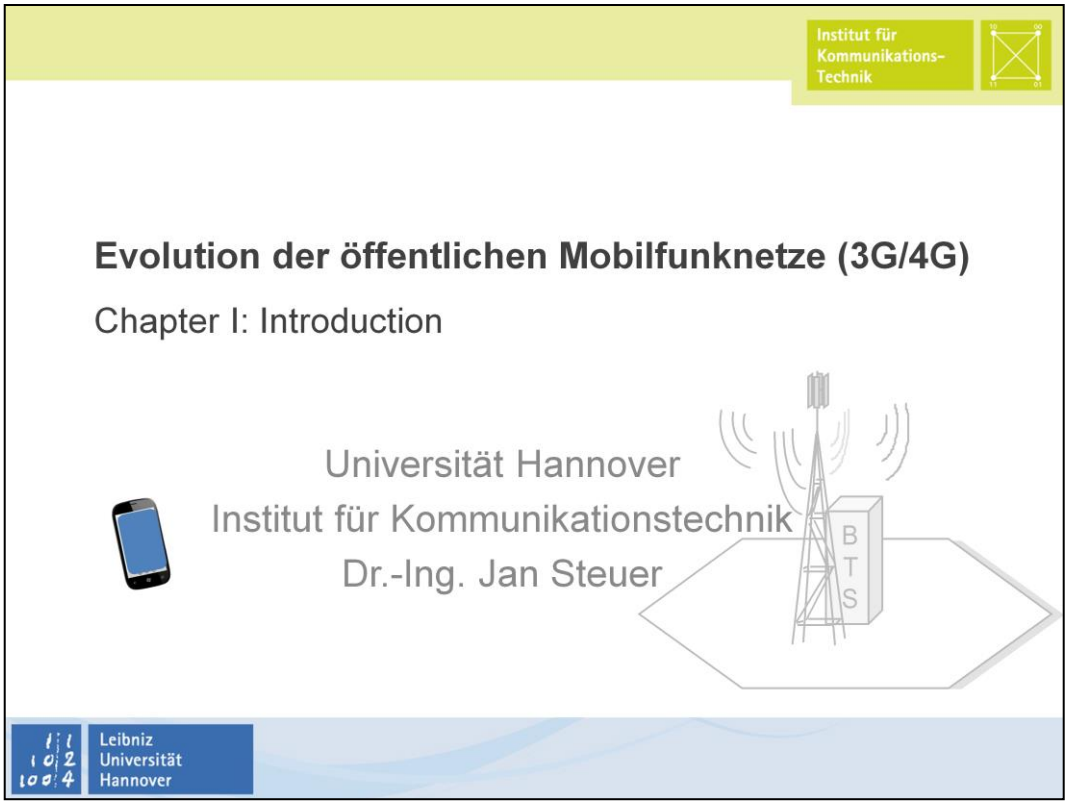

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Evolution of public radio networks

Institut für Kommunikations-Technik

1. Introduction/Overview GSM/UMTS
2. Basics: Radio Transmission
3. Basics: Radio Network Planning
4. Physical Layer
5. Radio Interface Protocols
6. Architecture / Core Network
7. Security
8. UMTS Evolution / LTE
9. Supplemtary Services

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Outline

Institut für Kommunikations-Technik

1. GSM to UMTS
2. History and Milestones
3. 3GPP
4. Standardisation
5. Licenses and Frequencies
6. GSM-UMTS Evolution
7. Overview Infrastructure
8. Further Concepts

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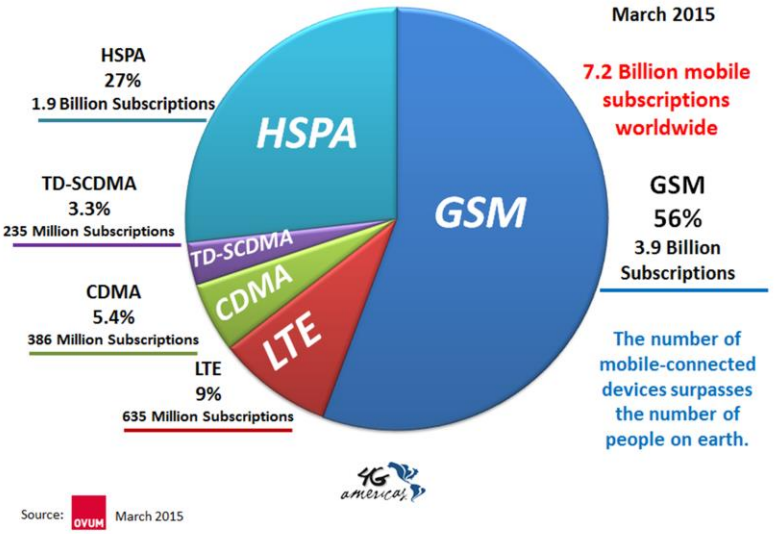
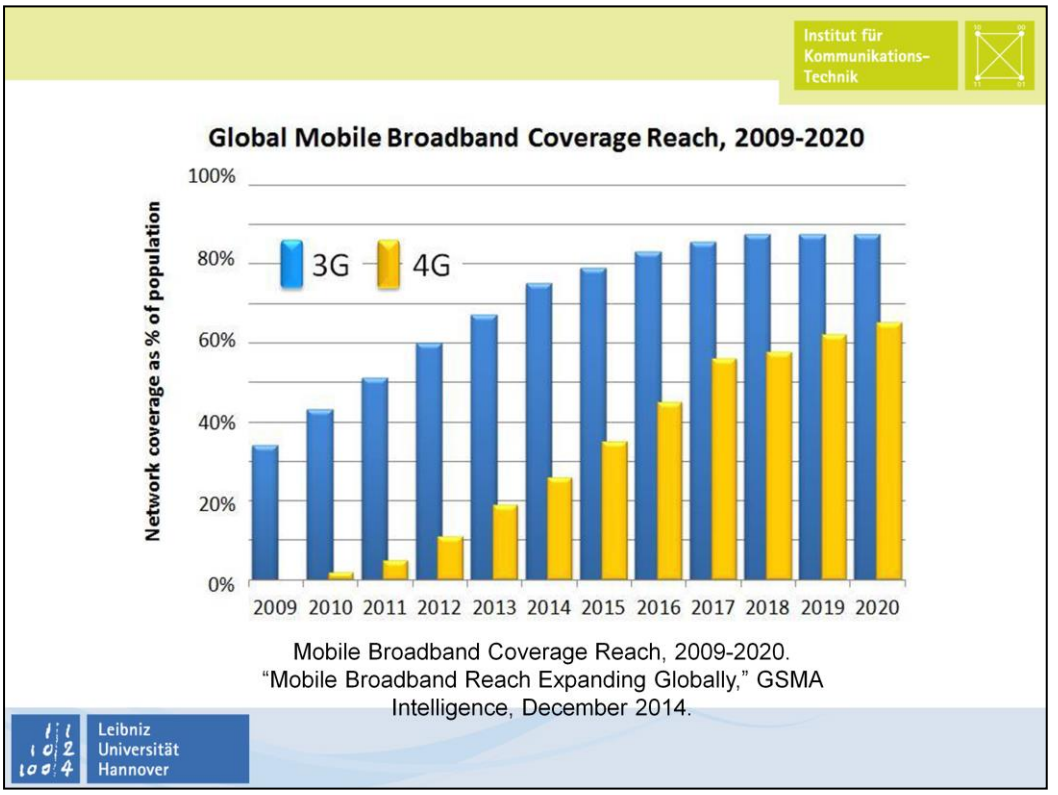
Global Mobile Subscribers and Market Share by Technology





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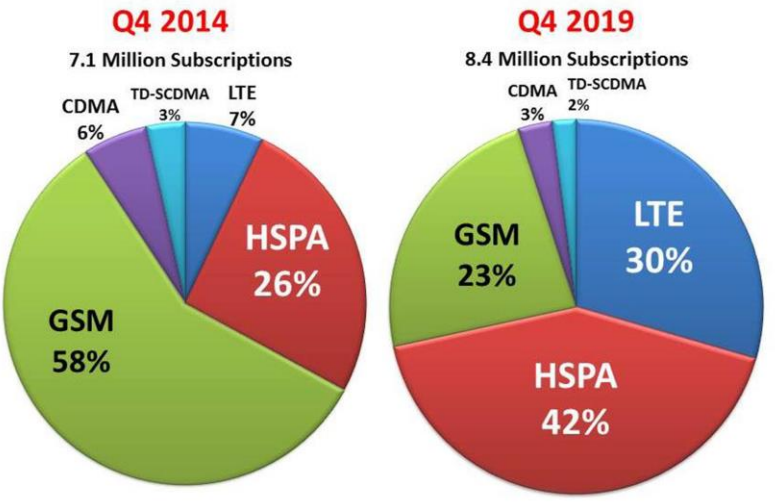
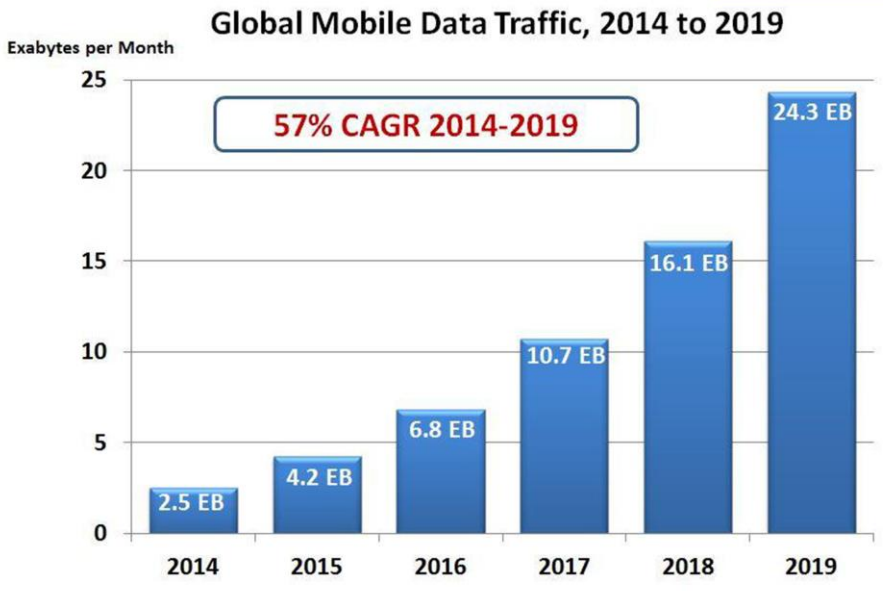
10 "Mobile Broadband Reach Expanding Globally," GSMA Intelligence, December 2014.



Global Mobile Technology Shares 4Q 2014 – Forecast 4Q 2019. Ovum, April 2015.



