Standards for Third Generation Mobile Communication

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Abstract

In mobile communications, the need for other applications than speech, such as data and video, is growing. To support these applications, the mobile communication systems must offer additional services like high speed packet switched data transmission. For GSM, additional standards are being developed to offer services which meet the requirements of next generation mobile communications. But also other new standards are under development. This paper gives an overview of the standards under development and discusses how a mobile communication network can evolve towards the next generation.

Abbreviations

3G	Third Generation
3GPP	3G Project Partnership
AMPS	Advanced Mobile Phone Service
ARIB	Association of Radio Industries and Businesses (Japan)
BSS	Base Station Subsystem
CAMEL	Customised Applications for Mobile Network Enhanced Logic
CDMA	Code Division Multiple Access
CWTS	Chinese Wireless Telecommunications Standardisation group
D-AMPS	Digital AMPS
EDGE	Enhanced Data rates for GSM Evolution
ETSI	European Telecommunications Standards Institute
IMT	International Mobile Telecommunications
IS	Industrial Standard
ITU	International Telecommunication Union
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Services
GSM	Global System for Mobile communications
G-UMTS	GSM based UMTS
HSCSD	High Speed Circuit Switched Data
NMT	Nordic Mobile Telephone
PCS	Personal Communication System
QPSK	Quadrature Phase Shift Keying
SGSN	Service GPRS Support Node
TIA	Telecommunications Industry Organisation (US)
TTA	Telecommunications Technology Association (Korea)
TTC	Telecommunications Technology Committee (Japan)
SIM	Subscriber Identity Module
UMTS	Universal Mobile Telecommunication System
UTRA	UMTS Terrestrial Radio Access
WAP	Wireless Application Protocol
WWW	World Wide Web

Introduction

The mobile communication systems that are operational nowadays are of the second generation. The first generation is characterised by analogue systems, like NMT in Europe and AMPS in the United States. The second generation comprises digital systems. These digital systems offer more capacity and services than the analogue systems within the first generation. Examples of second generation systems are GSM in Europe and D-AMPS and CDMA-One in the United States. Third generation (3G) systems differ from previous generations in the way that they will offer, besides speech, also various other applications.

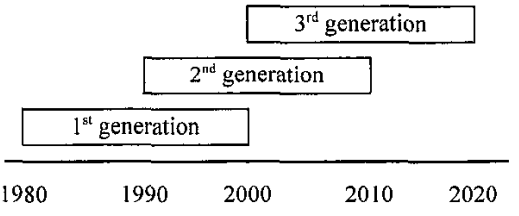


Figure 1: Generations mobile communications time schedule.

3G Requirements

The first and second generation of mobile communication systems are mainly designed for one application: speech. Nowadays an increasing need for multimedia applications can be observed. These applications, for which data transmission gets more and more important, can be:

- Internet services, such as WWW browsing and e-mail;
- database retrieval;
- video telephony;
- interactive video and sound (music and TV).

Some of these applications, like Internet-services, are already popular via fixed networks. But also in mobile networks the percentage data communication is growing. The introduction of for example WAP, which offers Internet-like services at low transmission rates, indicates already the existing need for this type of applications via mobile networks. Other applications, like video telephony, have not yet made a break through on the fixed networks, but are expected to become popular due to the mobile networks, for instance in remote expert applications.

3G systems for mobile communication must offer services that enable the mentioned applications. The most important services to fulfil the third generation requirements are:

- high bitrate (384 kbit/s in global environments and 2 Mbit/s in local environments);
- circuit and packet switched data transmission modes.

A packet switched mode is in the case of data transmission much more capacity efficient than a circuit switched mode.

At this moment standards for mobile communication systems that fulfil the 3G requirements are being developed. Current second generation standards are being upgraded so that current systems will meet near future requirements as much as possible (e.g. GSM phase 2+). These upgrades must ensure longest possible lifetime of current investments in the architecture of these systems. But also new standards for 3G systems are being developed (e.g. UMTS and CDMA2000).

GSM phase 2+

GSM is being developed within ETSI. GSM is initially standardised in two phases. With the growing need for 3G services, an extra phase (phase 2+) is under standardisation. This phase 2+ standard will consist of several releases, since it is impossible to standardise all additional services at once. Most important GSM phase 2+ services are described below.

- HSCSD (Release '96) is a circuit switched service which offers a higher bitrate (up to 57.6 kbit/s) by combining multiple (maximum 4) time slots. This service can already be implemented through a software update in the network. (1 GSM phase 2+ time slot offers 14.4 kbit/s).
- GPRS (Release '97) is a packet switched service which can offer a bitrate up to 115.2 kbit/s. Where circuit switched services are charged per time unit, packet switched services will probably be charged per unity of transmitted data. To implement GPRS, additional hardware in the network is required, like the SGSN (Service GPRS Support Node), which is the packet switch node between the Base Station Subsystem (BSS) and the packet switched network. These elements will be commercial available by the end of 1999.
- EDGE (Release '99) offers a bitrate up to 384 kbit/s by using an 8-state (8-QPSK) instead of the conventional 2-state (GMSK) modulation scheme. As a consequence the received signal to noise ratio must be larger so that the maximum cell size becomes smaller. Cells that are already capacity limited can keep their size (unless the capacity grows due to introduction of this service). For this reason EDGE will probably only be offered in high user density areas. To implement this service new radio transmitters and receivers are required. EDGE will become commercially available in about two years.

