

3G

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ABHILASH C.A

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DEPARTMENT OF ELECTRONICS ENGINEERING

COLLEGE OF ENGINEERING, CHENGANNUR

KERALA 689 121

<http://www.ceonline.edu>

1) INTRODUCTION

Marconi's innovative perception of electromagnetic waves and the air interface in 1897 was the first milestone on the important road to shared use of the radio spectrum. But only after almost a century later did mobile wireless communication start to take off. Despite a series of disappointing false starts, communication world in the late 1980's was rapidly becoming more mobile for a much wider segment of communication users than ever before. With the advent of wireless technology, a transition from point-to-point communication toward person-to-person communication (i.e.; independent of position) has begun. Testimony to this is the rapidly increasing penetration of cellular phones all across the world. In anticipation of the growing consumer demands, the next generation of wireless systems endeavors to provide person-to-person communication of the circuit and packet multi media data.

The first generation cellular networks, which were based on analog technology with FM modulation, have been successfully deployed since the early and mid 1980's. A typical example of a first generation cellular telephone system (**1G**) is the **Advanced Mobile Phone Services (AMPS)**. Second generation (**2G**) wireless systems employ digital modulation and advanced call-processing capabilities. In view of the processing complexity required for these digital systems, two offered advantages are the possibility of using spectrally efficient radio transmission schemes such as **Time Division Multiple Access (TDMA)** or **Code Division Multiple Access (CDMA)**, in comparison to the analog **Frequency Division Multiple Access (FDMA)** schemes previously employed and the provision for implementation of a wide variety of integrated speech and data services such as paging and low data rate network access. Examples of **2G** wireless systems include the **Global System for Mobile communication (GSM)**, **TDMA IS-54/IS-136** and **Personal Digital Cellular (PDC)**.

Third Generation (**3G**) wireless systems will evolve from mature **2G** networks with the aim of providing universal access and global roaming. More important these systems are expected to support multi dimensional (multi-information media, multi-transmission media, and multi-layered networks) high-speed wireless communication- an important milestone toward achieving the grand vision of ubiquitous personal communications. Introduction of wide band packet-data services for wireless Internet up to 2Mbps will be the main attribute of **3G** system.

2) WHAT IS 3G ?

The third generation of mobile cellular systems are intended to unify the diverse systems we see today into a seamless radio infrastructure capable of offering a wide range of services in different radio environments, with the quality we have come to expect from wire line communication networks.

Since the mid-80's, studies on **3G** systems have been carried out within the **International Telecommunication Union (ITU)**, where it was called **Future Public Land Mobile Telecommunication Systems (FPLMTS)**, lately renamed **International Mobile Telecommunications-2000 (IMT-2000)**. In Europe research and development on **3G** technology, is commonly referred to as the **Universal Mobile Telecommunication System (UMTS)** and **Mobile Broadband System (MBS)**, have been conducted under the European Community **Research into Advanced Communications in Europe (RACE)** and **Advanced Communication Technologies and Services (ACTS)** programs. With support from activities in Europe, the United States, Japan and developing countries, **World Administrative Radio Conference (WARC)** of ITU identified global bands **1885-2025Mhz** and **2110-2200Mhz** for **IMT-2000** including **1980-2010Mhz** and **2170-2200Mhz** for the mobile satellite component.

Key elements in the definition of **3G** systems are the radio access system and **Radio Transmission Technology (RTT)**. As a part of the standardization activities, a formal request by the **ITU-Radio communication standardization sector (ITU-R)** for submission of candidate **RTTs** for **IMT-2000** has been distributed by the **ITU**. In response to this 10 proposals were submitted. Most of the proposals use **CDMA** or **WCDMA** as their multiple access technique. So in this seminar we are presenting the common features of **WCDMA** based **3G** standards.

2.1) COMMON OBJECTIVES

Some major objectives envisioned for **IMT-2000** and their key differences from the current **2G** mobile systems can be briefly summarized as follows:

- Use of a common frequency band.
- Use of a small pocket terminal with worldwide roaming.

- Maximizing the commonality and optimization of radio interfaces for multiple operating environments, such as vehicular, pedestrian, office and **Fixed Wireless Access (FWA)** system.
- Significantly high transmission speed capability encompassing circuit and packet switched data with multimedia support.
- Support for both symmetric and asymmetric data transfer in all operating environments.
- Compatibility with wireless services, which currently exist.

Spectrum efficiency, quality and overall cost improvement as a result of utilization of advanced technologies such as DSP.

3) EVOLUTION TO 3G

The primary focus of third generation architectures will be to attempt to seamlessly evolve second generation systems to provide high speed data services to support multimedia applications such as web browsing. The key word is "evolve" - as the challenge to wireless equipment manufacturers is to provide existing customers, namely, service providers, with a migration path that simultaneously satisfies the requirements set forth by the International Telecommunications Union (ITU) for 3G wireless services while preserving customer investment in existing wireless infrastructure. The core of today's second generation networks provide the foundation on which third generation services –3G—are built. Next generation services will be delivered by a combination of existing and evolving digital equipments. The move to 3G is all about high-speed mobile data and IP traffic. That is why today's wireless networks will require greater band width and network capacity to support 3rd generation services.

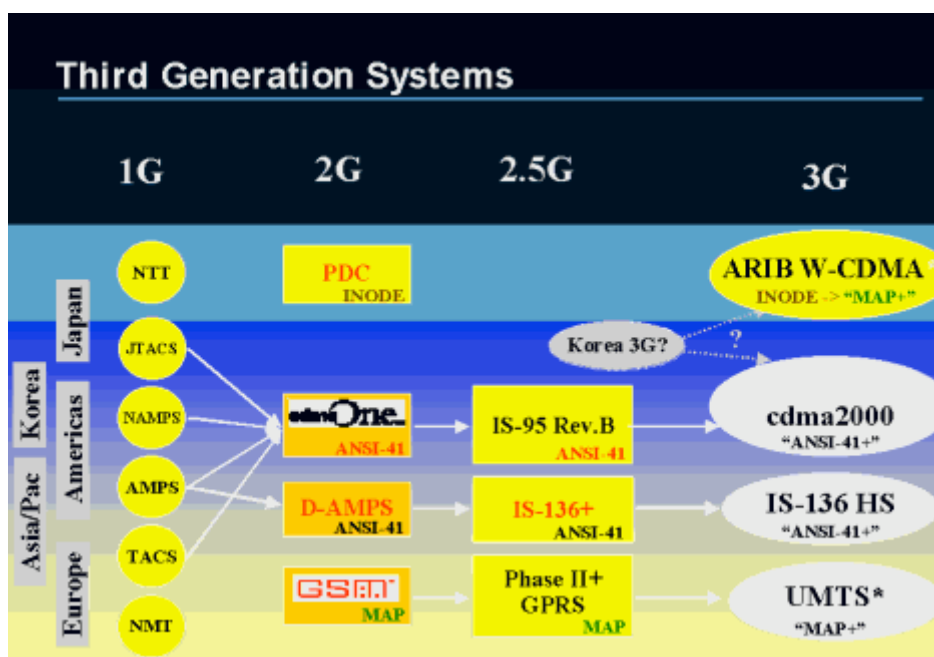


Figure 4.1: *Evolution path of Wireless Communication Systems*

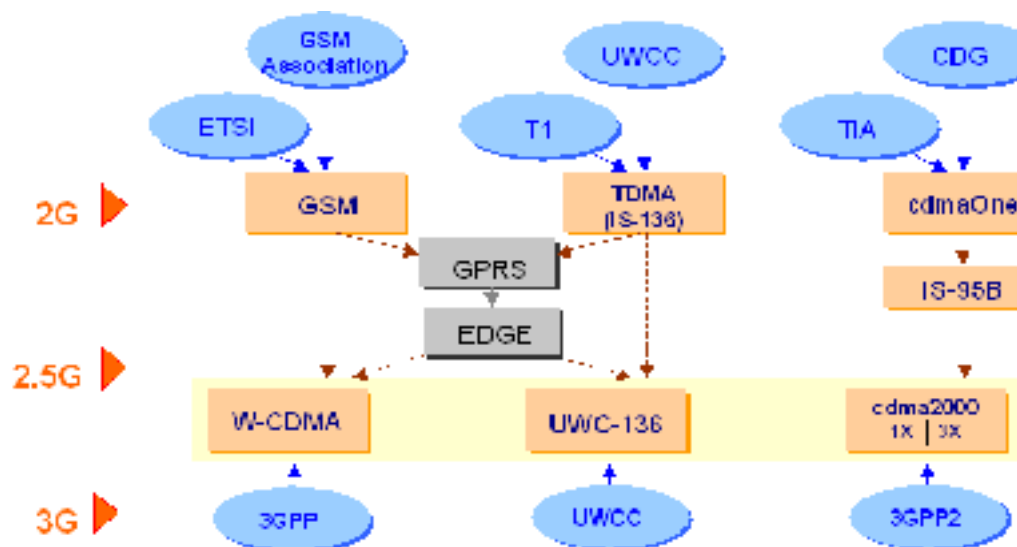


Figure 4.2 : Migration from 2G to 3G

3.1) GSM EVOLUTION

GSM networks will enhance packet data services primarily in three phases. General Packet Radio Services (GPRS) refers to the first phase of GSM network architecture enhancements that allow mobiles to connect to IP or X.25 based networks.