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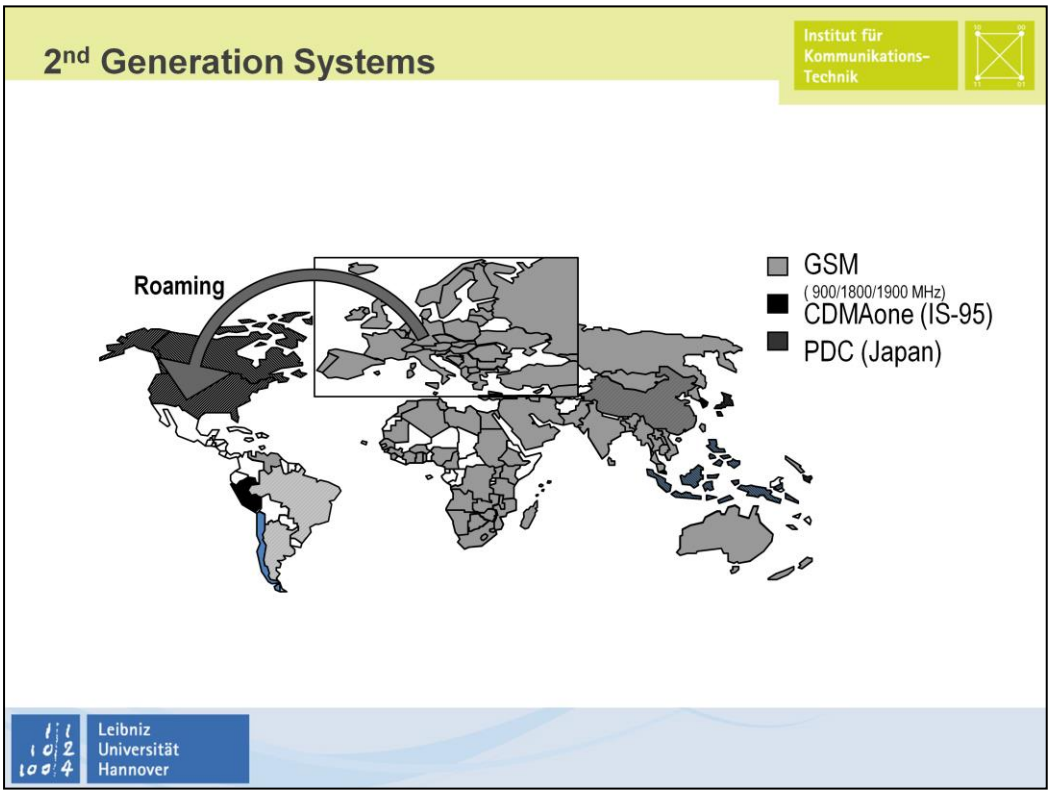
Global Mobile Data Traffic 2014 to 2019.
Cisco Visual Networking Index, 2014-2019, Cisco, February 2015.

Goals and Mission

See UMTS and LTE as a communications systems:

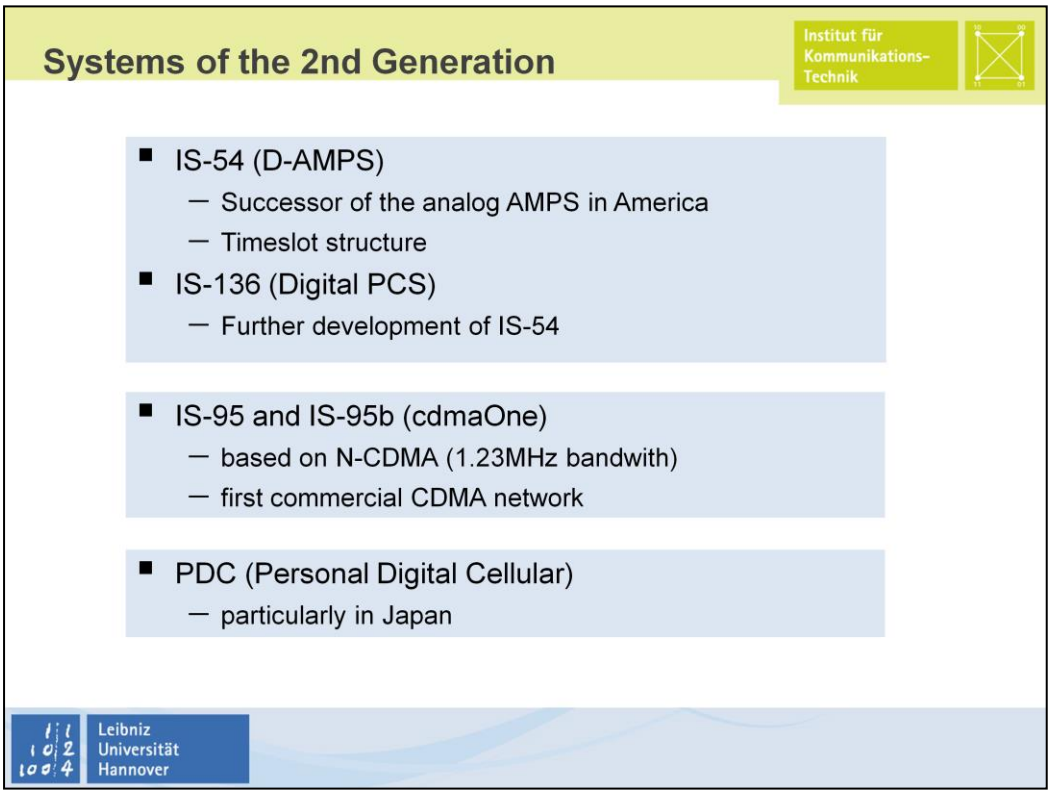
- Fit together parts of different lectures
  - Communications and networks
  - Coding
  - ….
- Understand
  - System
  - Radio interface (CDMA, radio transmission and error correction)
  - Information flows (signalling and protocols)
  - Commercial aspects
- How do protocols, radio interface characteristics and system components work together



The third generation of mobile communication systems, usually referred to as 3G, has been in discussion since the beginning of the 1990's under the term FPLMTS (Future Public Land Mobile Telecommunication Systems). This was taken to refer to the terrestrial branch of mobile communications. In the mid-1990's, the term was changed to IMT-2000, which is easier for non-English native speakers to use. IMT-2000 stands for International Mobile Telecommunications. 2000 indicates not only the time frame for introduction of the systems, but also the frequency band used (in MHz). In addition to terrestrial systems, IMT-2000 also includes 3rd generation mobile satellite systems. These were discussed under the term GMPCS for Global Mobile Personal Communication by Satellite.

The International Telecommunication Union (ITU) is responsible for the IMT-2000 specification. The ITU derives from the International Telegraph Union founded in Paris in 1865 and is the oldest existing telecommunications organization. In 1848 the ITU was included as a special organization in the United Nations (UN) and its headquarters were relocated to Geneva. The ITU is responsible for international coordination in the area of telecommunications – i.e., for the allocation of frequency spectrum, coordination of the development of telecommunication systems (space/satellites), promotion of bilateral agreement on low charges, coordination of actions for emergency rescue telecommunication services, implementation of studies, issue of regulations and recommendations, collection and publication of information regarding telecommunications, and much more.

The ITU is, as a result, also in charge of the global 3G coordination – i.e., for guidelines and frequency recommendations regarding IMT-2000.



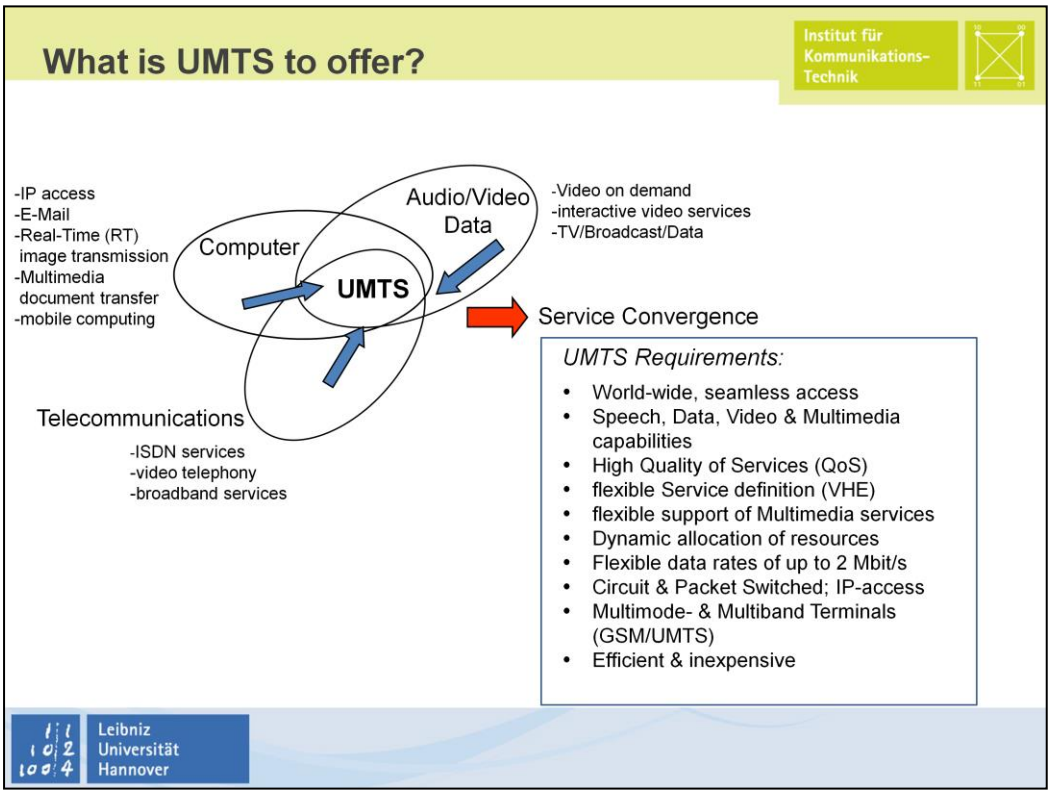
The 1st and 2nd mobile communication generations are characterized by a variety of different standards for various applications. Each of the standards has specific technical attributes, advantages and disadvantages, applications, ranges and costs, and has been optimized for different subscriber groups. Many of these systems exist (or existed) solely at regional or national level and are incompatible with each other. In contrast, in the 3rd generation of mobile communications, a family of compatible standards is to evolve under the umbrella term IMT-2000. These standards are intended to guarantee global mobile communications for diverse applications.
The general thinking is to provide customers with requested services regardless of their location and the prevailing infrastructure.
The IMT-2000 concept devised by the ITU includes the following major aspects:
• Global, seamless access to mobile communications systems (using terrestrial
•systems and mobile satellite systems – MSS)
• Compatibility between all members of the IMT-2000 family
• Downward-compatibility with the major 2G systems (e.g., GSM, IS-95)
• Convergence between mobile and fixed networks
• High data rates for mobile communications
• Circuit- and packet-switched (CS & PS) transfer of data
• Facilitation of multimedia applications
• Inexpensive, flexible telecommunications access also for developing countries.

GSM

GSM
GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

- standardised by ETSI since 1989
- working systems since 1991
- meantime over 1 billion customers worldwide
- well-engineered technology in large quantities
- qualified labour
- regularly new developments

long-term perspective for GSM worldwide (Germany: 2016)



What is UMTS to provide?

Three sectors that previously had little to do with each other are to converge in UMTS: the audio/video/data sector, the conventional telecommunications sector and the computer sector.

All three sectors will merge in the 3rd mobile communications generation. In addition to the classic telecommunications services, other services will also be available.

These will include video telephony, broadband data services, video-on-demand, interactive video services, TV and radio transmission, IP access, e-mail transfer, real-time data transmission, multimedia services – in general, everything connected with mobile computing.

In other words, services that were previously totally different in their nature are now converging.

Requirements for UMTS

•UMTS has to fulfill many different requirements – for example:

• Global, seamless accessibility,

• The system must be able to transfer voice, data, video and multimedia applications.

• High quality of service (QoS) must be guaranteed.

• Flexible multimedia services must be supported. In other words, resources must be capable of dynamic assignment with flexible data rates up to 2 Mbit/s, circuit-and packet-switched data transmissions must be supported and direct access to IP networks must be provided. Moreover, to achieve global accessibility, multimode and multiband terminals must not only allow UMTS operation, but also GSM or MSS.

• UMTS has to use existing frequency resources very efficiently and inexpensively to enable a mass market, also in less developed countries, to grow.

