The Future of GSM

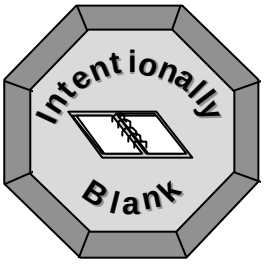
Chapter 15

This chapter is designed to provide the student with an overview of the possible future functionality of GSM-based systems.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- Describe the evolution of GSM to WCDMA systems
- Describe the technologies that will bridge these two systems including HSDSD, EDGE and GPRS
- Describe the 3G system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15: The Future of GSM

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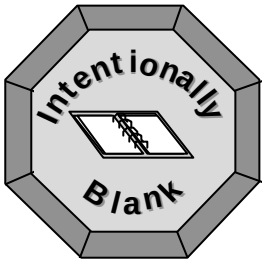
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INTRODUCTION

The market for mobile communications has grown explosively since the introduction of 2nd generation digital systems. The mobile phone has become common place in most developed countries. There are clear indications that the number of subscribers will not cease to increase in the coming years.

The market is predicted to boom tremendously for the next 5 years in all four continents. Americas, Europe and Asia.

So, let us look into the future to see how the market will grow:

By the year 2005, Ericsson believes the market will have reached 1.4 billion users.

- The worlds biggest market will be China, representing a big part of the future growth.

With an incredible increase in the number of users and in the minutes of use, as well as the introduction of new types of services for Mobile Internet - the operators need to prepare themselves to be winners in this new market.

In order to keep their shareholders happy they have to commit themselves to:

True network reliability in this huge network expansion

Early introduction of IP services that attract the Internet user

Reduced cost of operating the network aligned with this expansion

The Internet has also experienced explosive growth in the last decades with the number of subscribers doubling each year.

The mobile services are evolving beyond voice to Internet access and multimedia services, as the market demands are increasing. End users are becoming gradually used to multimedia communications with ever growing demands on bandwidth and Quality of Service (QoS).

Throughout the world the evolution of mobile communications is at different stages. For the end user to satisfactorily use advanced applications, mobile telephony networks are required to offer higher bandwidth.

With 2G systems, such as GSM, the highest available bandwidth affords a 56kbit/s download rate, which at best gives the end user internet text. To avail of video services, of either medium or high quality, operators are obliged to invest in 3G networks such as EDGE (Enhanced Data for the GSM Evolution) or UMTS (Universal Mobile Telephony Standard).

One of the main aspects of 3G is to support data services at high bit rates, up to 2 Mbit/s. To be able to support these bit rates, a new radio technology, Wideband Code Division Multiple Access (WCDMA) is used. This new technology will be discussed later in this chapter.

THE EVOLUTION OF GSM TO 3G

In the last two decades the wireless industry has gone through dramatic change sparked by the ever growing demands of the wireless consumer.

Europe, plagued by a number of incompatible analog cellular technologies i.e. NMT (Nordic Mobile Telephony) and TACS (Total Access Communications System), established a pan-European digital cellular telephone system called GSM. This common standard allows Europeans to roam in more than 100 countries. GSM is widely deployed throughout the world and is the predominant standard in Europe. GSM is also recognized as the world leader in terms of the number of subscribers.

In North America second generation system designs were in response to the increased capacity and quality demands of consumers. The systems developed were TDMA (Time Division Multiple Access) and cdmaOne.

The second generation of mobile telephony also saw the introduction of PDC, principally for use in Japan. In other parts of Asia, IS-136 or TDMA, IS-95 or cdmaOne were being used.

Data however had very little emphasis with these second-generation designs especially GSM and TDMA. Most networks improved efficiency and offered optional low rate circuit-switched and packet-switched data services.

One solution for offering low rate circuit-switched services was to "off-load" the data traffic from the 2G system and direct it towards the PSTN.

Until recently, the most advanced version of GSM circuit switched (CS) data services standard allowed for a data rate of 9.6kbit/s. In this version of GSM the user is allowed only one timeslot per carrier and because each timeslot has a maximum capacity of 9.6kbit/s, the capacity of this version in GSM is limited to 9.6kbit/s.

GSM has evolved to become a 3G network through several steps to make a "soft evolution". GSM as mentioned is optimized for speech and not for data and originally it only provides 9.6 kbit/s over the air interface.