The GSM/GPRS network architecture will further evolve to support Enhanced Data Rates for GSM Evolution (EDGE), which provides significant improvements over GPRS. Finally, the ETSI/ARIB Wideband CDMA (WCDMA) proposal provides a new air interface for GSM networks - supporting higher data rates that will meet or exceed UMTS/IMT-2000 specifications.

3.2) EVOLUTION OF IS-136

IS-136, sometimes referred to as North American TDMA (NA-TDMA), has a two-phase migration path as defined by UWC-136. In the first phase, referred to as 136+, significant enhancement will be made to allow for improved voice and data over the existing 30 kHz carrier, which uses 6 time slots per 40 ms frame. The second phase, referred to as 136 High Speed (136HS) will embrace the EDGE standard (at least in outdoor environments) in order to meet the requirements of UMTS/IMT-2000.

3.3) IS-95 EVOLUTION

IS-95, sometimes referred to as North American CDMA (NA-CDMA), has a two phase migration path: IS-95B and cdma2000. The key advantage of IS-95B and cdma2000 for existing CDMA operators is simple: preservation of capital investments. Both IS-95B and cdma2000 will provide a smooth migration path to IMT-2000 while maintaining backward compatibility with existing IS-95 infrastructure. In order to maintain backward compatibility, both IS-95B and cdma2000 will be based on synchronous base station operation and will therefore continue to rely on the GPS to maintain synchronicity. In addition, IS-95B and cdma2000 will continue to use 20 ms frames and perform closed loop power control on the reverse link at a rate of 800 times per second. Currently, IS-95 provides circuit-switched and packet-switched data at rates of 9.6 kbps or 14.4 kbps (depending on the speech coder) using a 1.25 MHz channel bandwidth and a chip rate of 1.2288 Mcps.

Evolution from 2G to 3G

Attribute	Voice	Data
Unit Of Communication	Call/Circuit	Session/Packet
Static Subscriber Data	HLR	Home Agent
Dynamic Subscriber Data	VLR	Foreign Agent
Mobility Paradigm	Handoff	Reregistration*
Billing	AMA/CDR	Radius/Diameter
Accounting Model	Per Minute	Per Byte
Billing Model	Per Minute	Fixed Rate
Traffic Delivery	Guaranteed	Best-Effort*
Delivery Timing	Real-Time	Not Guaranteed*
Latency	200msec	2+ Sec*
Wide-Area Mobility	Roaming	Forwarding*

4) 3G STANDARDS

Third generation cellular telephony is on its way - not, unfortunately, as a single worldwide system, but as three incompatible ones. The main difference the three lies in their choice of radio interface technology. This fact is crucial for several reasons, since the radio interface determines not only the fundamental capacity of a mobile radio network, but also how it deals with such issues as interference, distortion, handing off calls from one base station to another as users move around etc.

In one way or the other, all three approaches provide for adaptive bandwidth on demand. Two of the systems use wideband code division multiple access (WCDMA) for the radio interface. The other uses a time division multiple access (TDMA) radio interface technique.

4.1) WCDMA

One of the most promising approaches to the new third generation is to combine a wide band CDMA (W-CDMA) AIR INTERFACE with the fixed network of the GSM. With WCDMA a users' information bits are spread over an artificially broadened bandwidth. The job is done by multiplying them with pseudorandom bit stream several times as fast. The bits in the pseudorandom bit stream are referred to as chips, so the stream is known as chipping or spreading code. It increases the bit rate of the signal (and the amount of band width it occupies) by a ratio known as spreading factor, namely, the ratio of the chip rate to the original information rate.

The key device in any CDMA system is its correlation receivers, which stores exact copies of all the system's chipping codes. These codes are used by the receiver to multiply a received data stream, selecting the chipping code as was used in the transmitter. The devices also perform whatever mathematical functions required to restore the original user data. The result is that at the receiver output, the amplitude of the de-spread signal is increased by the spreading factor relative to the interfering signals. In the process, those interfering signals are diminished and add to the background noise level. This effect is called process gain.

CDMA the conversations occupy the same frequency band at the same time. But each interaction is multiplied by a different chipping code, and when the signals are de-spread, the only one that comes through intelligibly is the one whose

code was used by the de-spreader. The others simply add to the background noise level, which ultimately limit the number of users that can share a channel.

For the system to work two factors are key. First only soft handovers may be employed, since with them mobile terminals can maintain simultaneous connections to different base stations as they move among them. Second transmitted power should be strictly controlled so that signals from all mobile terminals arrive at the base station with about the same strength, despite their differing distances from the base station.

Strict power control is maintained with real time power control channels. The control channels operate at power command rate between 800Hz and 1.5kHz. That is base station equipment measures the power received from each mobile unit as much as 1500 times a second and issues command to the mobile at that rate to raise or lower their output power.

Many users can be accommodated. The maximum WCDMA chip rate is 3.84Mcps (mega chips per second) and yields a modulated carrier of about 5Mhz wide. System operators can deploy multiple carriers, each of which occupies 5Mhz. More over in a WCDMA system, multiple end users can share each 5Mhz channel.

In addition to the above mentioned features a WCDMA system can support both fixed and variable data rate users in an adaptive manner. The system does this by continually changing the way it distributes the channel's band width among the users, adjusting the spreading factors of each of the users in every 10ms.

The community abiding by the Global System for Mobile communications extends itself into 3G under the general rubric of Universal Mobile Telecommunication Services (UMTS). Their radio interface uses WCDMA radio techniques and is called UMTS Terrestrial Radio Access (UTRA).

WCDMA has two forms, distinguished by how they separate the two directions of communication. Frequency Division Duplex (FDD) employs separate uplink and downlink frequency bands with a constant frequency offset between them. The other form Time Division Duplexing (TDD) puts the uplink and downlink in the same band, and then time-shares transmissions in each direction. This mode is useful for operators with spectrum restrictions.

4.1.1) TRANSITION FROM GSM TO 3G

The WCDMA physical layer includes variable bit rate transport channels required for bandwidth on demand user applications. These can multiplex several services onto a single connection between fixed infrastructure and a mobile terminal. Some of the physical channels do not carry transport signals, they do not carry user information of any kind. They serve the physical layer itself, and include such resources as some pilot channels (that assist in modulation recovery), a synchronization channel (that lets mobile terminals synchronize to the network, and an acquisition channel (that establishes the initial connections to the mobile terminals). WCDMA resembles all CDMA systems currently deployed in that it applies the spreading function in two phases. An initial channelization code spreading is followed by a scrambling code spreading. The initial channelization code spreading alone determines the occupied bandwidth of the radio signal. As for the scrambling code, it is used to distinguish different mobile terminals at the base station's receiver and to distinguish multiple cell sites in the mobile terminal's receiver.

The second-generation IS-95 CDMA systems uses a single pseudo noise code common to all base stations, but applied by each base station with different time offsets. WCDMA elaborates on this scheme to allow for multiple connections to a single mobile terminal as well as variable spreading factors at the channelization spreading stage. Low user data rates get lots of coding gain with high spreading ratios while high user data rates get less coding gain because of their lower spreading ratios. The spreading details differ in down link (base to mobile) and the up link (mobile to base) directions. In the downlink direction the channelization codes separate different users in a cell. In the uplink direction they separate different physical channels (parallel connections) in a single mobile. All the spreading occurs in 10 ms frames at a constant chip rate of 3.84 Mcps.

WCDMA key features are:

- Wide band direct sequence CDMA, FDD and TDD support
- Support for 5, 10 or 20Mhz bandwidth
- QPSK modulation
- Closed loop power control
- Channel coding – convolutional
- Circuit or packet switched mode

4.2) cdma 2000

Sub-committee of TIA submitted a radio transmission technology called cdma 2000. This RTT protects investments in IS-95 equipments and systems. This is a multi carrier mode cdma. This is very similar to the frequency division multiplexing form of WCDMA. The chief differences from WCDMA are: 20 ms framing structure, instead of 10 ms and a slightly different spreading rate – 3.6864 Mcps which is exactly three times the IS-95 rate of 1.2288 Mcps. Multiple parallel connections can be established in up to three cdma carriers in what is called 3X operating mode.