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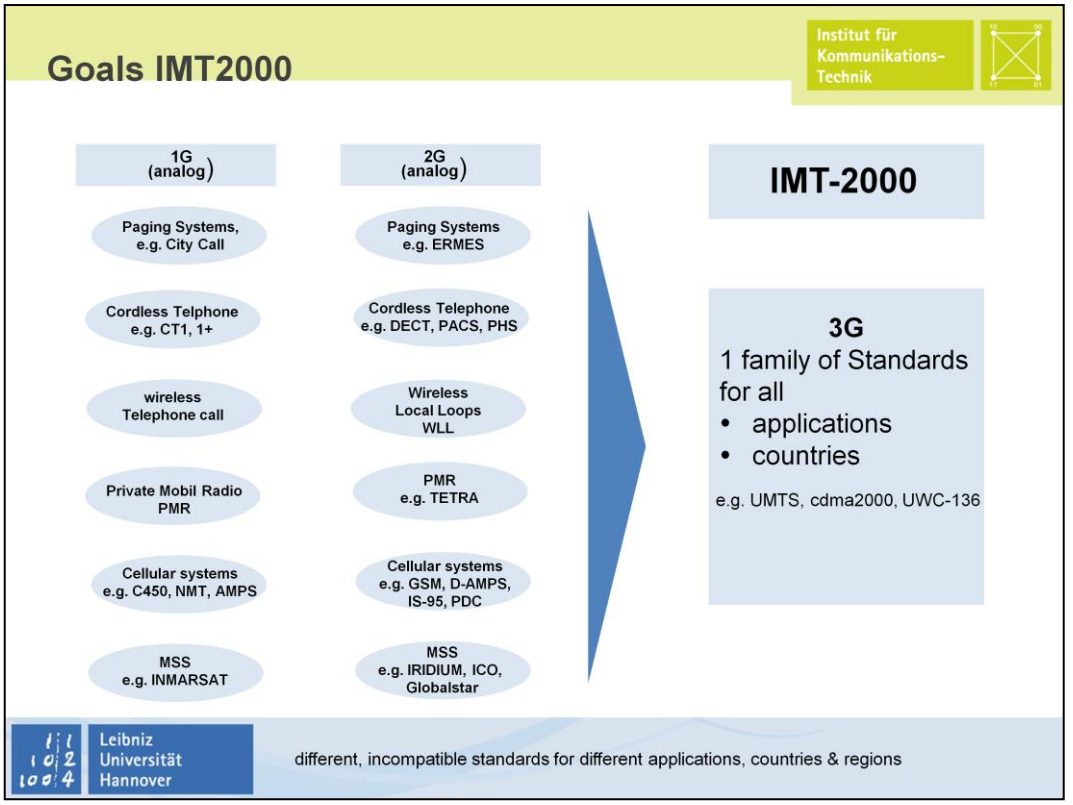
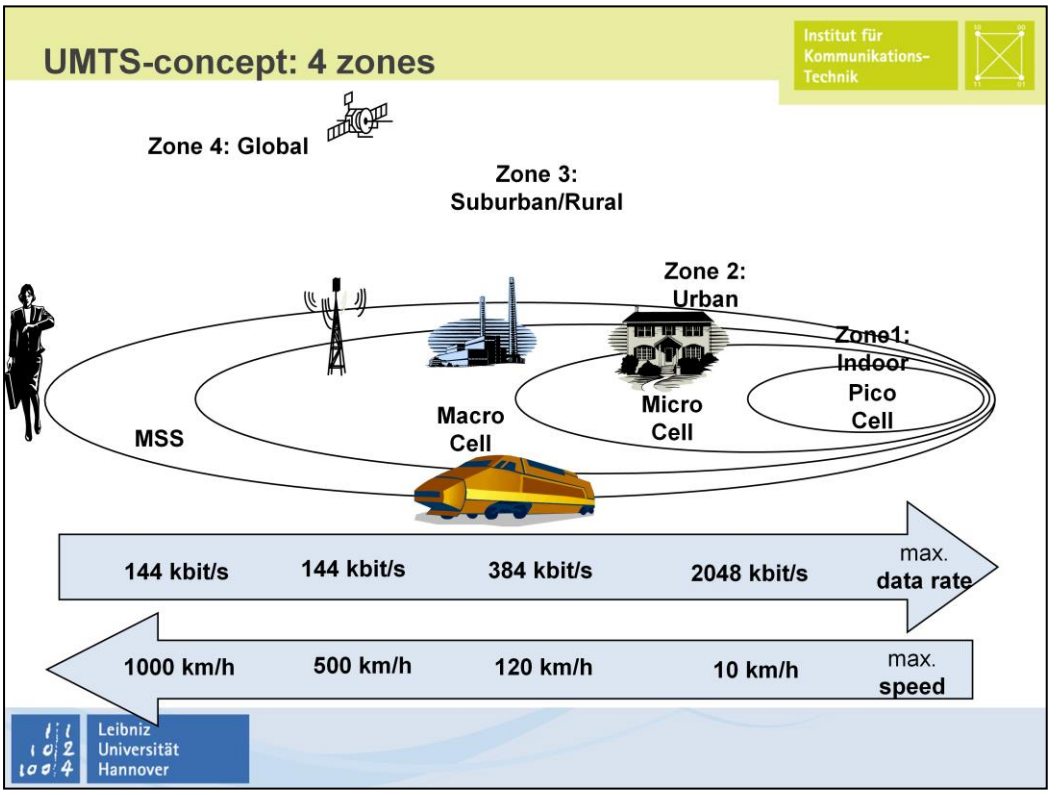
Goals IMT2000



different, incompatible standards for different applications, countries & regions



The 4-zone concept in UMTS is based on the IMT-2000 specifications of the ITU. The concept defines three terrestrially supplied zones (in-building, urban, suburban/rural) and one zone (global) supplied by MSS's (Mobile Satellite Systems).

Zone 1: Indoor

Zone 1 is made up of pico cells and is used for servicing large offices, domestic households, storys in skyscrapers, the stock exchange, etc. The service radius of the pico cells is in the order of several tens of meters – i.e., small areas with high user densities and little mobility (max. 10 km/h) are supplied. Coupled with the restricted mobility are high (ITU) requirements on the transfer rate (up to 2 Mbit/s). Up to 1920 kbit/s are theoretically possible with UMTS.

Zone 2: Urban

Zone 2 is made up of micro cells and is used for servicing so-called hot spots. These are inner city areas, public places, sports stadiums, exhibition and trade fair halls, airport terminals, railway stations, etc. The service radius of the micro cells is in the order of several hundreds of meters – i.e., relatively small areas with high user densities and little (max. 10 km/h) or medium (max. 120 km/h) mobility are supplied.

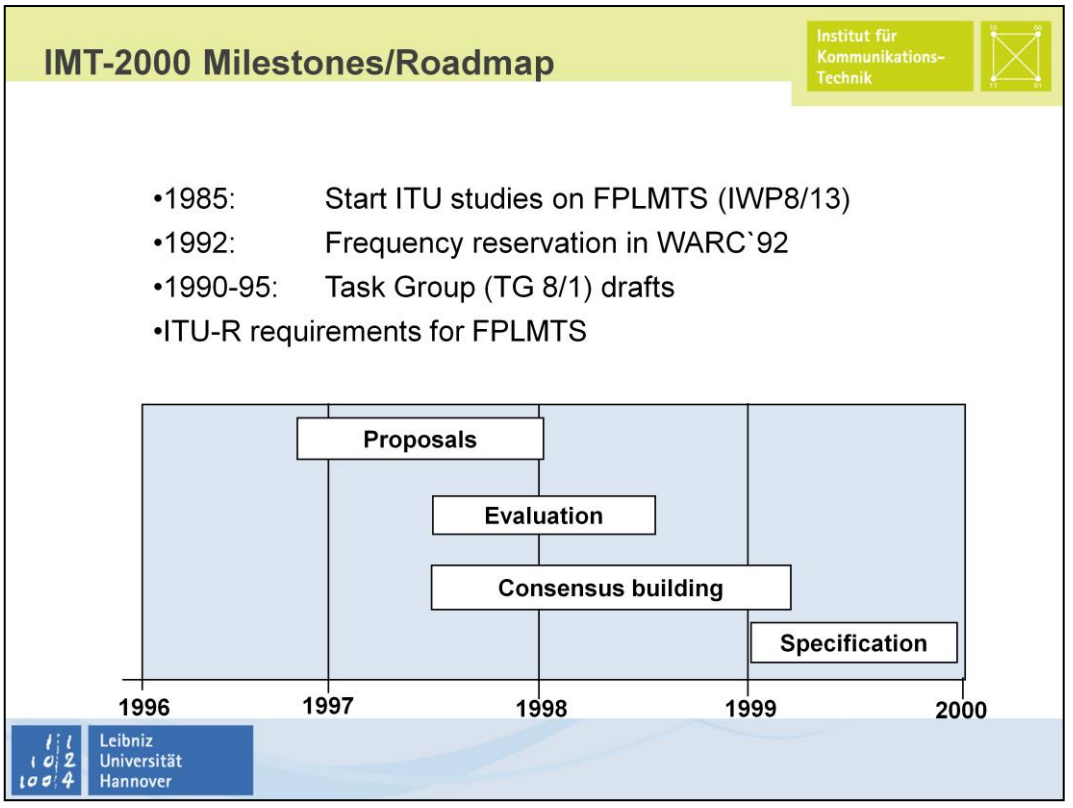
Coupled with the mobility performance are (ITU requirements) transfer rates (up to 2 Mbit/s for low mobility and up to 384 kbit/s for medium mobility). The target for medium mobility in UMTS is a data rate of up to 480 kbit/s.

Zone 3: Suburban/rural

Zone 3 is made up of macro cells and is used for servicing suburban and rural areas with population densities that are not too low. The service radius of the macro cells is in the order of several kilometers – i.e., relatively large areas with medium-sized user densities and medium (max. 120 km/h) or high (max. 500 km/h) mobility are supplied. Coupled with the mobility performance are (ITU requirements) transfer rates (up to 384 kbit/s for medium mobility and up to 144 kbit/s for high mobility).

Zone 4: Global

Zone 4 globally covers all rural, non-built-up, sparsely populated areas: in other words, everything not covered by zones 1 – 3. This includes the oceans, deserts, mountainous terrain and the polar regions. MSS's are to service these areas. They can provide coverage for areas ranging from several tens of kilometers (via beam spots) to areas with a radius of up to several thousands of kilometers. Supply for the highest mobility (up to 1000 km/h) should be possible at data rates of up to 144 kbit/s
(ITU requirement).



Due to the rapid development of the 1G systems at the beginning and during the middle of the 1980's, thought was already given at a very early stage by the ITU to the development of future, globally applicable standards. Studies on FPLMTS commenced in 1985 with the founding of a work group in the ITU designated as the Interim Working Party IWP8/13. Questions regarding the necessary bandwidths and frequency bands as well as the level of similarities required to ensure compatibility were discussed here. Also considered were the requirements of developing countries in which access to global telecommunications is crucial. The findings of the studies, compiled in the ITU-R Reports M.1153 (FPLMTS), M.1155 (Needs of the Developing Countries) and M.687 (FPLMTS) were taken into account, for example, in the recommendations for frequency reservation for the 3rd generation of mobile communications systems. These recommendations were finalized at the World Administrative Radio Conference in 1992 (WARC-92).

Additional guidelines for FPLMTS / IMT-2000 were defined in the 1990's by the ITU task group TG8/1.

Further development stages were as follows:

Drafting of proposals for IMT-2000 systems (3Q1996 – end of 1997)

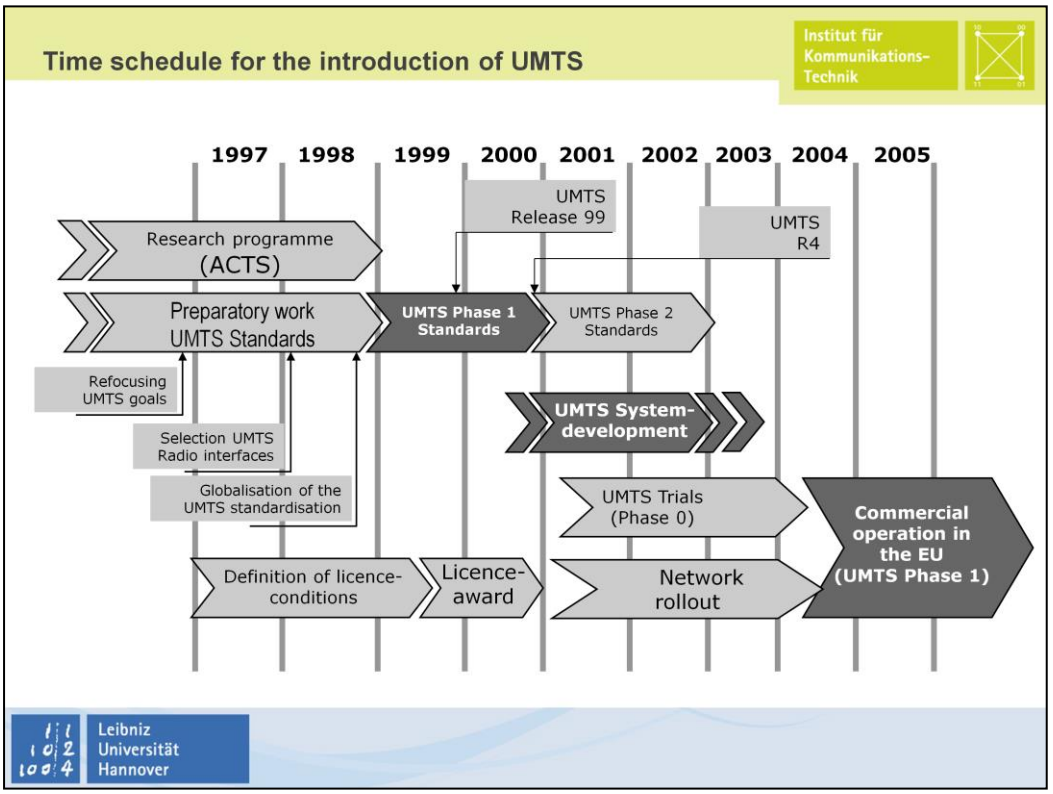
Evaluation of the proposals (2Q1997 – 3Q1998)

Consensus on Intellectual Property Rights (IPR) and compatibility (2Q1997 – 1Q1999)

Finalized specification of the individual standards for the IMT-2000 family (1999).