The most important steps involved in the evolution of GSM to increase the data transfer rate are:

- High Speed Circuit Switched Data (HSCSD)
- General Packet Radio Service (GPRS)
- Enhanced Data for the GSM Evolution (EDGE)

Figure 15-1 The Evolution of GSM

HSCSD

With the introduction of HSCSD (High Speed Circuit Switched Data) a more advanced version of GSM was introduced.

High Speed Circuit Switched Data (HSCSD) makes it possible to use several timeslots simultaneously in circuit switched mode. Today up to 4 timeslots can be used at the same time. Furthermore, the maximum data rate in one of the timeslots is increased from 9.6 kbit/s to 14.4kbit/s with the new coding scheme.

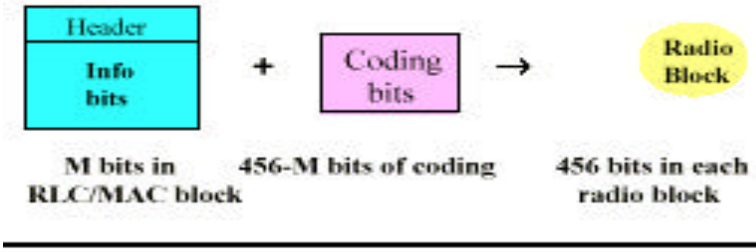
A combination of 4 timeslots gives a bit rate of 38.4-57.6kbit/s, which is comparable to ISDN. HSCSD is preferable for real time services (voice/video). For HSCSD implementation, only software modifications are necessary.

GPRS

The next step to more data service capability came in the form of GPRS (General Radio Packet Service).

The general trend in data applications is the generation of increasingly bursty data streams. To support data streams with higher bit rates a greater bandwidth is needed. Although HSCSD does well on bandwidth by combining multiple channels, it wastes scarce radio resources due to its circuit switched nature. It therefore became necessary to introduce packet switching in the existing GSM networks in order to provide an attractive bearer service for users wanting fast, efficient and cheap access to the internet and/or corporate intranet. Extending GSM networks to support packet switching services is therefore critical for operators wanting to position themselves in the 3G telecom market. GPRS is a prerequisite to support packet data in UMTS/WCDMA systems.

In GPRS four coding schemes (CS) have been defined corresponding to a different ratio of coding bits and information bits. The more coding bits that are added the more transmission is secured, but information rate decreases. Therefore CS 1 is the most secured coding scheme but provides the lowest information rate (9.04 kbit/s). CS 4 is the least reliable coding scheme, but has the highest rate of information bits (21.4kbit/s).



Coding	Max no of Info bits	Max data rate per TS (kbps)	Target C/I (dB)
CS-1	181	9.05	~6
CS-2	268	13.4	~9
CS-3	312	15.6	~12
CS-4	428	21.4	~17