The features of cdma-2000 can be summarized as follows:

- 1X and 3X 1.25Mhz channel
- MAC to support variable data rate
- Full support for packet and data services up to 2Mbps
- Voice over packet data

4.3) UWC-136 - The TDMA Mode

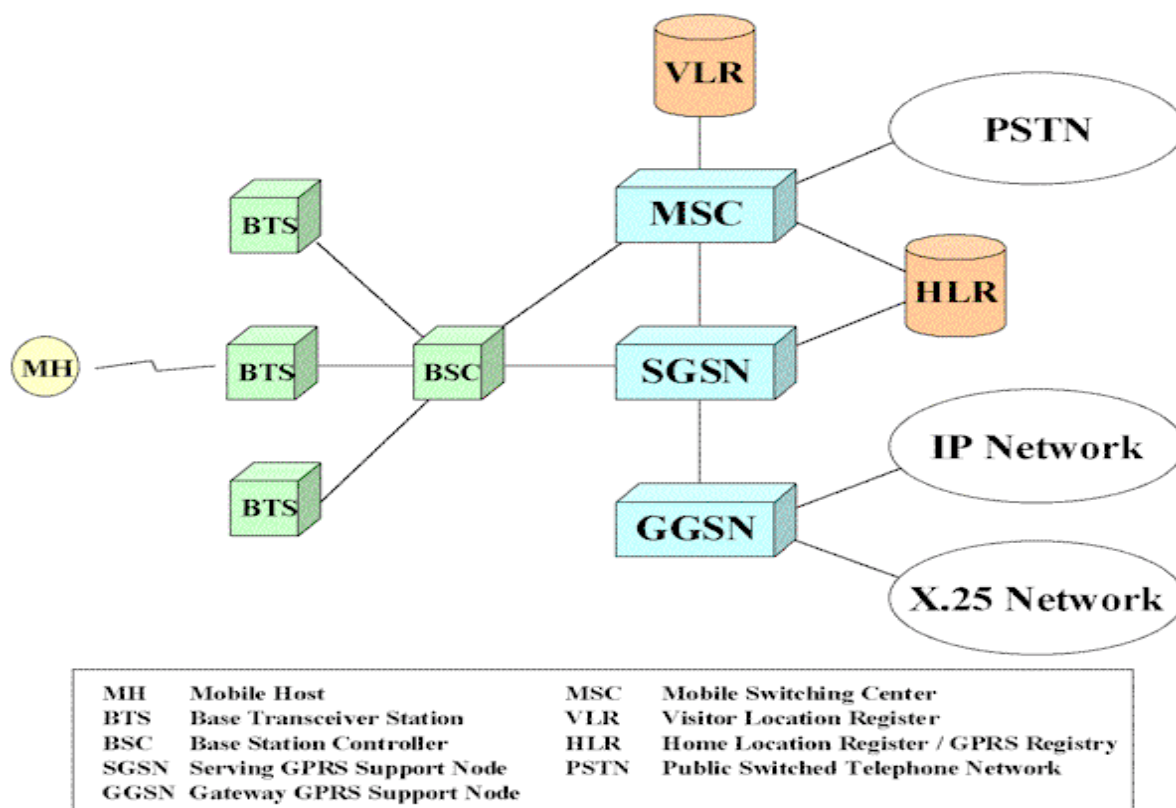


Figure 4.1: High Level GSM/GPRS Architecture

In North America, the second-generation 2G services are already deployed in the part of the spectrum reserved for 3G. So such operators with limited spectrum cannot employ wide band CDMA as their RTT to provide 3G services. There fore, some TDMA based 3G standards have been adopted by such operators, which are collectively known as UWC-136.

One of the modes is almost identical to GSM packet radio scheme called Enhanced Data rate for GSM Evolution (EDGE). Packet radio techniques are coupled with adaptive modulation- Gaussian Minimum Shift Keying (GMSK) and 8-Phase Shift Keying (8-PSK)- to give EDGE all of the 3G features except for its 2Mbps data rate.

5) 3G DATA RATES

The International Telecommunication Union (ITU) has laid down some indicative minimum requirements for the data speeds that the INT – 2000 standards must support. These requirements are defined according to the degree of mobility involved when the 3G call is being made. As such the data rate that will be available over 3G will depend upon the environment the call is being made in:

- **High Mobility:** 144 kbps for rural outdoor mobile use. This data rate is available for environments in which the 3G user is travelling more than 120 kmph in outdoor environments.
- **Full Mobility:** 384 kbps for pedestrian users traveling less than 120 kmph in urban outdoor environments.
- **Limited Mobility:** At least 2mbps with low mobility (less than 10 kmph) in stationary indoor and short range outdoor environments.
- **Satellite Environment:** 3G is supposed to provide a minimum data rate of 9.6 kbps in this environment.

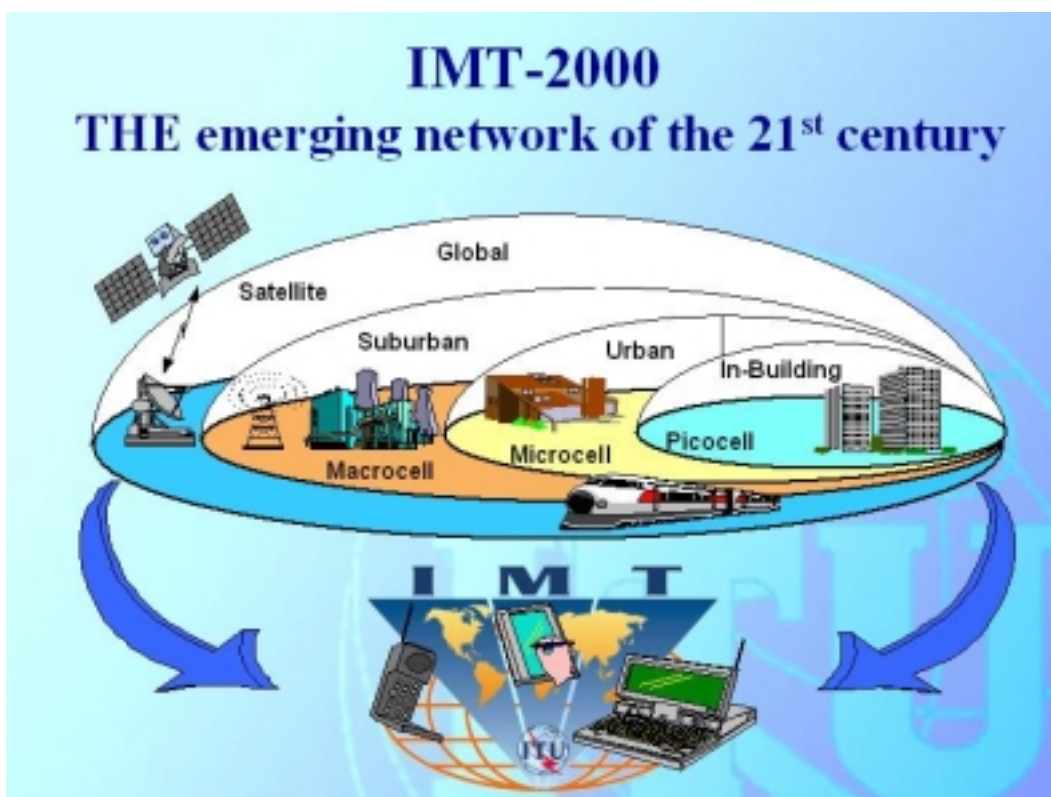


Figure 5.1: *The range of different networks offering different data rates*

6) 3G NETWORK ARCHITECTURE

The 3G network architecture is very complex and is difficult to understand & represent. So network reference model is used which makes its representation simpler.

NETWORK REFERENCE MODEL (cdma2000/3gpp2)

Reference models are graphical tools used to visualize, structure, and describe certain complex subjects. A few such models are widely used in the 3GPP2 wireless recommendations. Figure 6.1 presents the network entities and associated reference points that comprise a wireless network. The network entities are represented by squares, triangles and rounded corner rectangles; the reference points are represented by circles.

The network reference model is a functional block diagram. A network entity represents a group of functions, not a physical device. Sometimes, for practical reasons, the functional network entity is a physical device. The Mobile Station (MS) is an excellent example.

A reference point is a conceptual point that divides two groups of functions. It is not necessarily a physical interface. A reference point only becomes a physical interface when the network entities on either side of it are contained in different physical devices.