Another significant date was June 30, 1998 – the deadline for submission of Radio Transmission Technology (RTT) proposals to the ITU.

At the end of 1999 – i.e., on completion of the specification of the IMT-2000 Standards, the ITU's task of coordinating IMT-2000 was concluded.



12/1991: "Zero Meeting“ of the ETSI SMG5 (UMTS conception & coordination).

1996: Modification of the original UMTS plans for evolution from GSM to UMTS (GMM Report). UMTS is based on a developed GSM Core Network (GSM Rel. ' 99).

A new, broadband radio access called UTRA (UMTS Terrestrial Radio Access) is introduced in UMTS Phase 1.

1996 – Mid-1997: Phase 1 of the UTRA conception.
ETSI carries out general studies on UTRA and drafts different concepts. Five of the concepts are selected (SMG#23 plenary session).
06/1997 – 01/1998: Phase 2 of the UTRA conception.

The five UTRA concepts are evaluated. The results of the evaluation are compiled in the SMG#24 plenary session in 12/1997. Two of the concepts are selected for UTRA in a subsequent session held on 28/29.01.1998.

01/1998 – 06/1998: Phase 3 of the UTRA conception.

The two concepts chosen for UTRA are harmonized with each other and are entitled UTRA TDD and FDD mode. The harmonization is implemented in close cooperation with the Japanese standards association ARIB.
At the end of 06/1998 the UTRA proposal is submitted to the ITU.

12/1998: 3GPP founded.

Five major standards development organizations (SDO's) agree to jointly specify and further develop UMTS. 3GPP is established for this purpose.

07/1999: Harmonization of UMTS with CDMA2000.

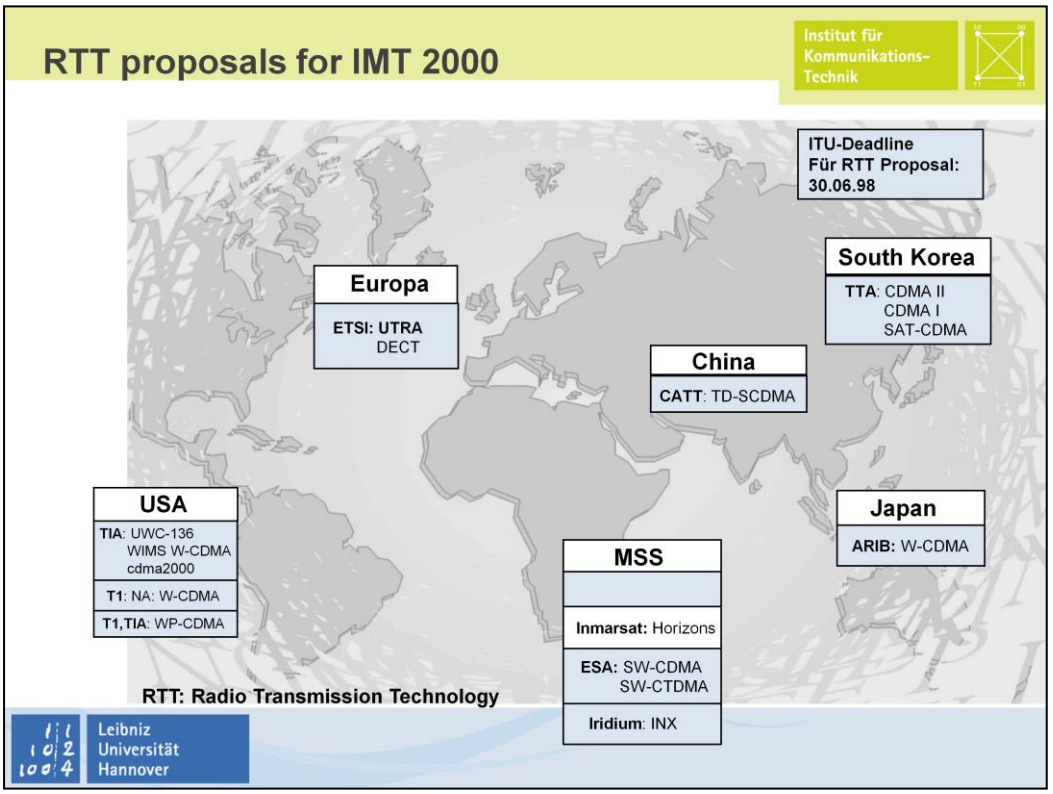
Due to major differences in policy implementation between the EU, Japan and the USA and the wish of an operator harmonization group (OHG), the 3GPP decides to harmonize UTRA with CDMA2000 (the successor to IS-95). There are now three different compatible 3G modes: UTRA TDD and FDD as well as MC-CDMA.

17.12.1999: Completion of the 3GPP work.

3GPP completes the first UMTS Annual Release (Rel. '99). It is adopted as a standard by the regional SDO's.

The licensing of UMTS frequencies commenced in 1999 is to be concluded for the most part in 2000. New 3G frequency bands to be reserved at the WRC2000 in 06/2000.

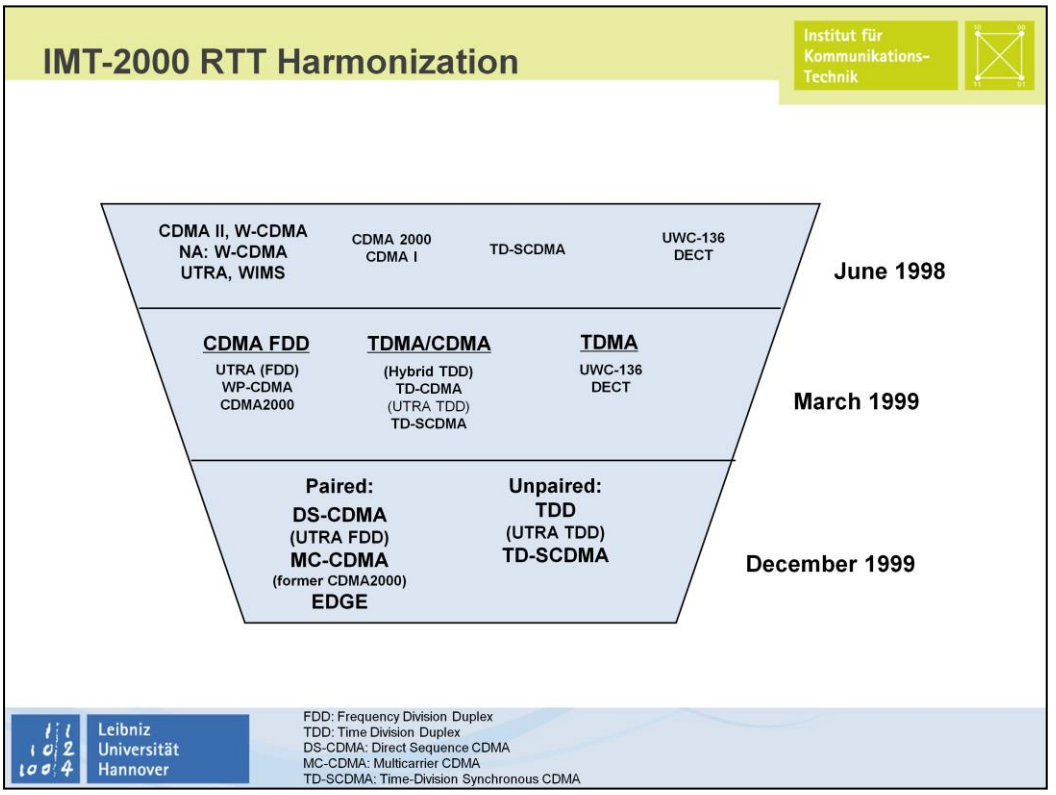
Initial large-scale field trials are to start in 2000, friendly user operation at the beginning of 2001. The commercial start for UMTS is planned for the end of 2001 in Japan and South Korea, 01/2002 in Europe.



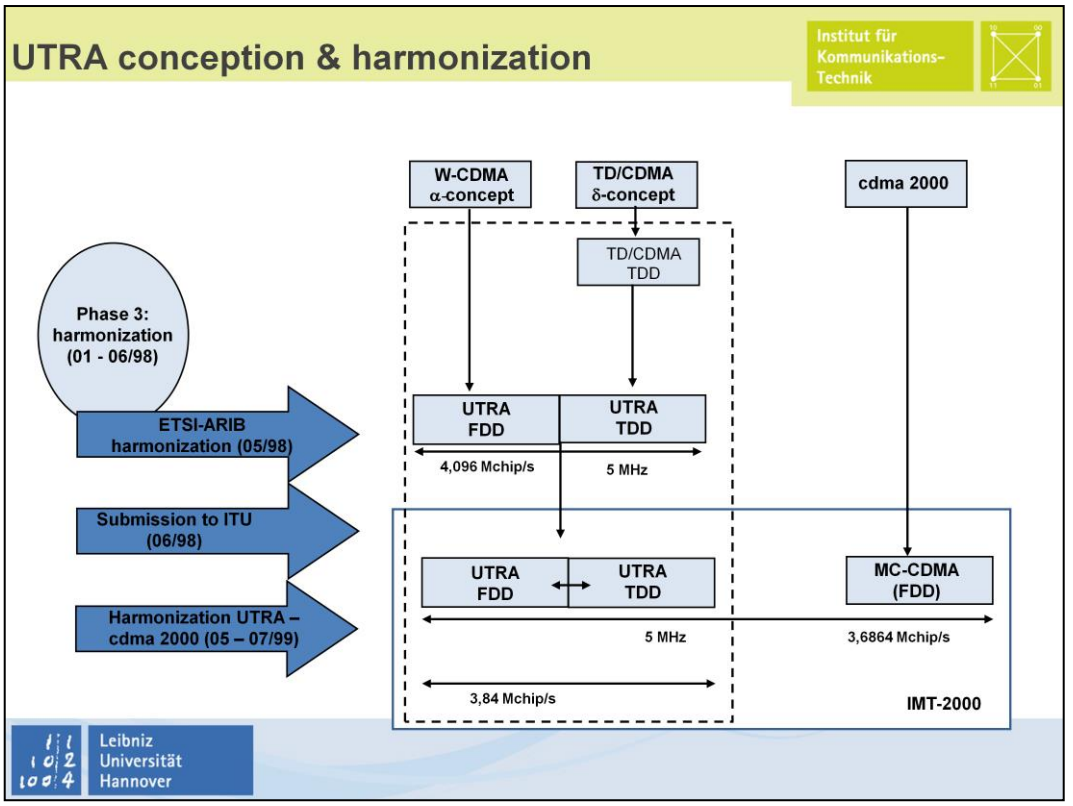
Different regional standards development organizations (SDO's) were involved in the development of IMT-2000 systems. 15 proposals for implementing IMT-2000 radio transmission technologies (RTT) were submitted to the ITU by the end of June (the official deadline). Two further proposals followed a few months later, but were still accepted.