Figure 15-2 Coding Schemes

GPRS NETWORK

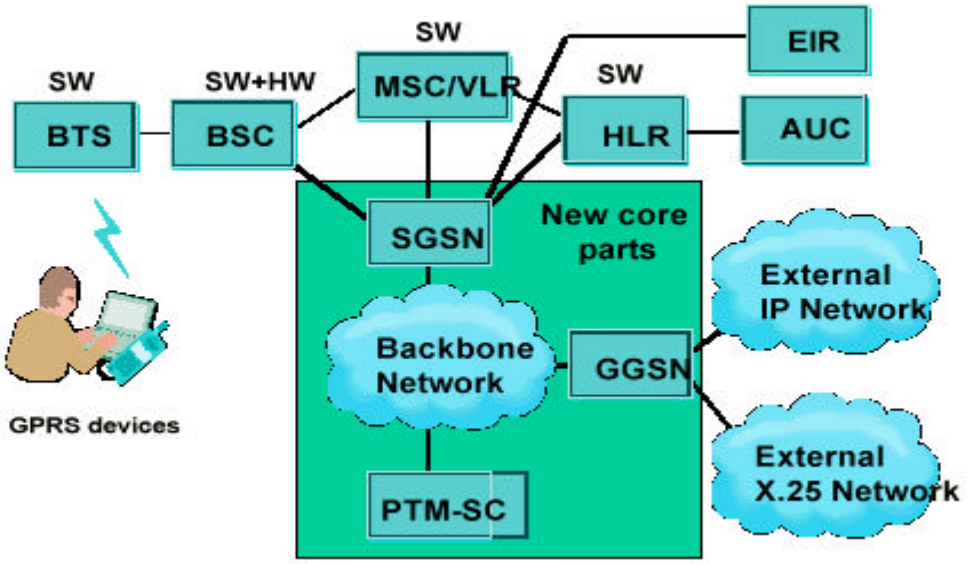


Figure 15-3 The GPRS Architecture

GPRS is a bearer service realized by the introduction of two new logical nodes in an existing GSM system: the SGSN (Serving GPRS Support Node) and the GGSN (Gateway GPRS Support Node). Another node that can be recognized in the diagram is the PTM-SC (Point to Multipoint Service Center) which will be involved in broadcast messages based on the location of the subscriber within a network.

A new unit is introduced into existing BSCs called the Packet Control Unit (PCU). The PCU consists of both hardware and software with a central and regional processor. Previously there was a theoretical maximum of 16 RPPs (Regional Packet Processors) held within a PCU. The system limit has now been increased from 16 to 64 RPPs per PCU, making it possible to handle high volumes of GPRS and EDGE traffic.

Please note that it is 64 RPPs per PCU and not per BSC.

Within the BTS only a software upgrade will be needed to support new channel coding schemes. The new software makes it possible to take advantage of improving radio conditions by providing more efficient coding schemes, adding fewer correction bits to data, thus increasing the raw data rate.

EDGE

Operators deploying GSM/GPRS systems have two paths from which to choose. With the addition of EDGE to a GPRS network, operators can introduce EGPRS (Enhanced GPRS) that offers speeds of up to 384kbit/s. An operator who acquires a license to operate in the new spectrum can implement UMTS, deploying WCDMA technology and offers access speeds of up to 2Mbit/s.

EDGE, which stands for Enhanced Data rates for Global Evolution, is an improved version of GPRS and a logical cost-effective step toward third-generation (3G) technology. The implementation of EDGE in Ericsson GSM networks creates minor changes in the network.

EDGE is an “add on” to the radio parts of GPRS, which means EDGE requires GPRS and can not work alone. With better signaling and a new modulation coding scheme, EDGE increases data transmission speeds to up to 384 kbit/s or higher. This translates into a bit rate of approximately 48 kbit/s per timeslot.

The EDGE standard has been defined for both circuit-switched and packet-switched traffic. The term EGPRS, which stands for Enhanced GPRS, refers to the packet-switching side of EDGE. EGPRS reflects the significant increase in data rates that GPRS provides when EDGE is deployed.

Therefore, EDGE comprises both EGPRS and ECSD (which stands for Enhanced Circuit-Switched Data). ECSD provides the same services as HSCSD, but with higher data rates. Data rates for EDGE are up to 64 kbit/s for transparent data and up to 57.6 kbit/s for non-transparent data.

Which means that the same service could be supplied by ECSD with fewer timeslots. This is a significant improvement to the 170 kbit/s transmission speeds that could be obtained over GPRS. On average, EDGE can handle three times the data throughput of GPRS using existing 800, 900, 1800 and 1900 MHz radio spectrum bands.

IMPACT ON THE GSM ARCHITECTURE

GPRS has a much larger impact on the GSM system than EDGE has. By adding the new modulation/coding to GPRS and making some adjustments to the radio link protocol, you get EGPRS, offering significantly higher throughput.

From a BSS point of view GPRS and EDGE (or EGPRS) have different protocols and different behavior. However, from a core network view the same handling is done, meaning that no changes are needed to existing infrastructure to support EDGE in the core network. This emphasizes the fact that EDGE is only an "add-on" for BSS and a far smaller step to introduce then GPRS is.