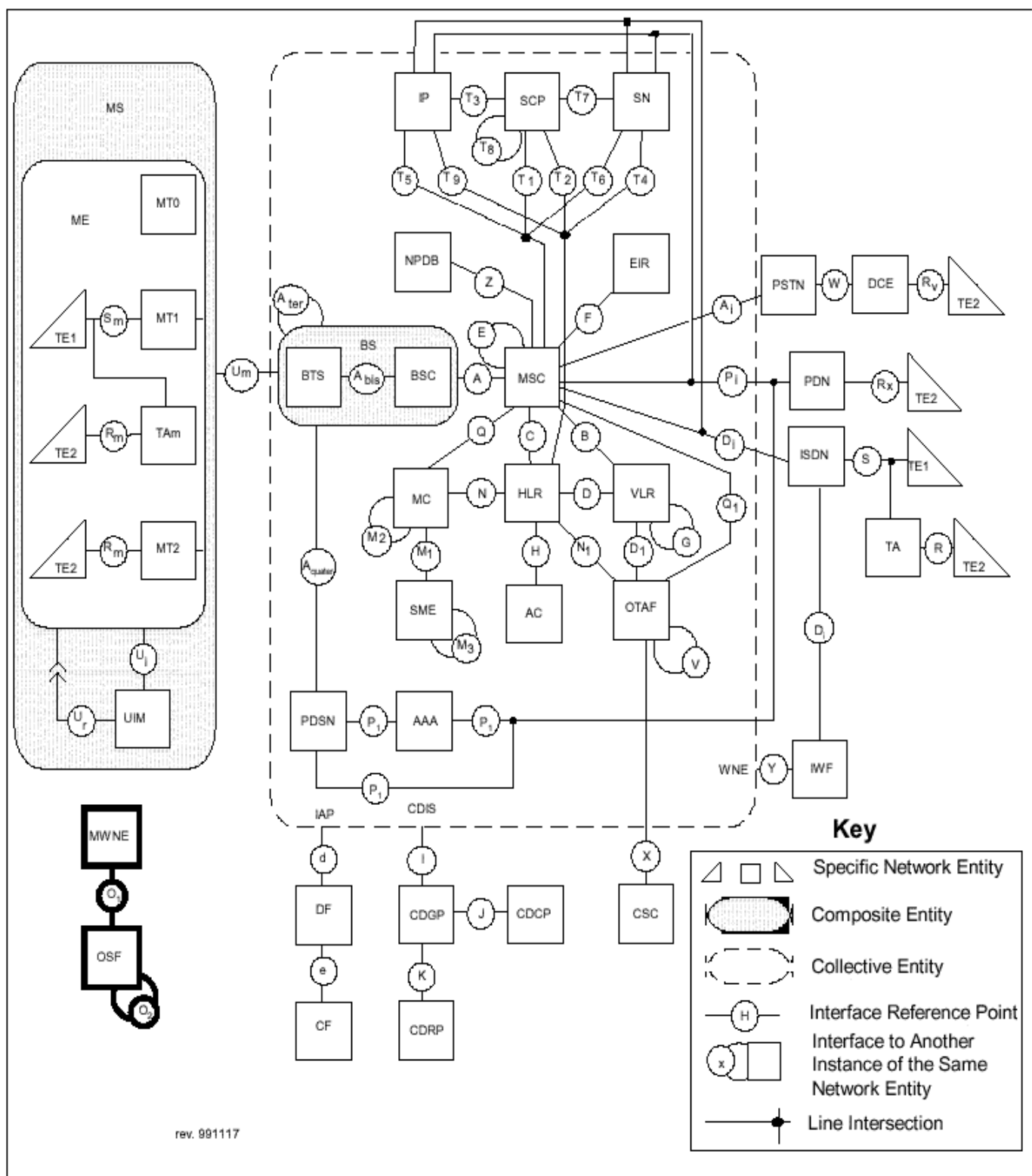


Figure 6.1: 3GPP2 Network Reference Model Architecture

The different components of the network are listed below:

AAA Authentication, Authorization, and Accounting

AC Authentication Center

BS Base Station

BSC Base Station Controller

BTS Base Transceiver System

CDCP Call Data Collection Point

CDGP Call Data Generation Point

CDIS Call Data Information Source

CDRP Call Data Rating Point

CF Collection Function

CSC Customer Service Center

DCE Data Circuit Equipment

DF Delivery Function

EIR Equipment Identity Register

HLR Home Location Register

IAP Intercept Access Point

IP Intelligent Peripheral

ISDN Integrated Services Digital Network

IWF Interworking Function

MC Message Center

MS Mobile Station

MSC Mobile Switching Center

MT Mobile Terminal

MWNE Managed Wireless Network Entity

NPDB Number Portability Database

OSF Operations System Function

OTAF Over-The-Air Service Provisioning Function

PDN Packet Data Network

PDSN Packet Data Serving Node

PSTN Public Switched Telephone Network

SCP Service Control Point

SME Short Message Entity

SN Service Node

TA Terminal Adapter

TE Terminal Equipment

UIM User Identity Module

VLR Visitor Location Register

WNE Wireless Network Entity

Authentication, Authorization and Accounting: The AAA is an entity that provides Internet Protocol functionality to support the functions of Authentication, Authorization, and Accounting. These IP functions are defined in Internet Engineering Task Force documents. The AAA interacts with the PDSN to perform AAA functions in support of the PDSN for requesting Mobile Stations. The AAA interacts with other AAA entities to perform AAA functions where the Home AAA is outside the serving mobile network.

Authentication Center (AC): The AC is an entity that manages the authentication information related to the MS. The AC may, or may not be located within, and be indistinguishable from an HLR. An AC may serve more than one HLR.

Base Station (BS): A BS is an entity that provides the means for MSs to access network services using radio.

It includes a BSC and a BTS.

Base Station Controller (BSC): The BSC is an entity that provides control and management for one or more BTSs. The BSC exchanges messages with both the BTS and the MSC. Traffic and signaling concerned with call control, mobility management, and MS management may pass transparently through the BSC.

Base Transceiver System (BTS): The BTS is an entity that provides transmission capabilities across the U m reference point. The BTS consists of radio devices, antenna and equipment.

Call Data Collection Point (CDCP): The CDCP is the entity that collects the *IS-124* format call detail information.

Call Data Generation Point (CDGP): The CDGP is an entity which provides call detail information to the CDCP in *IS-124* format. This may be the entity which converts call detail information from a proprietary format into the *IS-124* format. All information from the CDGP to the CDCP must be in *IS-124* format.

Call Data Information Source (CDIS): The CDIS is an entity that can be the source of call detail information. This information may be in proprietary format. It is not required to be in *IS-124* format.

Call Data Rating Point (CDRP): The CDRP is the entity that takes the unrated *IS-124* format call detail information and applies the applicable charge and tax related information. The charge and tax information is added using *IS-124* format.

Collection Function (CF) - [Intercept]: The CF is an entity that is responsible for collecting intercepted communications for a lawfully authorized law enforcement agency.

The CFs typically include:

- the ability to receive and process call contents information for each intercept subject.
- the ability to receive information regarding each intercept subject (e.g., call associated or non-call associated) from the Delivery function and process it.

Customer Service Center (CSC): The CSC is an entity where service provider representatives receive telephone calls from customers wishing to subscribe to initial wireless service or request a change in the customer's existing service. The CSC interfaces proprietarily with the OTAF to perform network and MS related changes necessary to complete the service provisioning request.

Data Circuit Equipment (DCE): A termination that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] V series, ITU-T [CCITT] X series).

Delivery Function (DF) - [Intercept]: The DF is an entity that is responsible for delivering intercepted communications to one or more collection functions.

The DFs typically include:

- the ability to accept call contents for each intercept subject over one or more channels from each Access function.
- the ability to deliver call contents for each intercept subject over one or more channels to a Collection function as authorized for each law enforcement agency.
- the ability to accept information over one or more data channels and combine that information into a single data flow for each intercept subject.

- the ability to filter or select information on an intercept subject before delivery to a Collection function as authorized for a particular law enforcement agency.
- the optional ability to detect audio in-band DTMF digits for translation and delivery to a Collection function as authorized for a particular law enforcement agency.
- the ability to duplicate and deliver information on the intercept subject to one or more Collection functions as authorized for each law enforcement agency.
- the ability to provide security to restrict access.

Equipment Identity Register (EIR): The EIR is an entity that is the register to which user equipment identity may be assigned for record purposes. The nature, purpose, and utilization of this information is an area for further study.

Home Location Register (HLR): The HLR is the location register to which a user identity is assigned for record purposes such as subscriber information (e.g. Electronic Serial Number (ESN), Mobile Directory Number (MDN), Profile Information, Current Location, Authorization Period).

Integrated Services Digital Network (ISDN): The ISDN is defined in accordance with the appropriate *ANSI T1* Standards.