The total of 17 proposals were devised and submitted by the world's most important SDO's – i.e., from ETSI (Europe), ARIB (Japan), TIA (USA), T1 (USA), TTA (South Korea) and CATT (China), as well as by the MSS operators ICO, Inmarsat, ESA and Iridium.

The 11 proposals submitted by the various SDO's refer to terrestrial, cellular systems. The other 6 proposals from the MSS operators concern satellite systems that are intended to provide genuine global coverage for the 3G systems.



Due to the demand for global compatibility of the IMT-2000 systems and as a result of the improved chances of the individual proposals, many of the RTT solutions proposed were harmonized. The harmonization reduced – in particular for the terrestrial, cellular systems – the number of RTT's during the period from the middle of 1998 until the end of 1999. The ARIB (W-CDMA) and ETSI (UTRA) proposals were harmonized and further jointly developed as UTRA FDD and TDD components (as a GSM successor system). The IS-95 successor system, CDMA2000, and the UTRA FDD/TDD components were also harmonized later on. This new IMT-2000 RTT
component referred to now as MC-CDMA (instead of CDMA2000) is for the most part harmonized with the UTRA TDD and FDD (now also known as DS-CDMA) components with the result that roaming is possible in theory between the system components. The Chinese TD-SCDMA proposal has also been retained as an IMT-2000 component.
At the same time, UWC-136 remains as a step toward optimization of D-AMPS in the direction of high data rates (equivalent to EDGE for GSM).
Remaining as "true" 3G systems are thus the IMT-2000 RTT's DS-CDMA (Direct Sequence CDMA – i.e., the UTRA FDD component), MC-CDMA (Multicarrier CDMA) and TD-SCDMA (Time Division Synchronous CDMA) for paired bands in addition to the UTRA TDD component for unpaired bands.



3rd Phase of the UTRA Conception: Harmonization

It was decided during the SMG#24A Plenary Session to use the concept for the paired bands in UMTS –i.e.,as UTRA FDD mode.The concept was to be used for the UMTS unpaired bands – i..e.,as UTRA TDD mode.Both modes were harmonized with each other by 06/1998 with the consequence that dual mode operation (FDD/TDD)presents no problems.Both modes were designed in such a way that handover to GSM is unproblematic.The bandwidth of both modes is 5 MHz,including the guard bands.4.096 Mchip/s was selected as the Rc.

The modes were also harmonized in the 3rd phase with the IMT-2000 proposal from ARIB (Japan),who supported the original concept as observers in ETSI.

The 3rd phase ended with the submission of the harmonized proposals by ETSI (UTRA FDD &TDD)and ARIB (WCDMA)to the ITU.

In the period following,the newly founded standardization project,the 3GPP,in which experts from ETSI (Europe),ARIB (Japan),TTA (South Korea),ANSI T1P1 (USA) and CWTS (China)participate,took over responsibility for completion of the UMTS Standard.

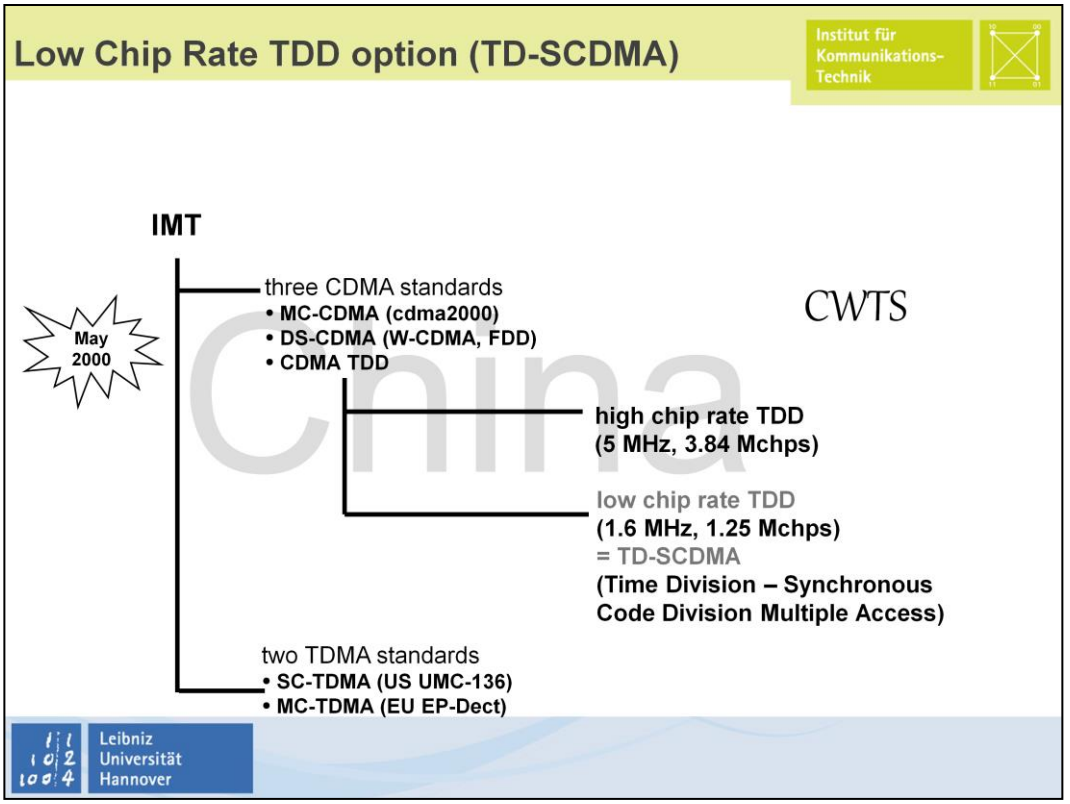
Harmonization of UTRA with cdma2000

The TIA (USA)proposal 'cdma2000'is intended as the 3G successor standard to IS-95.The technical parameters of cdma2000 and IS-95 are therefore very similar and ensure downward compatibility and handover between 2G IS-95 and 3G cdma2000. 3.6864 Mchip/s (for DL)and 1.2288 Mchip/s (for UL)were selected as the chip rates for cdma2000.In 06/1998 cdma2000 was also submitted as an IMT-2000 proposal to the ITU.

In the period following,major economic and patent law-related difficulties arose between the groups involved in IS-95 /cdma2000 and GSM /UMTS (WCDMA).For example,the different patents for CDMA and the 3G licensing in Europe and Asia were contentious points.The USA threatened to invoke the WTO (World Trade Organization) and block the work for approval of the IMT-2000 proposals in the ITU.

In order to put an end to the wrangling and to satisfy the requirements of an Operator Harmonization Group (OHG),the 3GPP accepted an OHG proposal in 07/1999 for harmonization of UTRA and cdma2000.

The result of the harmonization was as follows:UTRA TDD and FDD along with cdma2000 are given similar parameters to allow the development of chipsets for mobile stations for all three modes.The three modes are based on DS-CDMA and can be accommodated in 5 MHz of bandwidth.The signaling is harmonized.The following core differences still exist:UTRA can be used for non-synchronized networks,MC-CDMA for synchronized. UTRA TDD and FDD use 3.84 Mchip/s as chip rate;MC-CDMA n x 1.2288 Mchip/s.



Low Chip Rate TDD option (TD-CDMA)

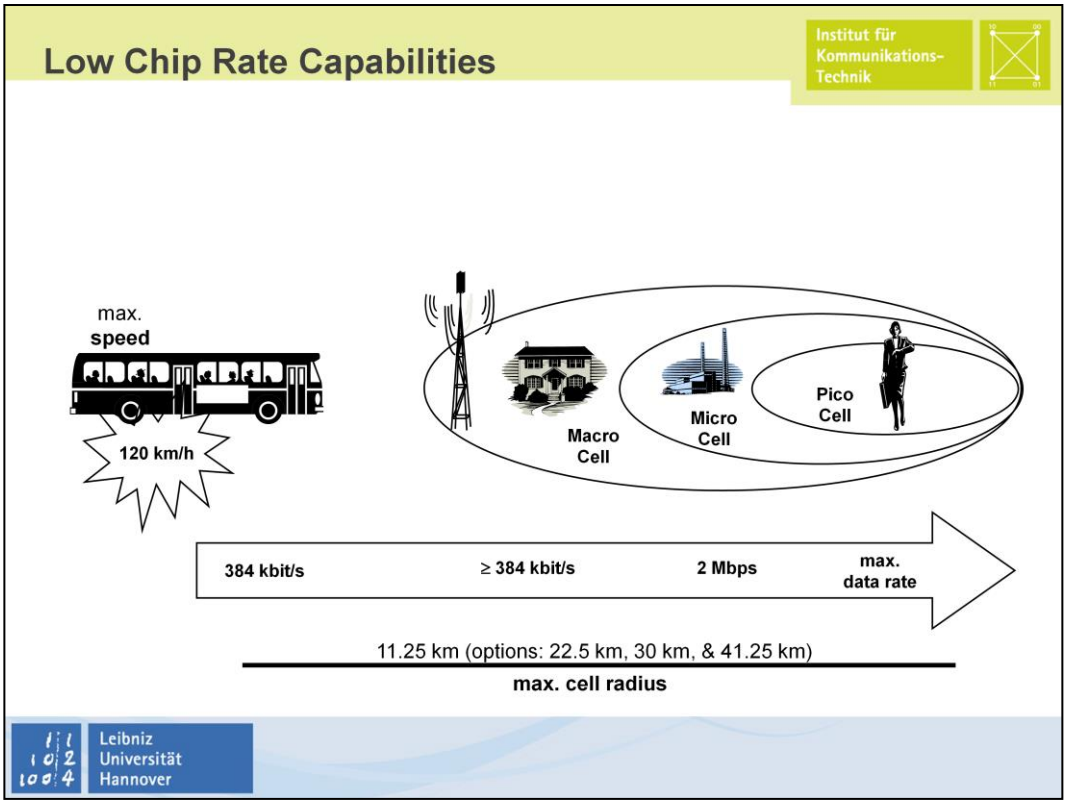
In 1985 most of the first generation mobile communication systems were just launched, and there were just some 100000 subscribers world-wide. In the same year, the working group ITU WG8 was founded at the ITU (Internataional Telecommunication Union) to design a framework of requirements for 3rd generation mobile communication systems. IMT-2000 is a framework on how a 3rd generation radio interface has to look like, and how the network evolution from the 2nd to the 3rd generation mobile communication system has to take place. In May 2000, the World Radio Conference (WRC-2000) officially approved IMT-2000. With that, a 3rd generation wireless radio access network can use five specifications:

- Two TDMA standards: SC-TDMA (US UMC-136) and MC-TDMA (European EP-DECT)
- Three CDMA standards: MC-CDMA (cdma2000), DS-CDMA (W-CDMA), and CDMA TDD (including both TD-SCDMA and UTRA TDD).

All CDMA standards will be specified as UMTS radio interface solutions. In early 1999, there were only two CDMA air interface solutions with UMTS: DS-CDMA, called the UTRA FDD mode, and the UTRA TDD mode. Both were using a carrier was integrated. The main target was to archive a harmonization of IS-95B successor system cdma2000 with UMTS.

Since 1998, the China Academy of Telecommunication Technology (CATT), a research institute of the Chinese Ministry for Information and Industry was tightly cooperating with Siemens to design a 3rd generation narrowband TDD solution in full compliance with IMT-2000. This air interface solution became first known under the name TD-SCDMA (Time Division-Synchronous Code Division Multiple Access). The Chinese standards developing organization CWTS archived ist integration as 4th radio interface solution within UMTS. Within the UMTS specification, the UTRA TDD mode now exists with two options:

- TDD high chip rate (3.84 Mchps and 5 MHz bandwidth), and
- TDD low chip rate (1.28 Mchps and 1.6 MHz bandwidth), often also called TD-SCDMA.