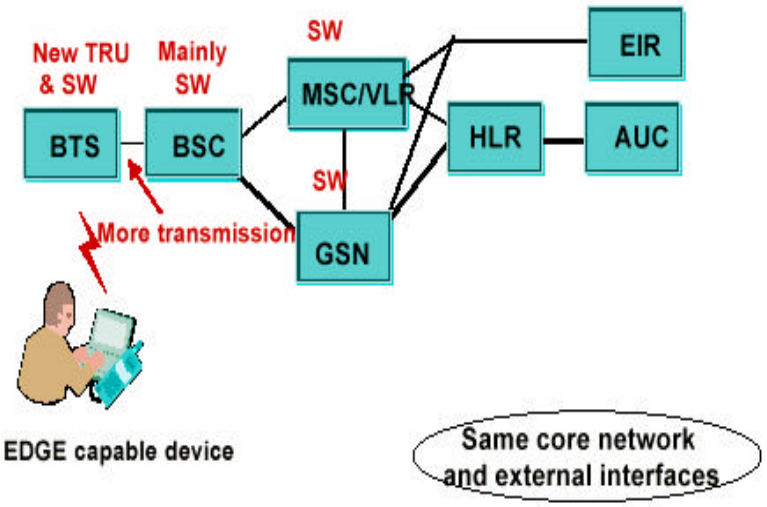


Figure 15-4 Network Modification due to EDGE

Apart from enhancing the throughput for each data user, EDGE also leads to an increased capacity. More users can be supported on the same timeslot, which means a decrease in the number of radio resources needed to support the same traffic. Capacity can thus be freed up for voice services.

With EDGE it is far easier to make circuit switched and packet switched traffic coexist when battling over the same radio resources. Thus in tight planned networks with a limited amount of spectrum, available EDGE should also be seen as a capacity booster for the data traffic.

EDGE MODULATION TECHNIQUE

The modulation type that is used in GSM is called Gaussian Minimum Shift Keying (GMSK), which is a type of phase modulation. This can be visualized in a so-called I/Q-diagram that shows the real (I) and imaginary (Q) components of the transmitted signal.Transmitting a 0-bit or a 1-bit is then represented by incrementing the phase with + ½ π. Every symbol that is transmitted represents one bit; i.e. each shift in the phase represents one bit.

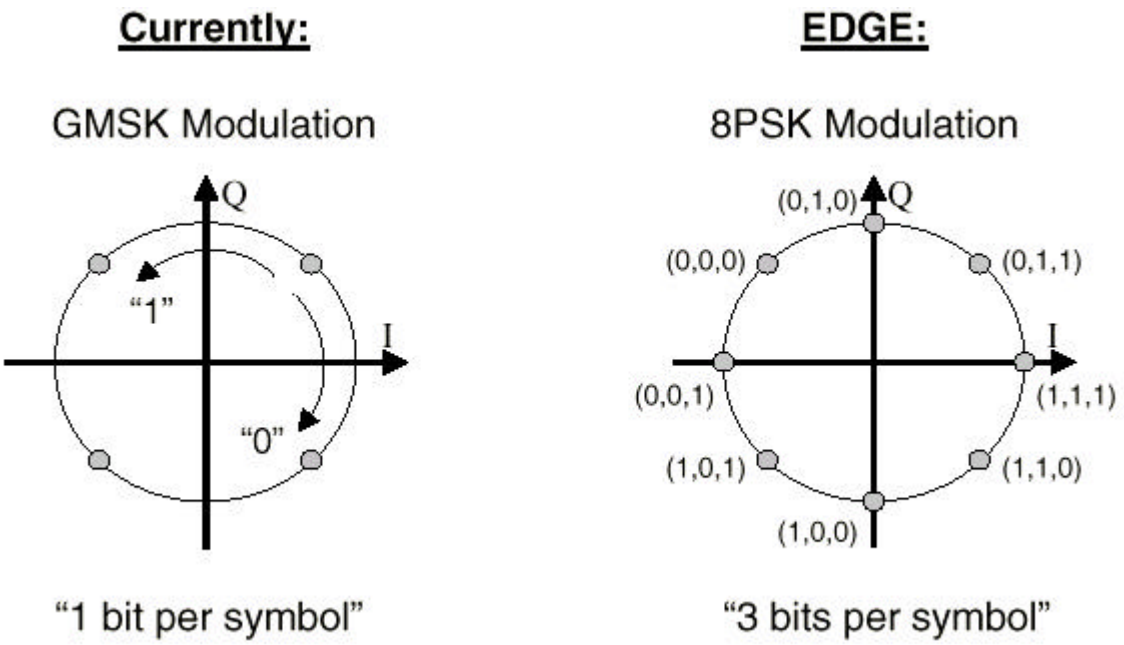


Figure 15-5 EDGE Modulation

In order to have higher data rates per time slot, a new modulation method, called 8 Phase Shift Keying is required. This is the modulation technique for EDGE.