Intelligent Peripheral (IP): The IP is an entity that performs specialized resource functions such as playing announcements, collecting digits, performing speech-to-text or text-to-speech conversion, recording and storing voice messages, facsimile services, data services, etc.

Intercept Access Point (IAP): The IAP is an entity that provides access to the communications to, or from, the equipment, facilities, or services of an intercept subject.

Interworking Function (IWF): The IWF is an entity that provides information conversion for one or more WNEs. An IWF may have an interface to a single WNE providing conversion services. An IWF may augment an identified interface between two WNEs, providing conversion services to both WNEs.

Managed Wireless Network Entity (MWNE): A wireless Entity within the Collective Entity or any specific Network Entity having OS wireless management needs, including another OS.

Message Center (MC): The MC is an entity that stores and forwards short messages. The MC may also provide supplementary services for Short Message Service (SMS).

Mobile Station (MS): A wireless terminal used by subscribers to access network services over a radio interface. MSs include portable units (e.g., hand-held units), units installed in vehicles, and somewhat paradoxically, fixed location MSs. The MS is the interface equipment used to terminate the radio path at the subscriber.

Mobile Switching Center (MSC): The MSC switches MS originated or MS terminated traffic. An MSC is usually connected to at least one BS. It may connect to the other public networks (PSTN, ISDN, etc.), other MSCs in the same network, or MSCs in different networks. The MSC may store information to support these capabilities.

Mobile Terminal 0 (MT0): A self-contained data capable MS termination that does not support an external interface.

Mobile Terminal 1 (MT1): A MS termination that provides an ISDN user-network interface.

Mobile Terminal 2 (MT2): A MS termination that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] V series, ITU-T [CCITT] X series).

Number Portability Database (NPDB): The NPDB is an entity which provides portability information for portable Directory Numbers.

Operations Systems Function (OSF): The OSF is defined by the Telecommunications Management Network (TMN) OSF. These functions include Element Management Layer (EML), Network Management Layer (NML), Service Management Layer (SML), and Business Management Layer (BML) functions spanning across all operations systems functions (e.g., Fault Management, Performance Management, Configuration management, accounting management and Security Management).

Over-The-Air Service Provisioning Function (OTAF): The OTAF is an entity that interfaces proprietarily to CSCs to support service provisioning activities. The OTAF interfaces with the MSC to send MS orders necessary to complete service provisioning requests.

Packet Data Serving Node (PDSN): The PDSN is an entity that provides Internet Protocol functionality to the mobile network. A PDSN establishes, maintains and terminates link layer sessions to the Mobile Station. A PDSN routes IP datagrams to the PDN. A PDSN may act as a Mobile IP Foreign Agent in the mobile network. A

PDSN may have interface to one or more Base Stations to provide the link layer session. A PDSN interacts with the AAA to provide IP authentication, authorization, and accounting support. A PDSN may interface to one or more IP networks either public or Intranet to provide IP network access.

Packet Data Network (PDN): A PDN, such as the Internet, provides a packet data transport mechanism between processing network entities capable of using such services.

Public Switched Telephone Network (PSTN): The PSTN is defined in accordance with the appropriate *ANSI T1* Standards.

Service Control Point (SCP): The SCP is an entity that acts as a real-time database and transaction processing system that provides service control and service data functionality.

Service Node (SN): The SN is an entity that provides service control, service data, specialized resources and call control functions to support bearer-related services.

Short Message Entity (SME): The SME is an entity that composes and decomposes short messages. A SME may, or may not be located within, and be indistinguishable from, an HLR, MC, VLR, MS, or MSC.

Terminal Adapter (TA): An entity that converts signaling and user data between a non-ISDN and an ISDN interface.

Terminal Adapter m (TA_m): An entity that converts signaling and user data between a non-ISDN and an ISDN interface.

Terminal Equipment 1 (TE1): A data terminal that provides an ISDN user-network interface.

Terminal Equipment 2 (TE2): A data terminal that provides a non-ISDN user-network interface (e.g., ITU-T [CCITT] Vseries, ITU-T [CCITT] X series).

User Identity Module (UIM): The UIM contains subscription information such as the NAM and may contain subscription feature information. The UIM can be integrated into any mobile terminal or it may be removable.

Visitor Location Register (VLR): The VLR is the location register other than the HLR used by an MSC to retrieve information for handling of calls to or from a visiting subscriber. The VLR may, or may not be located within, and be indistinguishable from an MSC. The VLR may serve more than one MSC.

Wireless Network Entity (WNE): A Network Entity in the wireless Collective Entity

Reference Points

The U m reference point is the only reference point that is by definition a physical interface. The other reference points will be physical interfaces if network entities on either side them are contained in different physical devices. An interface exists when two Network Entities are interconnected through exactly one Reference Point.

Reference Point A: the interface between the BSC and the MSC.

Reference Point A I: the interface between the IP and the PSTN, plus the interface between the MSC and the PSTN, plus the interface between the SN and the PSTN.

Reference Point A bis: the interface between the BSC and the BTS.

Reference Point A ter: is the BS to BS interface.

Reference Point Aquater: the interface between the PDSN and the BS.

Reference Point B: the interface between the MSC and the VLR.

Reference Point C: the interface between the MSC and the HLR.

Reference Point D: the interface between the VLR and the HLR.

Reference Point d: the interface between an IAP and the DF.

Reference Point D 1: the interface between the OTAF and the VLR.

Reference Point D I: the interface between the IP & the ISDN, the IWF & the ISDN, the interface between the MSC & the ISDN & the interface between the SN & ISDN.

Reference Point E: the interface between the MSC and the MSC.

Reference Point e: the interface between the CF and the DF.

Reference Point F: the interface between the MSC and the EIR.

Reference Point G: the interface between the VLR and the VLR.

Reference Point H the interface between the HLR and the AC.

Reference Point I: the interface between the CDIS and the CDGP. The operations supported by this interface are described in *IS-124*.

Reference Point J: the interface between the CDGP and the CDCP. The operations supported by this interface are described in *IS-124*.

Reference Point K: the interface between the CDGP and the CDRP. The operations supported by this interface are described in *IS-124*.

Reference Point L: Reserved.

Reference Point M 1: the interface between the SME and the MC.

Reference Point M 2 the MC to MC interface.

Reference Point M 3: the SME to SME interface.

Reference Point N: the interface between the HLR and the MC.

Reference Point N 1: the interface between the HLR and the OTAF.

Reference Point O1: the interface between an MWNE and the OSF.

Reference Point O2: the interface between two Operations Systems Functions (OSFs).

Reference Point P I: the interface between the MSC, the IWF, the PDSN, the AAA, and the PDN. This reference point is also the interface between the PDSN and the AAA.

Reference Point Q: the interface between the MC and the MSC.

Reference Point Q 1: the interface between the MSC and the OTAF.

Reference Point R: the interface between the TA and the TE2.

Reference Point R m: the interface between the TE2 and the TA m plus the interface between the TE2 and the MT2.

Reference Point R v: the interface between the DCE and the TE2.

Reference Point R x: the interface between the PPDN and the TE2.

Reference Point S: the interface between the ISDN and the TE1.

Reference Point S m: the interface between the TE1 and the MT1 plus the interface between the TE1 and the TAm.

Reference Point T 1: the interface between the MSC and the SCP.

Reference Point T 2: the interface between the HLR and the SCP.

Reference Point T 3: the interface between the IP and the SCP.

Reference Point T 4: the interface between the HLR and the SN.

Reference Point T 5: the interface between the IP and the MSC.

Reference Point T 6: the interface between the MSC and the SN.

Reference Point T 7: the interface between the SCP and the SN.

Reference Point T 8: the interface between the SCP and the SCP.

Reference Point T 9: the interface between the HLR and the IP.

Reference Point U I: the interface between the integrated UIM and a MT.

Reference Point U m: the interface between the BS and the MS, which corresponds to the air interface.

Reference Point U r: the interface between the Removable-UIM and a MT.

Reference Point V: the interface between the OTAF and the OTAF.

Reference Point W: the interface between the DCE and the PSTN.

Reference Point X: the interface between the CSC and the OTAF.

Reference Point Y: the interface between a Wireless Network Entity (WNE) & IWF.

Reference Point Z: the interface between the MSC and the NPDB.