Other important GSM phase 2+ standards with respect to 3G, are among others CAMEL and SIM Application Toolkit. CAMEL creates the possibility to offer an homogeneous service (e.g. Pre Paid) via different GSM networks. The SIM Application Toolkit enables the SIM module to execute various functions which is important to enable applications like e-commerce.

To make use of GSM phase 2+ services, the end user terminal must be designed to support the phase 2+ services.

UMTS

To ensure current GSM investments as long as possible and to keep European industries ahead also within the next generation of mobile communications, ETSI also started standardisation of a 3G system, under the name UMTS. UMTS is regarded as an evolution of GSM. This means that the GSM based part of UMTS (G-UMTS) makes use of the GSM core network.

To ensure world-wide acceptance, standardisation of UMTS is transferred to 3GPP in which the standardisation institutes ARIB (Japan), CWTS (China), ETSI (Europe), T1 (United States), TTA

(Korea) and TTC (Japan) participate. Table 1 shows the UMTS time schedule.

Table 1: UMTS time schedule

Milestone	date
UTRA	January 1998
concept and basic parameters	February 1999
licences	begin 2000
standards	begin 2000
trails (phase 0)	during 2001
phase 1 operational	2002

(Source: UMTS Forum).

UMTS will offer the required services with respect to 3G (384 kbit/s in globally and 2 Mbit/s locally). Only for the satellite component, which should guarantee availability everywhere, concrete standardisation has not been started yet.

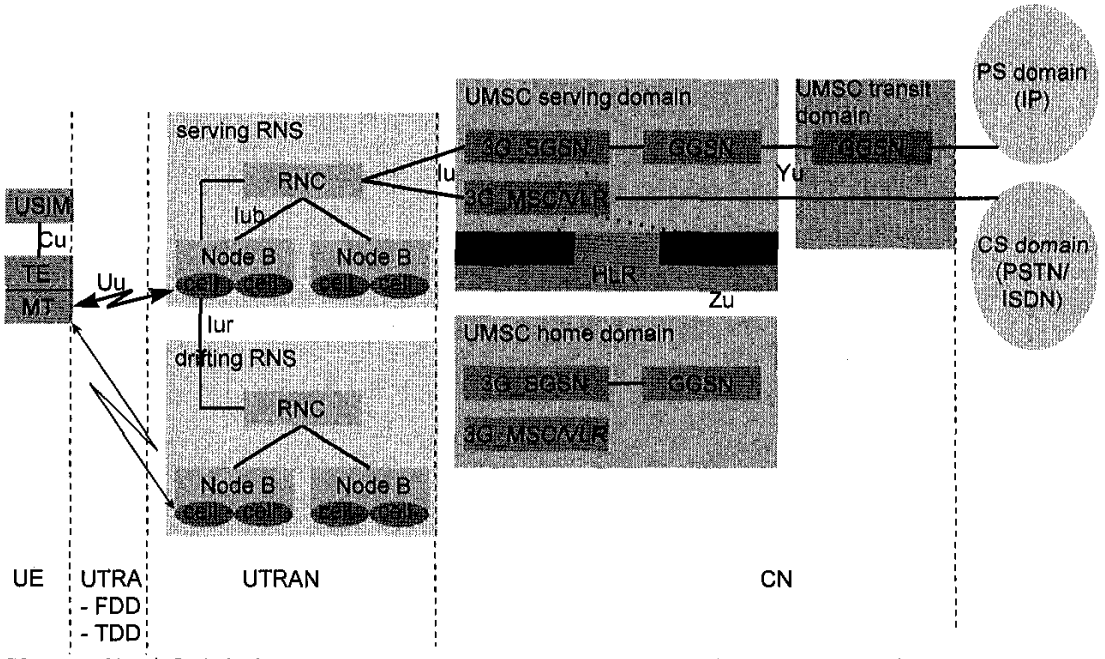
The UMTS standard is divided in four parts:
1. UE: User Equipment;
2. UTRA: UMTS Terrestrial Radio Access;
3. UTRAN: UTRA Network;
4. CN: Core Network.

The UTRA comprises two modes: the Time Division Duplex (TDD) mode and the Frequency Division Duplex (FDD) mode. The FDD mode supports relatively large cells and high mobility, but the TDD mode supports asymmetrical traffic which agrees with the traffic behaviour in most cases of data communication.

Table 2: Comparison UTRA FDD and TDD mode.

FDD mode	TDD mode
large cell size	small cell size
high mobility	low mobility
symmetric link	asymmetric link

The UMTS standard describes the interfaces between the system elements. Figure 2 is a schematic view of the interfaces between the elements which are defined within G-UMTS. In G-UMTS the CN corresponds to the GSM core network. Which means that when implementing UMTS, the GSM core network can be (re)used. In order to achieve this, GPRS has to be implemented in the GSM network, since UMTS uses the packet switched element SGSN.