TDD low chip rate capacities

The TDD high chip rate solution was especially designed to complement the FDD-mode, especially in the pico cell environment. In the pico cells, IP based asymmetric traffic is expected, which is best supported by a TDD solution. Furthermore, pico cells are normally installed in hot sports, where the high spectral efficiency of the TDD mode is another plus. Pico cells are applied in slow motion environments, where the UE speed disadvantage of the TDD mode and the limited cell range of the TDD mode is not a major drawback.

The TDD low chip rate mode supports the radio environment as required by the ITU IMT-2000. In compliance with the hierarchical cell structure there are

- Macro cells (vehicular environment), where speeds of up to 120 km/h and data rates of up to 384 kbps are possible,
- Micro cells (pedestrian environment), where data rate of 384 kpbs or more are possible, and
- Pico cells (indoor environment), where data rates up to 2 Mbps are possible.

The maximum cell radium is about 10 km (11.25 km). This cell radius can be offered without causing an interference between uplink and downlink. Depending on the interference level the operator is willing to accept, cell radii of 22.5, 30 and 41.25 km are possible.

Therefore the TDD low chip rate mode can be applied to serve both

- hot spot or high density areas with demand for high speed data services, and
- macro cells to offer (enhanced) service coverage.

Handover and cell (re-)selection takes place like in the TDD high chip rate mode.

E.g., handover between the different UTRA modes is supported, as well as to other mobile communication systems, such as GSM.

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In December 1998, five regional standards organizations (Japan: ARIB and TTC, Europe: ETSI, South Korea: TTA, USA: T1) agreed to found a new global standardization body. The objective of this body, known as 3GPP, is the joint standardization, testing and continued development of UMTS.

The cooperation between many of these globally important standards organizations is intended to assure that UMTS can establish itself as the core 3G standard thereby facilitating global roaming and a genuine mass market for 3G.

The 3GPP guidelines were completed by March 1999.

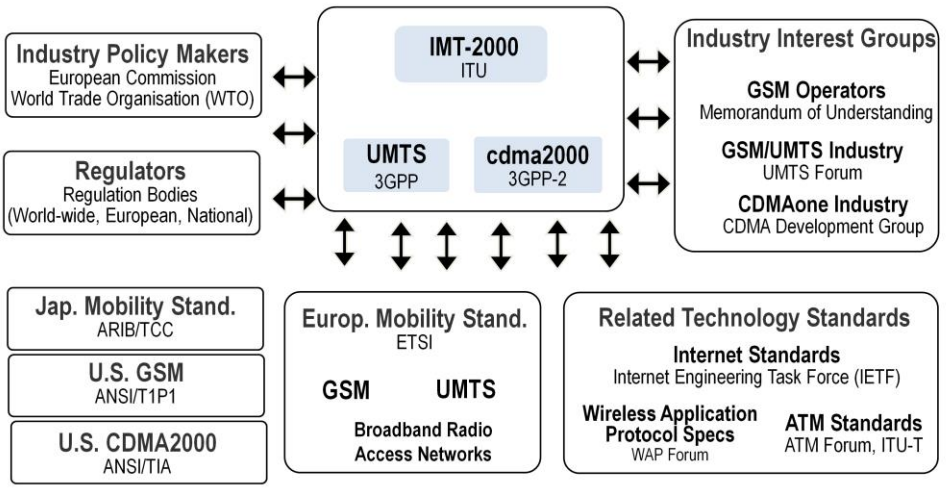
3GPP distinguishes between "organizational partners“, "market representation partners" and "observership status“.

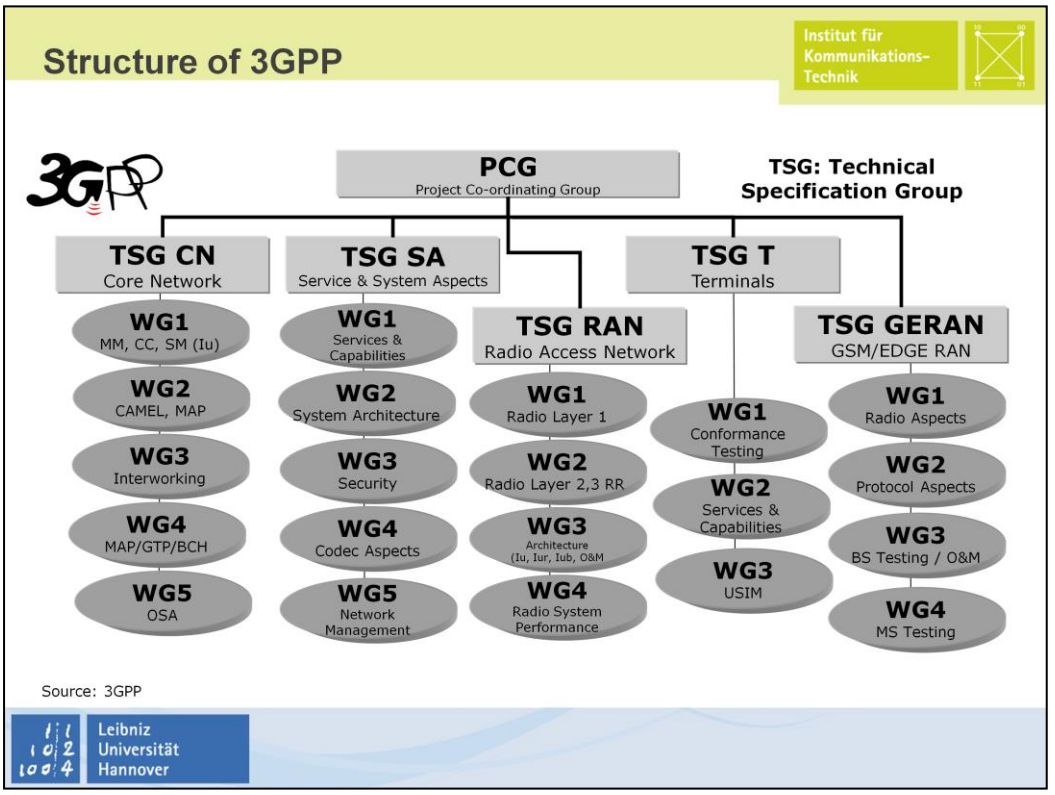
Organizational partners delegate experts to 3GPP to work on the development of the standard. Market representation partners can make submissions to 3GPP, and engage in the investigation of market demands, services, compilation of studies, etc. Observership status is given to organizations with access to the 3GPP committees but without any voting power.

Since the founding of the 3GPP many other organizations have agreed to active involvement in the project.

For instance, by the beginning of the year 2000, the CWTS (China) joined as an organizational partner; the UMTS Forum, GSM Association, GSA,UWCC and Ipv6 Forum as market representation partners MPRs and TIA and TSACC are engaged under observership status.

Organisations involved





3GPP originally has been divided into a project coordinating group (PCG), four technical specification groups (TSG's) and 16 working groups (WG's). The PCG coordinates the work of the various TSG's and WG's. The TSG's are responsible for devising the standard – i.e., the recommendations for UMTS.

There are TSG's for each of the following topics: "Radio Access Network", "Service & System Aspects", "Core Network" and "Terminals".

A fifth TSG has been created in July 2000: GERAN (GSM/EDGE Radio Access Network). Its principal responsibilities will be the maintenance and development of GSM Technical Specifications and Technical Reports, including GSM evolved radio access technologies such as GPRS and EDGE.

15 of the working groups are working on studies regarding different aspects of the standard. The studies are used by the TSG's as a basis for drafting recommendations. A further working group known as the ad-hoc group on ITU coordination is

responsible for maintaining contact with the ITU.

CAMEL is a platform created by the European Telecommunication Standardization Institute (ETSI), which introduces the basic concept of intelligent networks (IN) in the GSM mobile radio system. CAMEL uncouples the service control from the control of the trunking scheme and then transmits it from the switching center computers to separate computers. Accordingly, it is no longer necessary to load the corresponding software in all mobile switching centres (MSC) to accommodate new services. Instead, these new services can be tailor made for certain customer groups, and will be available even if the user is moving outside of his or her home network. CAMEL helps operators provide new services – independent of the manufacturer and without intervention in the network technology.

USIM: universal SIM

CoreMedia Content Application Platform (CAP)

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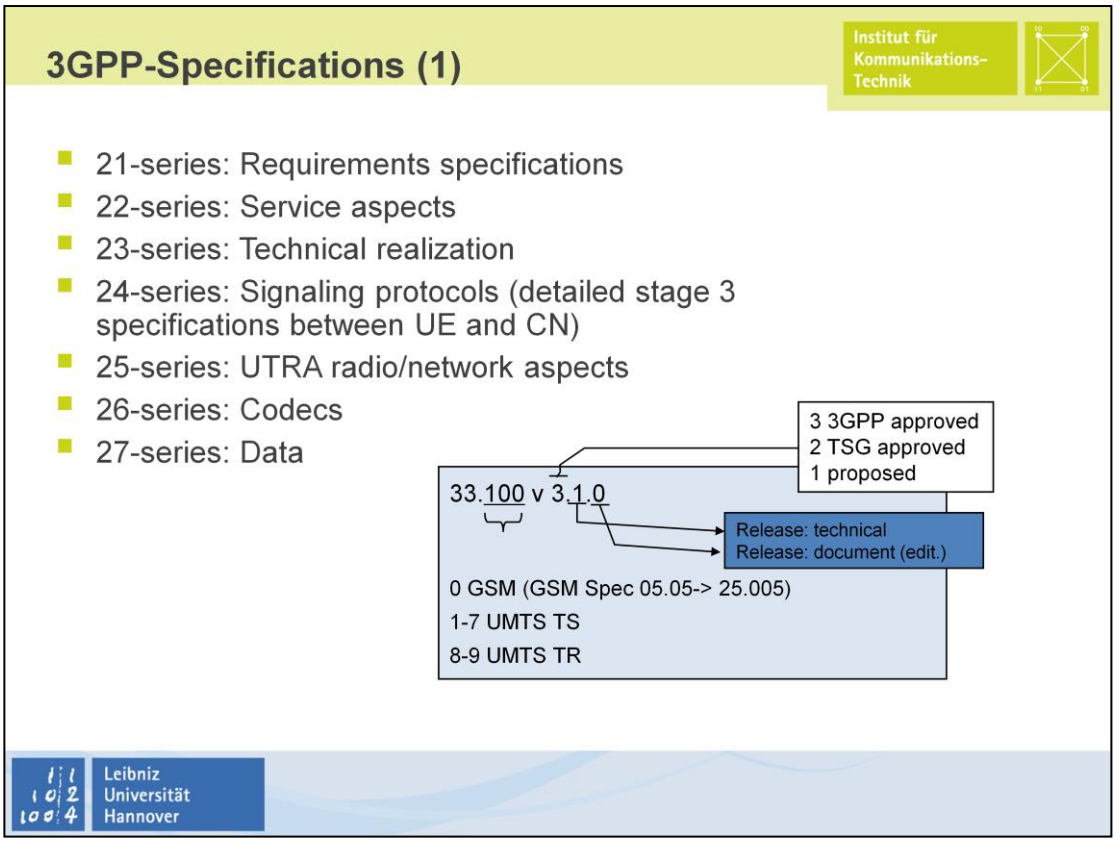

The UMTS (3G) Standard drafted by the 3GPP is based on the success and experiences of the GSM Standard.
The first UMTS (3G) Release – completed at the beginning of the year 2000 and known as the UMTS Annual Release 1999 – is based in many areas on the GSM Annual Release 1999. This is true in particular for the Core Network (CN) and the service aspects. There are also very many '3G-only' specifications. This refers particularly to the implementation of the UTRA radio interface.
The UMTS (3G) Standard is divided into different series (Series 21 to 34). These are in turn subdivided into individual specifications.
Recommendations of the UMTS (3G) Standard as known as technical specifications. Their numbering is derived from the numbering system of the GSM Standard. A technical specification (TS) is numbered as "3G TS ab.cde", where "ab" represents the series and "cde" the particular specification. Up to 1000 specifications are therefore possible in any one series. This is a larger scale than is the case for GSM. Specifications derived from the GSM Rel. '99 are numbered after the corresponding GSM series plus 20. The "c" in the TS is set to "0" here. For example: 3G TS 27.007 is a technical specification deriving from the GSM Rec. 07.07.
The numbering system is explained in detail in the 3G TS 21.101.
The 3G TS 21.101 also provides an overview of all series and individual 3G technical specifications.