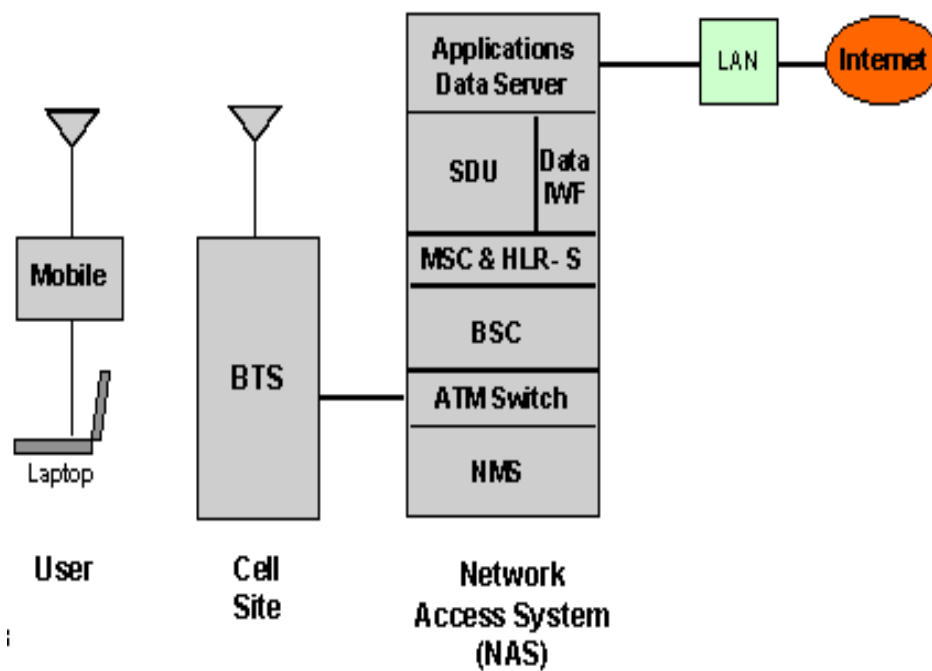


Figure 6.2: A simplified block diagram of a 3G system

7) 3G DUPLEX TECHNIQUES

3G standards employing WCDMA uses two types of duplexing techniques: *Time Division Duplex (TDD)* and *Frequency Division Duplex (FDD)*.

Frequency Division Duplex

The frame structure in the FDD component is different in the uplink and downlink. In the uplink, the data and control channels are I/Q multiplexed, whereas in the downlink data and control channels are time multiplexed. The FDD component applies two-layered consisting of spreading codes and scrambling (long) codes. The I/Q multiplexed DPDCH and DPCCH in the uplink are quadrature phase shift keying (QPSK) modulated. Each channel is scrambled with a specific code for DPDCH and for DPCCH, and then scrambled with a mobile station specific scrambling code to distinguish different mobile stations. Each DPDCH is assigned its own channelization code.

On the downlink multiple codes are transmitted with possibly different spreading factors for the different DPCHs depending on the service. The data modulation is QPSK. Spreading is performed by channelization codes for each DPCH and a cell specific scrambling code to distinguish different cells. In the downlink the scrambling code is a cell specific 10ms (40960 chips) segment of a Gold code sequence. The FDD component supports both synchronous and asynchronous inter cell operation.

Time Division Duplex

The TDD component is based on TD-CDMA, which is a combination of TDMA and CDMA. Each time slot comprises several (maximum 16) orthogonal spreading codes. Different user rates are supported by code and/or time slot pooling. In the uplink the variable orthogonal spreading rate is also applied.

Due to the same carrier frequency in the uplink and downlink, a TDD system requires a frame synchronized network to control interference for coordinated operation.

8) WCDMA CHANNEL STRUCTURE

The WCDMA channels can be classified as follows. A logical channel is defined by the type of information transferred. The logical channel types are:

- Control Channels (CCH) with logical broadcast control channel (L-BCCH), logical forward access channel (L-FACH), logical random access channel(L-RACH), and dedicated control channel(DCCH)
- Traffic channels (TCH) with dedicated traffic channel (DTCH) and user packet traffic channel (UPCH)

The physical layer offers information transfer services to the medium access control (MAC) and higher layers. The physical layer transport services are described by how and with what characteristics data are transferred over the radio interface. An adequate term for this is the transport channel. Transport channels can be generally classified into two types:

- Common channels with broadcast control channel (BCCH), paging channel (PCH), forward access channel (FACH), and random access channel (RACH)
- Dedicated channels (DCH)

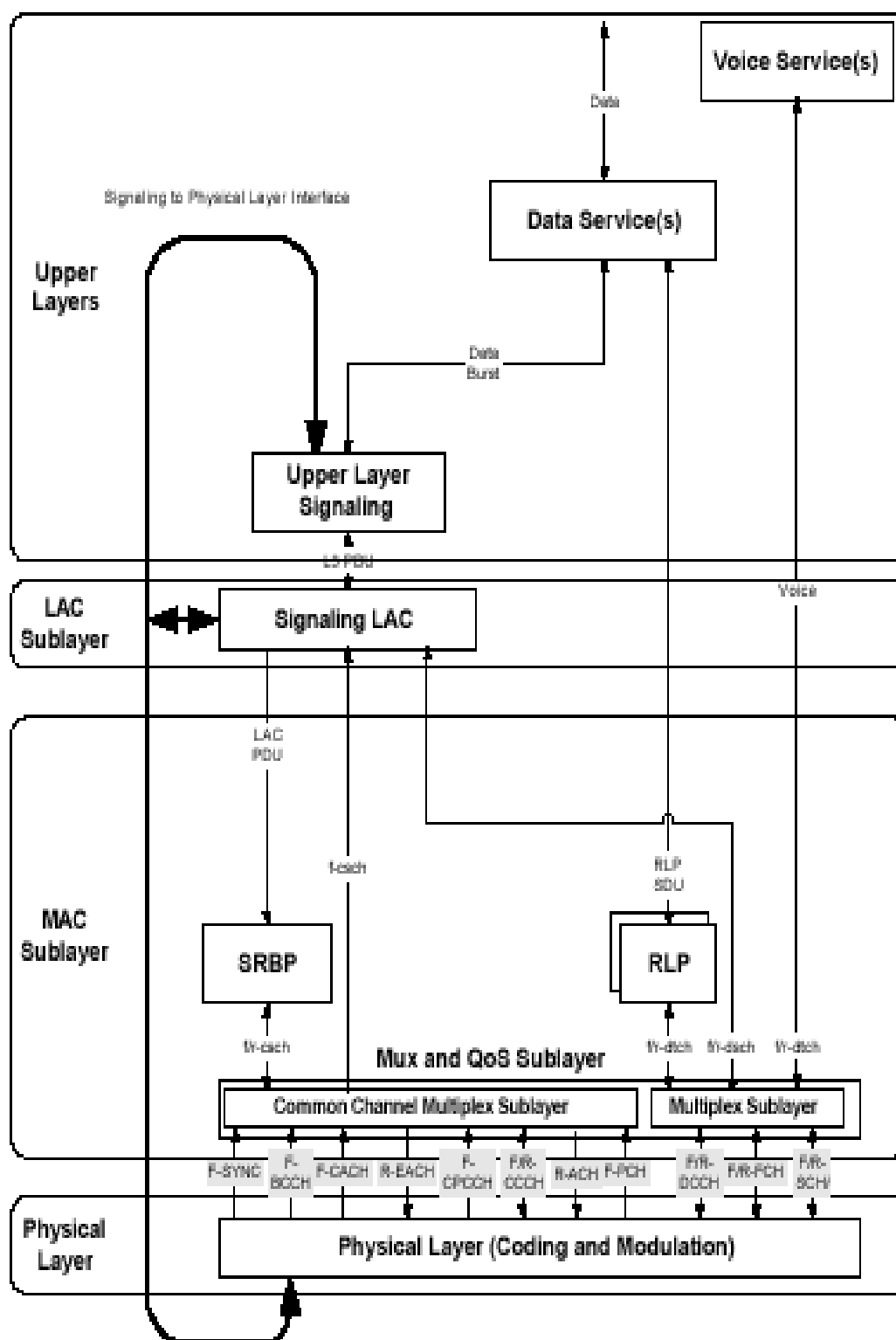


Figure 8.1: CDMA channel structure

9) 3G PROTOCOLS

The protocol stack proposed for 3g wireless platform is shown below:

WAP
TCP
IP
IP over WmATM
WmATM with WAAL
MAC
DBA
Physical Layer

WmATM cells are generated through the wireless ATM adaptation layer (WAAL). The DBA (Dynamic Bandwidth allocation) layer handles dynamic bandwidth allocation to increase the spectrum utilization. The wireless application protocol (WAP) is the de facto world standard for the presentation and delivery of wireless information. As per the International telecommunication union- radio communication standard sector (ITU-R) IOMT-2000 radio transmission technology adopts the CDMA and TDMA for the physical layer, which contain 16 time division duplex time slots and each slot can be composed of up to 64 CDMA codes for the 3g wireless systems.

Different services have various quality of service requirements as well as system parameters, so the bandwidth allocation should be dynamic and adaptive. This kind of MAC (Media access controller) can be implemented using DSP. 3G also supports Internet access through the mobile terminal, therefore it has to support TCP/IP protocols.