CS	Circuit Switched
GGSN	Gateway GPRS Support Node
HLR	Home Location Register
MSC	Mobile services Switching Centre
MT	Mobile Termination
PS	Packet Switched
RNC	Radio Network Controller
RNS	Radio Network System
SGSN	Service GPRS Support Node
TE	Terminal Equipment
USIM	UMTS Subscriber Identification Module
VLR	Visitor Location Register

Figure 2: Schematic view of the G-UMTS elements and interfaces.

In the GSM system the interface between the BSS and the core network is the A-interface for the circuit switched mode and the G_b-inteface for the packet switched mode. In the G-UMTS system the interface between the UMTS BSS and the CN is the I_u-interface. The UMTS BSS can be connected to the GSM core network via the elements I_u-A-interface for the circuit switched mode respectively I_u-G_b-interface for the packet switched mode (see Figure 3).

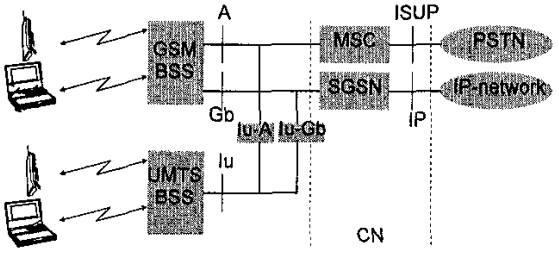


Figure 3: Connection of a UMTS BSS to a GSM network.

Evolution from GSM towards 3G

Current GSM networks can evolve towards 3G by implementing the GSM phase 2+ standards. The data transmission speed can be relatively easily enhanced by implementing HSCSD. The introduction of GPRS is more costly, but offers a higher data transmission speed and is more capacity efficient. GPRS is an essential service towards 3G because it introduces the packet switch node into the network. Next step is the choice between EDGE or UMTS. This evolutional process is depicted in Figure 4.

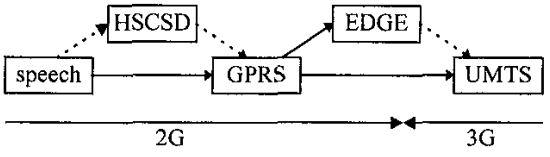


Figure 4: GSM evolution towards 3G.

With the introduction of the new services, the data transmission speed for (terrestrial) mobile data communication will grow the following years as shown in Figure 5.

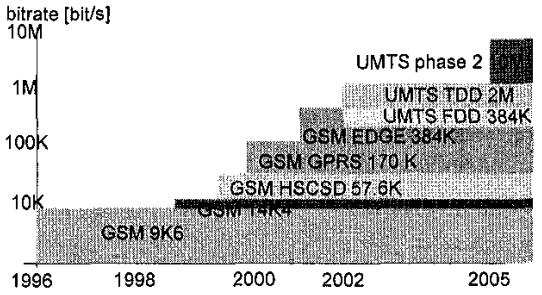


Figure 5: Growing bitrate with introduction of new services in the coming years.

IMT-2000

World-wide standardisation of 3G systems for mobile communication is co-ordinated by the ITU under the name IMT-2000. 15 proposals, of which 10 terrestrial and 5 satellite, have been submitted to the ITU. The ITU strives not for one global standard but the 'Family of Systems' concept. Which means that the various 3G-standards in the world should have a Radio Transmission Technology (RTT) which are similar. It looks like that this RTT will be wide-band CDMA. The standards that meet this common RTT are UMTS (UTRA), CDMA-2000 and W-CDMA. The standardisation of the RTT is continued by 3GPP-2 in which ARIB (Japan), TIA (United States), TTA (Korea) and TTC (Japan) participate. W-CDMA is the name of Japanese RTT proposal for the third generation of mobile communications, for which the ARIB is responsible. Also in UTRA and CDMA-2000 a wide-band CDMA component is included. Therefore this technique gives a sound basis for a world-wide standardisation. At this moment W-CDMA systems are operational as trail and will become commercially available soon.

Conclusions

The need for other applications than speech over mobile communication is growing. For this reason, network services will be implemented, which will support these new applications. Most important new facilities are high speed packet switched data transmission. The GSM phase 2+ services will meet the requirements to mobile communications for the coming years. In the long term a specific 3G standard has to be implemented. The 3G standard UMTS is designed as an evolution of GSM. That will say the GSM core network can be reused within UMTS.

Authors

Koen van Staalduinen obtained his degree of Electrical Engineer in 1993 at Delft University of Technology, where he specialised in the field of Telecommunications. After his graduation Koen van Staalduinen followed a two year post graduate designer course in the field of Information Technology at the same university. He started his career at Ericsson Business Mobile Networks, Ericssons' DECT competence centre. As deployment engineer he was responsible for the system requirements with respect to the radio link part of Ericsson's DECT products. Presently Koen van Staalduinen works as a mobile communications consultant at the Netherlands Organization for Applied Scientific Research TNO. Most of his projects are in commission of the Netherlands telecommunications regulator and other governmental organisations.

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