8PSK modulation has the same qualities in terms of generating interference on adjacent channels as GMSK. This makes it possible to totally integrate EDGE channels into an existing frequency plan and to assign new EDGE channels in the same way as standard GSM channels.

The chosen modulation method, for EDGE 8PSK, is a linear modulation, where three consecutive bits are mapped onto one symbol in the I/Q-plain. Since the symbol rate, i.e. the number of symbols sent within a certain time, is kept the same as for GMSK, but each symbol now represents three bits instead of one, the total data rate is increased with a factor three. Of course this does not come without a penalty. The distance between the different

"symbols" is shorter in the 8PSK case. Hence, it is more difficult for the radio receiver to detect which symbol it has received. In good radio conditions, this does not matter. In poor radio conditions it does, but then the "extra" bits could be used to add more error correcting coding and the correct information could be recovered. Only in very bad radio environments is GMSK more efficient.

THE THIRD GENERATION OF MOBILE SYSTEMS

INTRODUCTION

Analog mobile networks are considered to be the first generation of mobile systems. Digital mobile network are considered to be the second generation of mobile systems. The third generation of mobile systems is currently being defined in various standardization groups around the world.

One characteristic of true third-generation services and applications will be the infrastructure capabilities to deliver several services in parallel to each end user/terminal. This means subscribers to services can carry on a voice conversation in parallel to accessing an intranet or extranet to obtain important information or participate in a videoconference and at the same time exchange e-mails and/or multimedia mails.

The general concepts for third generation systems are grouped under the concept of the International Mobile Telecommunications 2000 (IMT-2000) system, as being defined by ITU-T. This is complemented by development of Universal Mobile Telecommunications System (UMTS) by ETSI. UMTS aims to deliver wide-area/high-mobility data rates of 384 kbits/s and up to 2 Mbits/s for local-area/low-mobility coverage.

To be able to support these bit rates, a new radio technology, Wideband Code Division Multiple Access (WCDMA) is used. Frequency spectrum has already been allocated for these third-generation services in the 2 GHz frequency band.

Predictions for the future of such a system include statistics such as “Mobile multimedia will account for 16% of mobile subscribers, 25% of operator revenues and 60% of network traffic in the year 2005”.

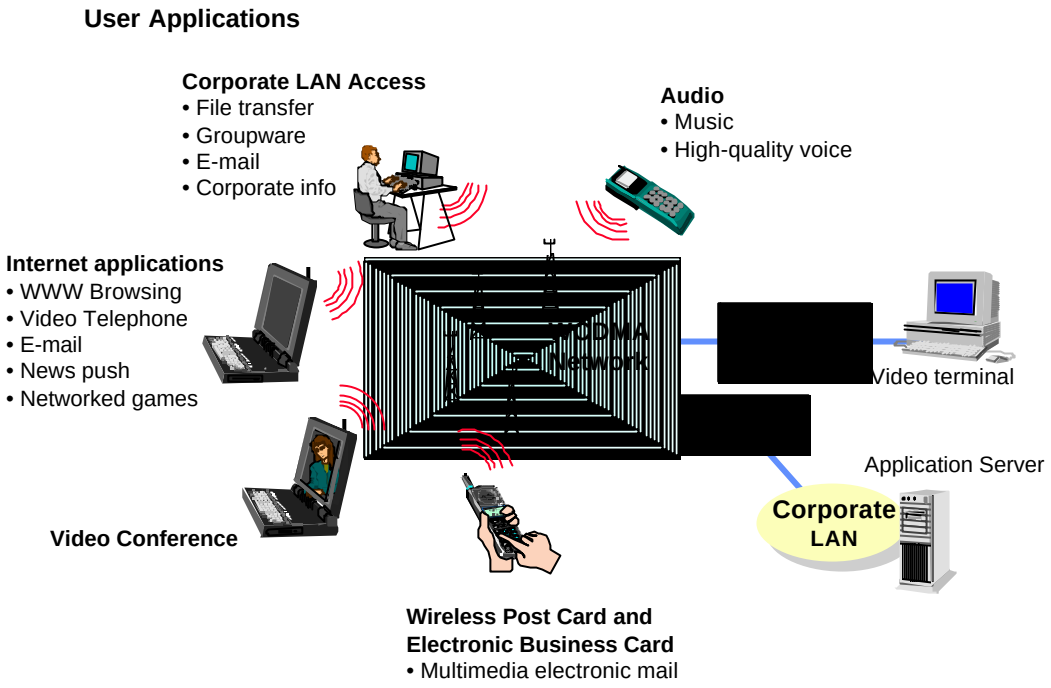


Figure15-6 Mobile multimedia services

SERVICES

Some basic planned 3G services include:

- Voice/high-quality audio
- High-speed data transmission including still photographs
- E-postcard in combination with digital cameras
- Video conferencing and multimedia

Some future wireless scenarios for wideband wireless multimedia can comprise the following services:

- Interactive news delivery (voice, video, e-mail, graphics)
- Multimedia e-mail (text, graphics, video clips)
- Interactive audio (CD-quality voice, video, graphics)
- Video conferencing, large file transfer
- Web browsing (dynamic Internet-based games, etc)
- Downloading large files from intranets

- Position/location-dependant "push" info
- Electronic commerce
- Telemetry for traffic and security systems

IMPLEMENTATION

Ericsson is currently working on supplying a solution for UMTS using Wideband Code Division Multiple Access (WCDMA) and GSM. EDGE and CDMA2000 are the other alternatives for operators. EDGE will work on existing spectrum and the operators network resulting in high data rate offerings to the end user. CDMA2000 is another cost effective path to 3G services. CDMA2000 builds on the installed base of over 100 million cdmaOne users, leveraging previous investments and industry-wide expertise in developing cdmaOne mobile stations. The CDMA2000 solution is gaining popularity in North America, Latin America, Japan and South Korea. It will provide users with data rates comparable to that of EDGE and WCDMA.

WIDEBAND CODE DIVISION MULTIPLE ACCESS (WCDMA)

As an access method, Code Division Multiple Access (CDMA) is an alternative to TDMA. However, there are several key differences in implementation between TDMA and CDMA.

The basic concept of CDMA is to simultaneously handle several MSs without dividing the radio carrier by time slots. Instead, each MS is given a decoding key. Then the information for several MSs is transmitted downlink at the same time. Functions in each MS can then be used to analyze the information and to decode only that information which is relevant to itself. Security is ensured as each MS does not have the decoding key for other MSs and will therefore not be able to decode any other MS's information.

The problem of interference is avoided using such intelligent functions, but as the number of users of the same carrier increases, the more difficult it becomes for an MS to decode its own information. For this reason, it is desirable to have a wide bandwidth when using CDMA solutions. This leads to the term WCDMA.

The services proposed within 3G involve transferring large amounts of data to and from MSs. Ericsson is involved in the WCDMA concept operating with a 5 MHz carrier separation to fully use the inherent benefits of code division multiple access technology.

Given the large bandwidth, each WCDMA terminal connection may access several services simultaneously. Each service can be optimized at the required data rate and quality.