10) 3G HANDSET

The common trends in 3G terminals are:

- Bigger and better screen technology- screens will be color and must have considerably larger screen areas.
- Video and multimedia are central to the technology demonstration. So videoconference is an application that many of the concept terminals anticipate.
- Majority of 3G terminals include a miniature camera built into it.

10.1) HARDWARE REQUIREMENTS

Third generation handsets will demand new levels of performance from their RF sections. To meet the wider bandwidth, increased linearity and lower power requirements lead to high speed, low noise, bipolar integration technologies such as GaAs. One of the main challenges will be in the mixed signal area such as analog to digital converters and digital to analog converters that will have to operate at 10 mega samples per second. 3G products will be able to reduce the number and size of external passive devices used for filtering and coupling. Another difficulty is accommodating variable carrier bandwidth. So we move digitization of signals much closer to antenna enabling designers to use programmable DSPs to perform demodulation and decoding. It takes around 60 MIPS worth of DSP to support a typical GSM phone whereas a 3G EWCDMA phone will require 300 MIPS.

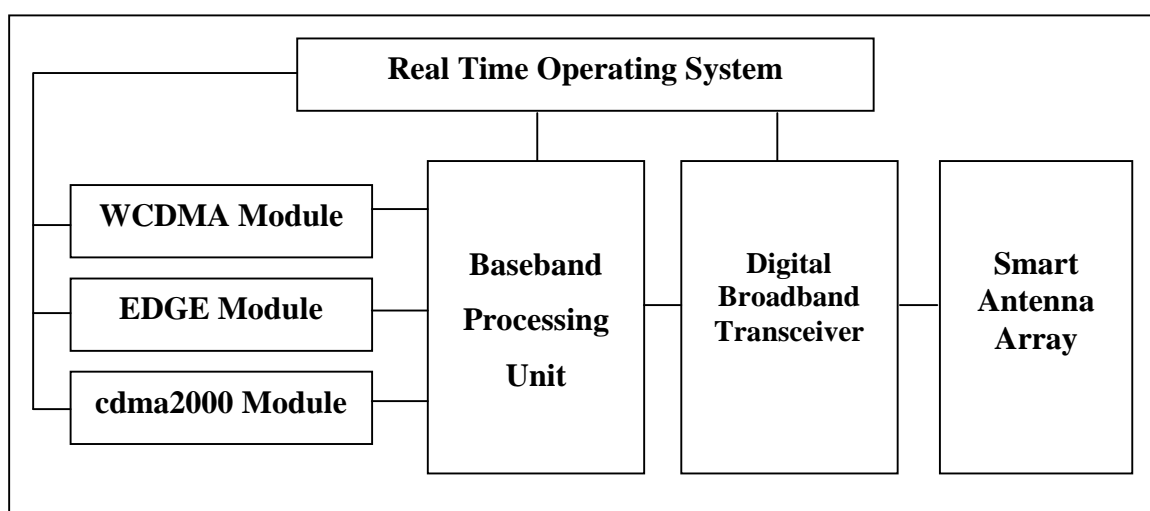


Figure 10.1: An implementational framework of a 3G (tri-mode) phone with support for global roaming

Users, operators & vendors want to improve the flexibility & capability of their wireless communication equipments by using software reconfigurable radio technology offers a potential of substantially improved operational capability at a lower cost. It also offers multi mode operations using the same hardware by simply changing the embedded software. This supports multi mode global roaming phones at an affordable price.

The main functional blocks in a 3G handset are the following :

1. **A Smart Antenna Array:** This antenna array is capable of controlling transmitted power according to the control information from the BTS. Most 3G systems employ a closed loop power control
2. **Front End High Speed ADC & DAC:** The third generation terminals make use of high speed ADC and DAC in the RF stage. This helps to use programmable DSP circuitry for up and down conversions, modulation-demodulation and coding-decoding functions.
3. **A Microcontroller:** This microcontroller controls the DSP operations and also helps in power management. In most of the 3G phone chipsets the microcontroller and the DSP are integrated into a single chip.
4. **Colour LCD Display:** As 3G system supports multimedia applications and mobile teleconferencing, a comparatively larger multi colour LCD display is necessary.
5. **Signal Processing Circuitry:** This will be a DSP processor which will handle digital audio decoding, video streaming, voice compression, channel coding, modem, equalization, encryption, echo cancellation, speech recognition, noise suppression security encryption and decryption, for mobile commerce and more to add new functionality to digital wireless phones (The world's lowest power DSP, the new TMS320C55x™ announced February 22, 2000, is the processor of choice for the next-generation digital wireless phones and a whole new generation of wireless Internet appliances)

10.2) SOFTWARE REQUIREMENTS

As the 3G phones use programmable hardware an embedded operating system is used in addition to this to handle user interface of the phone a Java Virtual Machine is used.

11) 3G-QUALITY OF SERVICE

First and second-generation cellular systems provided their circuit switched resources to subscribers with a fixed quality of services (QoS). Networks in the latest generation, on the other hand, will assign default QoS profiles to users and their applications. A subscriber's application negotiates a suitable QoS profile with the network which allots its resources according to the default profile or with some alternative profile, depending on the load on the network, the propagation conditions and QoS profiles authorized by user's subscription.

At the subscriber level, four kinds of traffic can be distinguished: conversational, streaming, interactive and background.

Conversational traffic is the most familiar type of traffic. Fairly tolerant of errors, conversational and videoconferencing traffic have different throughput requirements, but they demand a constant and rather short end-to-end delay.

Streaming traffic applies to applications that can start processing the traffic for presentation to the user before the whole file is transmitted to the subscriber. It can work within a small range of delays and throughput delays.

Interactive traffic is used by online applications, in which a subscriber is allowed to interact with a server of some kind: Web browsing, e-commerce, games and location-based services. Interactive traffic can work acceptably over an intermediate range of delays and throughput rates.

Finally, *background traffic* is very tolerant of delays, works within a wide range of throughput rates, but is relatively intolerant of errors. These include applications such as e-mail, short messaging services and file downloads. Background traffic is the most naturally compatible with packet data networks.

12) 3G APPLICATIONS

There are several applications that will be enabled by the broadband wireless communication channels that will come with 3G. These applications include:

AUDIO

Audio or video over the Internet is downloaded (transferred, stored and played) or streamed (played as it is being send but not stored). The different compression algorithms such as MP3 can be used. With 3G, MP3 files will be downloadable over the air directly to the phone via a dedicated server. The large computational power available in the 3G phones helps the decoding of MP3 formats.

VOICE OVER INTERNET PROTOCOL

Another audio application for 3G is Voice over IP (VoIP) – the ability to route telephone calls over the Internet to provide voice telephone service at local call rates to anywhere in the world. With the higher data rates supported by 3G, VoIP will be available on mobile phones.

STILL IMAGES

Still images such as photographs, pictures, letters, postcards, greeting cards, presentations and static web pages can be send and received over mobile networks just as they are across an IP based network.

MOVING IMAGES

Sending moving images in a mobile environment has several vertical market applications including monitoring parking lots or building sites for intruders or thieves, sending images of a patient from an ambulance to a hospital, mobile video conferencing applications etc.

VIRTUAL HOME ENVIRONMENT (VHE)

A Universal Mobile Telecommunications Services (UMTS) service that is often mentioned in the vendor's brochures is so called Virtual Home Environment, a service that simply lets customers have seamless access with a common look and feel to their services from home, office or on the move in any city

as if they were at home. VHE is there fore aimed at roamers, a small subset of mobile phone users. VHE could also allow some other useful services by placing their Universal Identity Module into any terminal and those terminals could be other than mobile devices (if smart cards are more widely supported than they are today).

ELECTRONIC AGENTS

Electronic agents are supposed to play an important role for mobile working in the future – as agents are dispatched to carry out searches and tasks on the Internet and report back to their owners. This is an efficient way to get things done on the move. Electronic agents are defined as “ mobile programs that go to places in the network to carry out their owner’s instructions”. Agents are self-contained programs that roam communication networks, delivering and receiving messages or looking for information or services. Certainly, 3G terminals will give their owners much more control over their lives than today’s mobile phones. They will be e-assistance, e-secretaries, e-advisors, e-administrators etc. This kind of control is what home automation applications anticipate.

DOWNLOADING SOFTWARE

In the 21st century, software will increasingly be downloaded electronically from the Internet rather than purchased as boxed products in stores. This is like file transfer applications that involve downloading the software itself. We might, for example need WinZip or adobe acrobat to read a file and can download that over the 3G network to a 3G terminal. Additionally Application Service Provision (ASP) market in which software platforms and server software is being hosted by third parties and accessed by client software mimics this thin client world in which the bandwidth is high enough for applications and files to be retrieved from the Internet on the fly whenever they are needed.