Structure of the standard R99

	GSM before R4	GSM after R4	UMTS R99+
Requirements	01.xx	41.xxx	21.xxx
Service aspects	02.xx	42.xxx	22.xxx
Tech. Realization	03.xx	43.xxx	23.xxx
Signalling (UE-NW)	04.xx	44.xxx	24.xxx
(U)TRA aspects	05.xx	45.xxx	25.xxx
CODECs	06.xx	46.xxx	26.xxx
Data	07.xx	47.xxx	27.xxx
Signalling (RSS-CN)	08.xx	48.xxx	28.xxx
Signalling (intra-FN)	09.xx	49.xxx	29.xxx
Management	10.xx	50.xxx	30.xxx
UIM/SIM	11.xx	51.xxx	31.xxx
O&M	12.xx	52.xxx	32.xxx
Security Aspects	13.xx	53.xxx	33.xxx
Test Specs			34.xxx
Security Algorithm			35.xxx

3GPP-Specifikations (2)

- 28-series: Signalling protocols (stage 3 specifications of protocols between RSS and CN)
- 29-series: stage 3 specifications of protocols within CN
- 30-series: Program management
- 31-series: USIM
- 32-series: Operation and maintenance
- 33-series: Security aspects
- 34-series: Test specifications

UMTS Release 99 (R99)

- Based on GSM Phase 2+
- Higher data rate and QoS-support
- Data rate as in N-ISDN for CS-Data
- USIM like GSM-SIM
- ATM and IP permitted
- Services: Speech, emergency call, SMS, narrowband data

- Core Network adopted from GSM Phase 2+, hardly unchanged
- Higher data rates of the air interface might not be carried by Core Network in any case
- VHE, OSA etc. might not be available from the very beginning

3rd Generation Partnership Projekt (3GPP)

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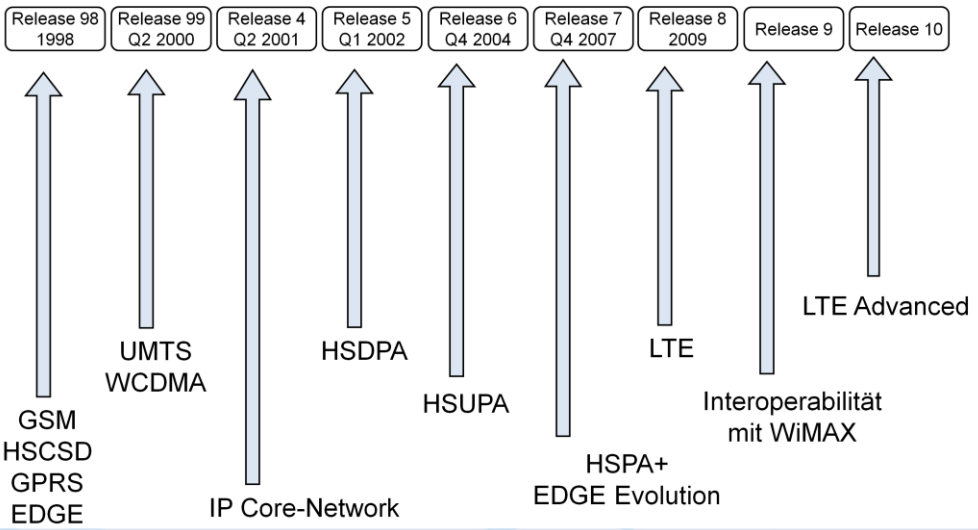

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UMTS Releases

3GPP	Specified Features
1999: Release 99	Bearer Services: 64 kbps circuit switched, 384 kbps packet switched; Call services: GSM compatible, USIM based, CAMEL Phase 3; FDD and TDD Radio (3,84 Mcps); Location Services, New Codec (AMR)
2001: Release 4	EDGE Radio; TDD Low Chip Rate Radio (1,28 Mcps) Improved Location Services (Emergency), USIM toolkit, MExE Repeater Specification; Multimedia Messaging
2002: Release 5	IP Multimedia Subsystem (IMS); IPv6, IP transport in UTRAN HSDPA 10 Mbps (ITU-R update of M.1457); CAMEL Phase 4; Wideband AMR (16 kHz); Improvements in GERAN, LCS, MExE, etc.
2003: Release 6	IMS improvements, Presence service; WLAN Integration Multimedia Broadcast and Multicast (MBMS); Digital Rights Management; Network Sharing
Current Release	14 3GPP LTE Advanced Pro

UMTS Release 2000 (R4/R5)

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- based on R99
- Coding
  - High rate speech codecs
  - Transcoding
- regulation questions
  - EMV
  - Conformance test
- pure IP-Core Network
- higher rate data services

- VoIP
- IP-controlled call establishment
- SAT, MExE, CAMEL, OSA
- Location Services
- Inter-System and Inter-Release-Roaming

Completely new fixed network concept!

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UMTS-Frequency ranges

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China only: 2300-2400 MHz

What do you realize?

Spektrum-Allocation

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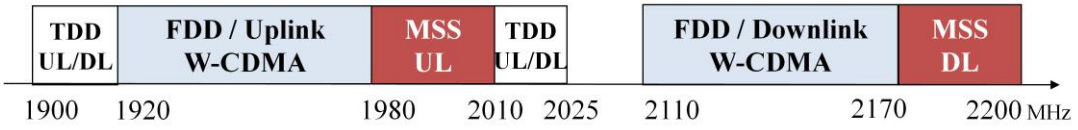
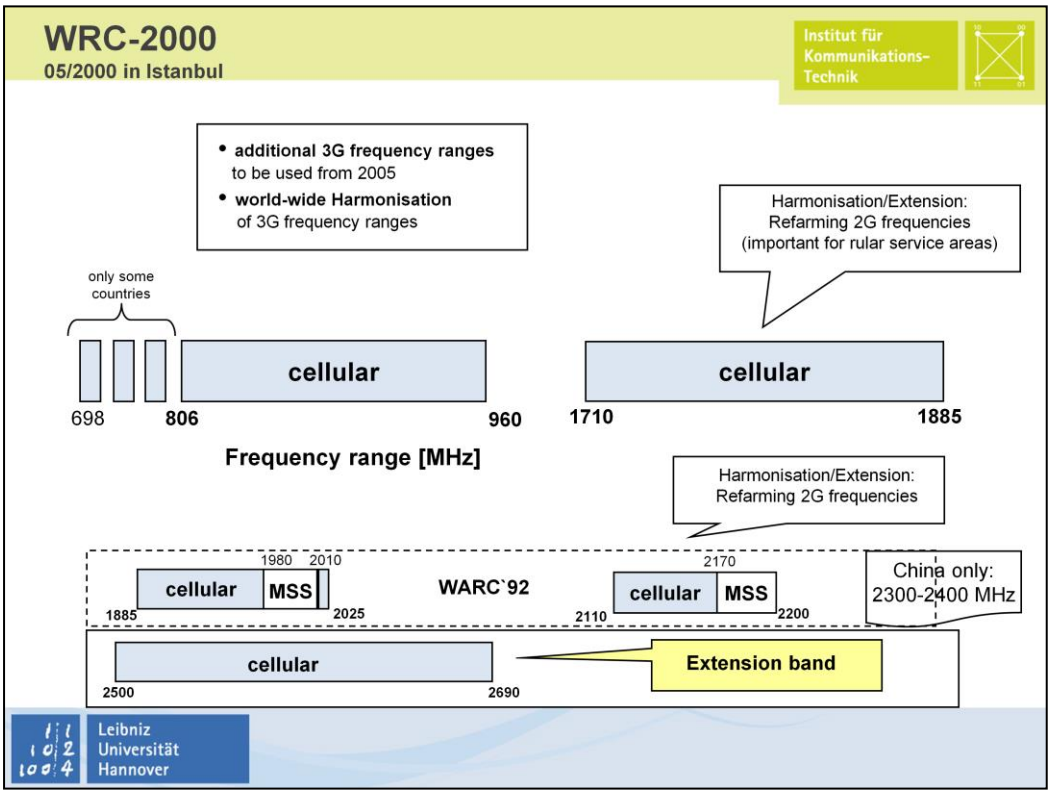
MSS: Mobile Satellite System

UMTS-Frequency ranges Europe



- W-CDMA FDD-Mode for symmetrical frequency ranges n x 5MHz
  - 2 x 60 MHz ⇨Uplink : [1920, 1980] MHz / Downlink : [2110, 2170] MHz
  - suitable for Makro cells and symmetrical traffic, like dialogue voice and low data rate (limited by downlink)
  - Function: Cell Coverage for traffic load
- W-TDMA/CDMA TDD-Mode for asymmetrical frequency range n x 5MHz
  - Asymmetrical frequency range from 35 MHz ⇨ [1900, 1920] and [2010, 2025] MHz
  - Limited to micro- und pico cells (Indoor applications), suitable for asymmetrical services (“high speed asymmetric packet data”)



WRC World Radio Conference

The additional bands identified for 3G terrestrial components are:

806 – 960 MHz

1710 – 1885 MHz

2500 – 2690 MHz

The bands, which had been identified for 3G in WARC'92 remain unchanged:

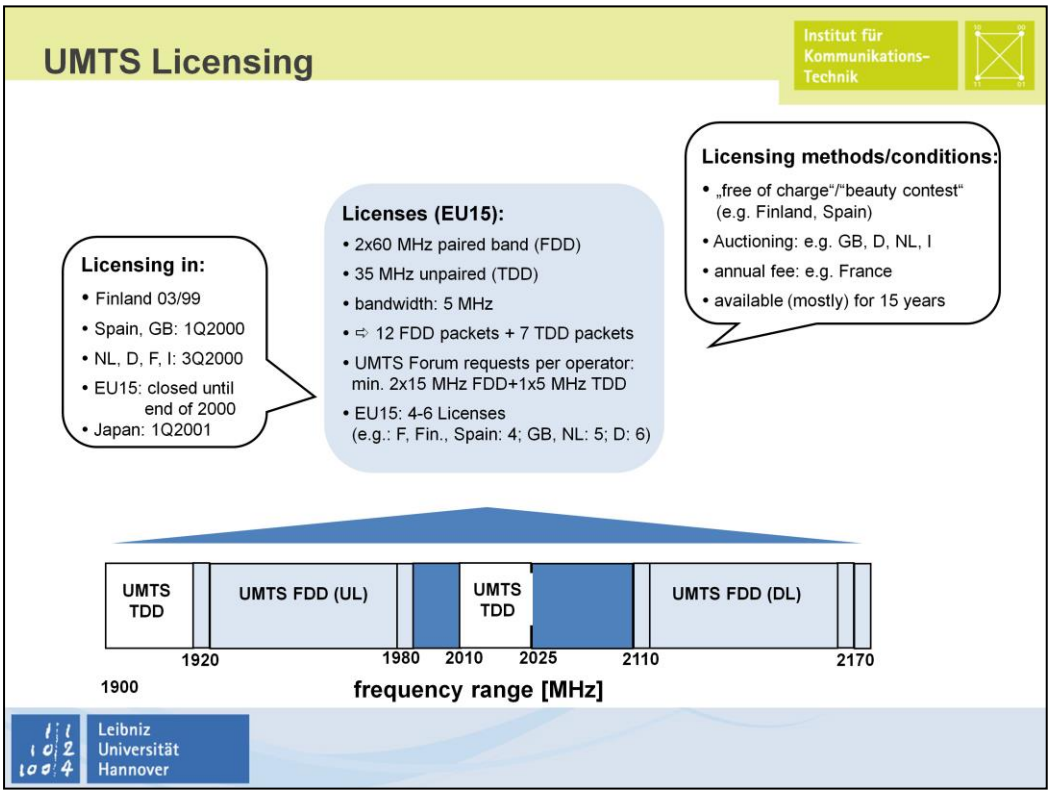
1885 – 2025 MHz

2110 – 2200 MHz

The frequency ranges below 1GHz are especially useful for rural services and developing countries. Some countries are planning to use the following frequency range additionally for 3G implementation: 698 – 806 MHz.

