless technology world, a historical overview of evolving wireless technologies and an examination of how the communication industry plans to implement wireless technology standards to address the growing demand for wireless multimedia services.