THE MIGRATION PATH

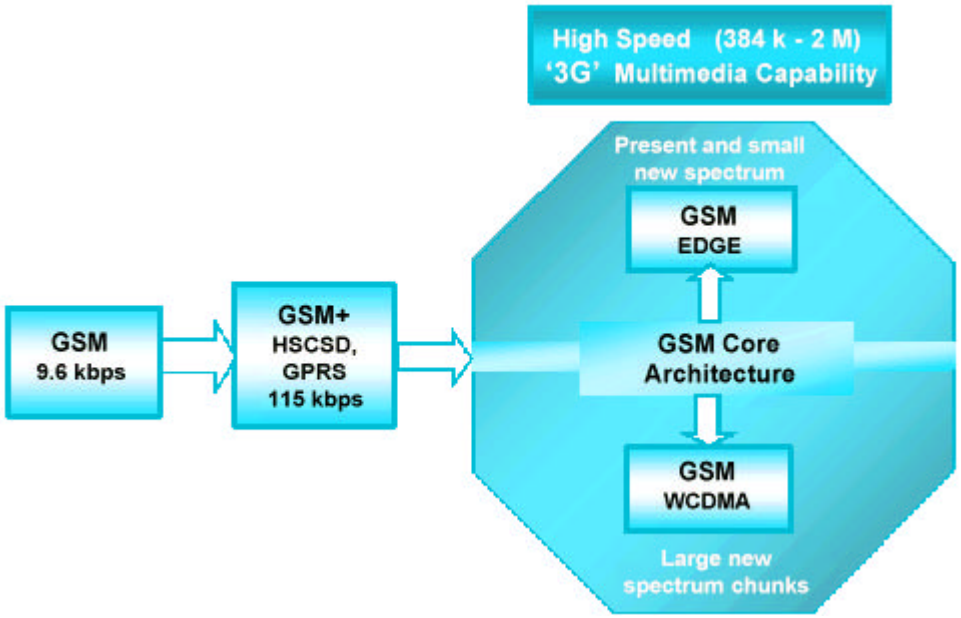


Figure 15-7 The Migration of GSM to 3G

Going forward, GSM will continue to evolve to meet demands for high-data rates through two complementary developments.

First, the existing MS-network interface has evolved to include high bit rates for wide-area coverage, through HSCSD and packet-switched data through General Packet Radio Services (GPRS) that will provide theoretical data rates up to 170 kbits/s.

Second, GSM will evolve to meet with third generation requirements by offering data rates up to 384 kbits/s in all existing GSM frequencies. A high-level modulation method, EDGE (Enhanced Data for GSM Evolution), will be used to support both packet-switched and circuit-switched data.

To reach this level of throughput, two air interfaces will co-exist: the evolved GSM (TDMA) and the new UMTS interface (WCDMA).

Using dual-mode GSM/3G global handsets - with GSM providing coverage and 3G delivering new functionality - operators will be able to fully leverage additional wideband services in their GSM networks with full service transparency across the enormous GSM worldwide presence.

The radio access network will be a distinct overlay network for the two types of air interfaces. For the WCDMA radio access network, some of the existing GSM concepts will be reused but many principles and structures will be new. The core network for

WCDMA systems will be an evolution of todays GSM circuit and packet switching networks.

As a result the GSM MSC has evolved to support circuit-switched accesses from the MS towards either telecommunications-based networks e.g. PSTN, PLMN or data communications-based networks e.g. Internet, thus becoming a GSM-UMTS MSC. This means that the same MSC will be handling both TDMA and WCDMA accesses. This will likely include roaming and handover between these two radio access networks for the same MS.

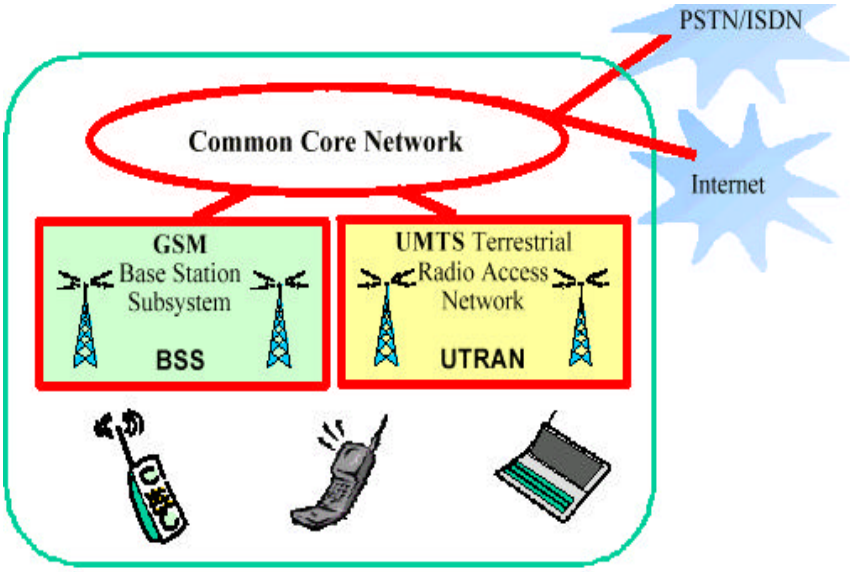


Figure 15-8 Evolution of GSM to UMTS

Ericsson's product offerings allow GSM-operators to take full advantage of their current 2G infrastructures in order to optimize the overall GSM/WCDMA system and to provide a cost effective solution while at the same time minimizing the impact on the operating GSM network.

A number of opportunities for infrastructure sharing exist which are outlined below. To the extent that the current 2G network needs to be adapted in order to co-exist and inter-work with the new 3G equipment. For operators that already have GSM, 3G networks are built on top of an enhanced GSM core Network.