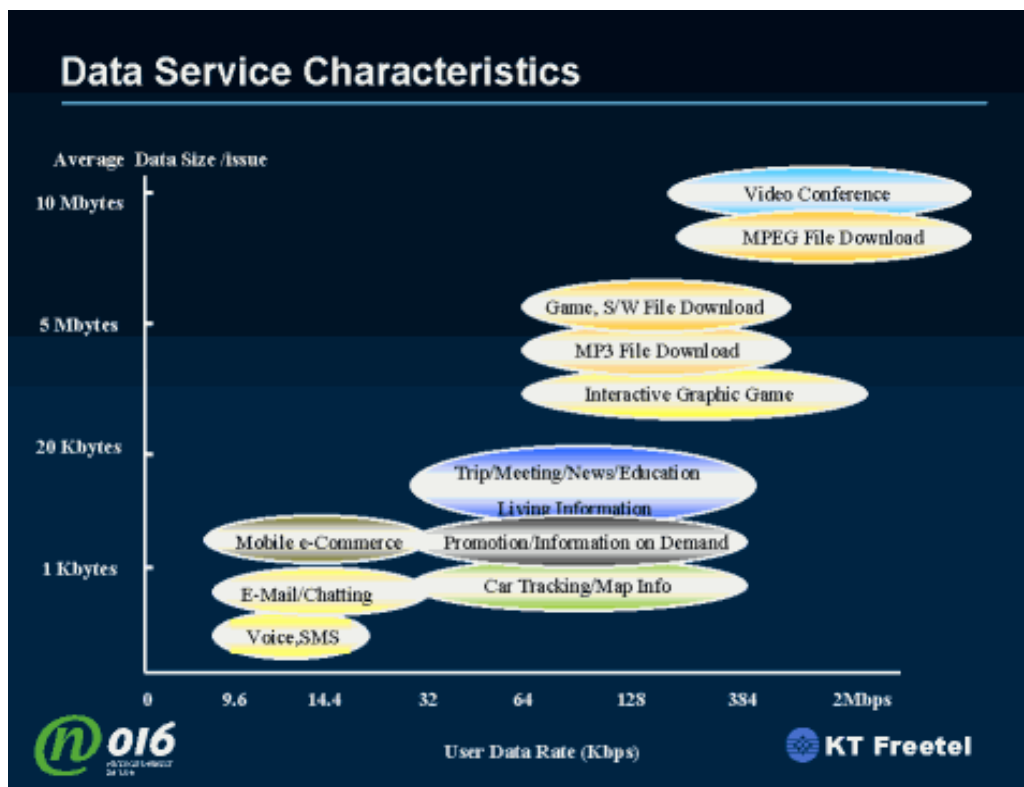


Figure 12.1: Different 3G applications and corresponding data rates

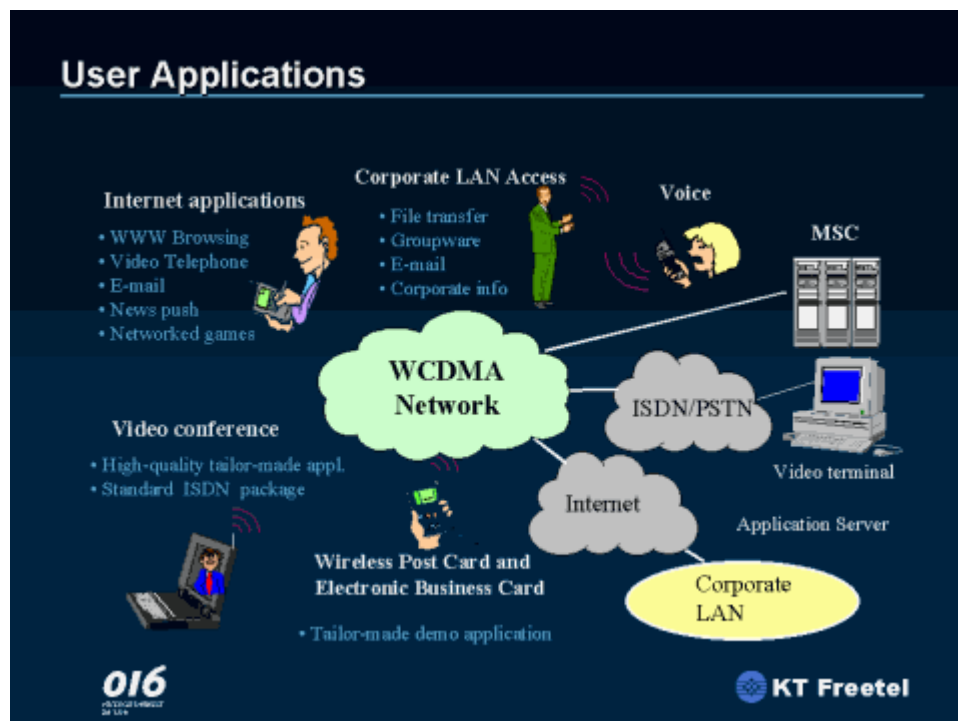


Figure 12.2: User Applications

13) 3G DRAWBACKS

The main draw back of 3G is its high cost. Considering a typical example, to set up 3G trial network infrastructure The Nippon Telephone and Telegraph had to invest 18\$ billion in 1999. Also a 3G phone may cost 1000\$+.

The second disadvantage is shorter battery life of 3G phones when compared to 2G mobile phones. This is because 3G phones have a comparatively larger display screen and the increased power consumption of modern high speed DSP processors used in 3G phones.

The most important disadvantage of 3G services is the lack of an internationally uniformed standard. The third generation cellular telephony is on its way, not as a single worldwide system but as three incompatible ones. This will make the global roaming difficult. For global roaming we have to use multimode phones, which can operate in different radio interface standards and this will result in costlier handsets.

14) VISIONS OF THE FUTURE

3G is capable of providing very high data rate in different radio environments. It can provide dream multimedia services. At present there is no hope of a wireless communication technology, which can perform better than 3G. It is expected that the trends should last into a Fourth Generation (4G) of even better spectrum efficiencies, higher radio carrier frequencies, even higher user data rates, and a blizzard of new non voice applications plus the terminals to support them.

A wireless terminal that is your gateway to the world of voice data, video and multimedia communications sounds possible sooner. The year is 2005, your traveling in the passenger seat of your work-colleague's car with a laptop computer in front of you, you sip a cup of coffee while you write a short report on the meeting you attended that day. Suddenly, you hear the tone that tells you there's an incoming videoconference call. You click on the screen icon, the computer screen changes and you see your assistant's face. The two of you have a brief conversation. Then she tells you about a new intranet site that could be useful for your next customer meeting. So without interrupting the conversation, you take a look at the website, and your assistant guides you to the most interesting pages. A few minutes later, your sales department calls and sends you the technical specifications and pricing information that you need for your next meeting. At the same time you send your completed report to the eight people who need copies. Meanwhile, a memo from one of your co-directors arrives on your computer. It's about an important item on your own company, broadcast on that morning's TV news report. A clip of the TV item is attached to the e-mail, so you watch it. This is not science fiction, it a preview of everyday communication services that will be a commercial reality within the next few years. So called "third generation" wireless services (also referred to as "3G services") will significantly expand the range of options available to users and allow communications, information and entertainment services to be delivered via wireless terminals. The exciting thing is that the foundation for these services has already been laid down – in a shape of today's digital mobile phone networks. All that is needed to support these advanced multimedia services is to expand the information capacity, or "bandwidth" of the radio communications technology.

15) CONCLUSION

A tremendous growth of mobile subscribers is expected, with nearly 1.8 billion in the year 2010 with a dominant base in Asia. GSM is the mobile radio standard with the highest penetration world wide. Mobile multimedia will increase after the year 2000 to about 60% of the traffic in the year 2010. Therefore third generation systems have to support a wide range of services from voice to low data rate up to high data rate circuit switched and packet oriented services. In addition a high grade of asymmetry for data application is expected. With this wireless breakthrough, unified IP network including wireless and wireline provides a generic information transmission platform for value added personal Internet services and multidimensional wireless communication services.

In this seminar we briefly surveyed the evolution 3G wireless systems from 2G and 2.5G technologies. Similarities and key differences between the various 3G proposals submitted to ITU-R are reviewed. IN order to have a common standard for RTT, it is imperative to carry out harmonization in an international level. With the recent technological breakthroughs in digital signal processing, RF and battery technologies as well as developments in modern VLSI chip designs, the dream of ubiquitous communication between any one, any where, at any time is becoming a reality. To cut it short, we can say that the wireless information super highway is converging to 3G and during the coming decade we will see how 3G will make the other wireless communication methods obsolete.