The focus of the 3G extension is the frequency range between 2500 – 2690 MHz.

Reference is also made to the 2300 – 2400 MHz frequency range, which is the preferred choice of China.



The licensing of UMTS was commenced in Finland in 03/1999. The remaining EU15 nations, other Western and Central European countries, Japan and South Korea, South Africa, Australia and New Zealand are to follow in 2000.
The licensing process should be completed by the end of the year 2000 so as to provide UMTS operators with the security they require for planning.

Different licensing methods are used. A number of countries (e.g., Finland) prefer the distribution of licenses free of charge.
Most other countries (including Germany, the United Kingdom and the Netherlands) would prefer different auction systems (open and closed). The acquisition of licenses is linked in most countries to different conditions. The conditions include guarantees for commencement of UMTS operation and the requisite service level with UMTS after a particular time (e.g., 50% of the population after 5 years). The lifetime of the licenses will be limited to 20 years in most cases. Regional licenses are not excluded. In general, however, operators prefer national licenses.

2 x 60 MHz are available for paired bands (FDD) and a total of 35 MHz for unpaired bands (TDD) for the EU15. There are therefore 12 packets for paired bands and 7 packets for unpaired bands to be allocated for use with the UMTS 5-MHz bandwidth. The UMTS Forum specified a minimum of 3 packets for paired bands (i.e., 2 x 15 MHz) and 1 packet for unpaired bands (i.e., 1 x 5 MHz) per operator for optimum deployment of UMTS. If licenses are to be granted nationally, this implies a maximum of 4 operators in each country. For this reason, 2 x 10 MHz for paired bands will also be allocated in countries with high population densities, thereby allowing 5 or 6 licenses to be acquired.

UMTS-Licenses in Germany

License holder (Licensee):

- Auditorium Investments Germany S.A.R.L. (KPN, E-Plus, NTT DoCoMo)
- DeTeMobil Deutsche Telekom Mobilnet GmbH
- ✗ Group 3 G (Telefonica, Sonera)
- Mannesmann Mobilfunk GmbH (Vodafone)
- ✗ MobilCom Multimedia GmbH (France Telecom)
- VIAG INTERKOM GmbH & Co. (British Telecom)

License requirements:

- Number portability
- Call-by-Call
- National roaming to other GSM networks
- Coverage of 50% of the population by 2005

UMTS coverage

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50 % of the population means:

- Approximately 8% of the surface of Germany
- Rest can be served by roaming

Coverage Today?

2003: 25% coverage

2005: 50% coverage

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Company	Frequency Range	Frequency Bands	Price
Telefónica Deutschland	700 MHz 900 MHz 1800 MHz	2x10 MHz 2x10 MHz 2x10 MHz	1.198.238.000 €
Telekom Deutschland	700 MHz 900 MHz 1800 MHz 1500 MHz	2x10 MHz 2x15 MHz 2x15 MHz 20 MHz	1.792.156.000 €
Vodafone	700 MHz 900 MHz 1800 MHz 1500 MHz	2x10 MHz 2x10 MHz 2x25 MHz 20 MHz	2.090.842.000 €
Total		**270 MHz**	**5.081.236.000 €**

http://www.bundesnetzagentur.de/DE/Sachgebiete/Telekommunikation/Unternehmen_Institutionen/Frequenzen/OeffentlicheNetze/Mobilfunknetze

5G Timeline

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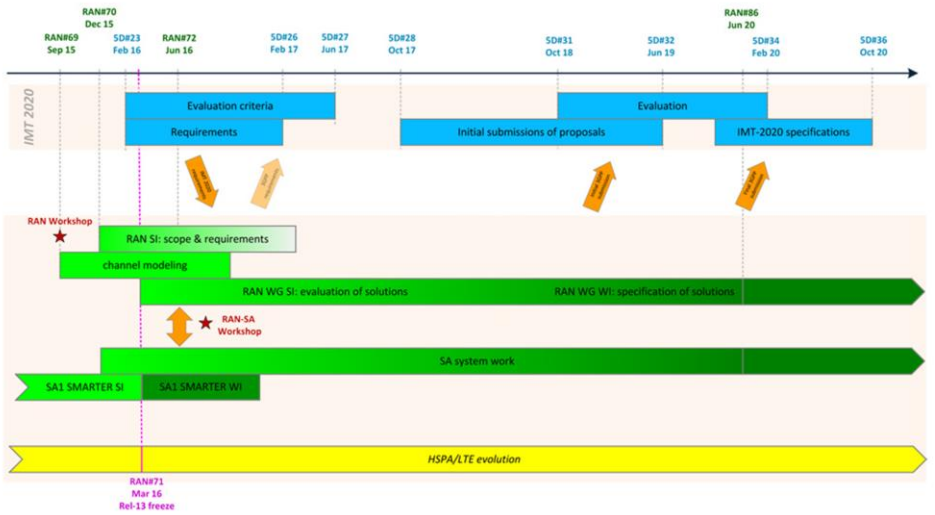

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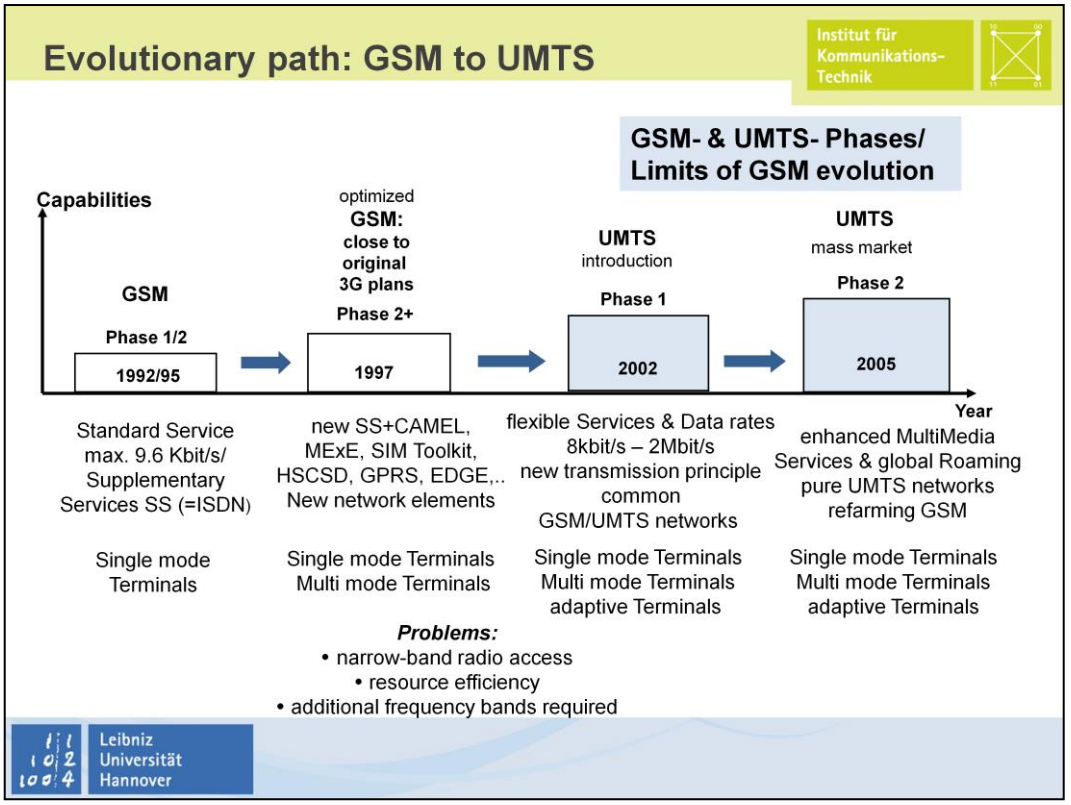


The original planning for the GSM Standard in the 1980's was to include all specifications on ratification of the standard. In 1988 it became clear that this was not possible in the specified time frame. For this reason, GSM was released in a preliminary version in 1990.

GSM Phase 1

The preliminary version of the GSM Standard released in 1990 for GSM900 and in 1991 for GSM1800 is referred to as the GSM Phase 1. Phase 1 contains all definitions required for the operation of digital GSM mobile communication networks. Transfer of speech data is the core focus. Data transfer is defined for rates from 0.3 to 9.6 kbit/s. Only a few supplementary services are included.

GSM Phase 2

After completion of the Phase 1 work, the GSM Standard was fully revised. This work was concluded in 1995 and represents the GSM Phase 2. Phase 2 includes a wide range of supplementary services comparable with the ISDN standard in digital fixed networks. A more efficient voice codex was also defined.

GSM Phase 2+

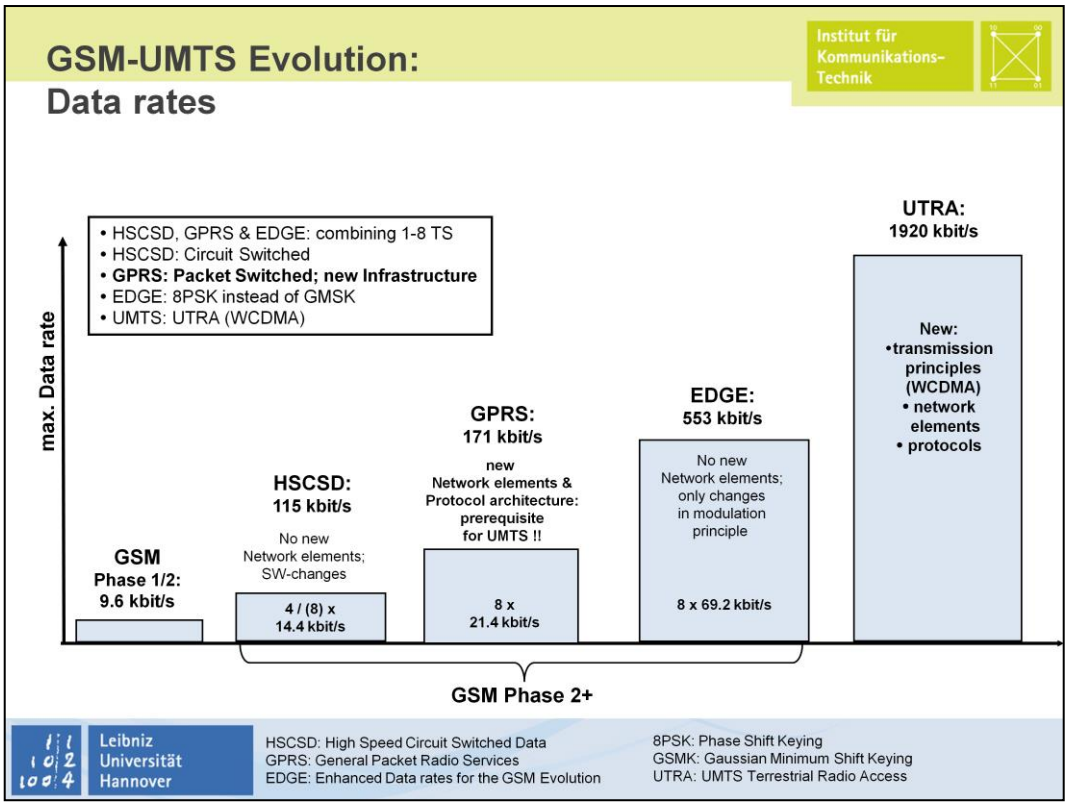
Phase 2+ enables prompt responses to the requirements of the mobile communications market and to new technical developments. The GSM Standard is not overall revised in Phase 2+; instead it has been extended by individual up-to-date aspects on a yearly basis since 1996 (in so-called Annual Releases). Major aspects included IN services, high data rate transmission, and improved voice codes. Also particularly important were extensions to the GSM network and the protocol structure, which in the Annual Release '99 represented the basic requirements for introduction of UMTS. GSM is limited by the narrowband radio access, the efficiency of resource usage and a lack of additionally available frequency bands.

UMTS Phase 1

From 2002, UMTS will introduce a new, broadband radio access based on the GSM core networks (CN) that is optimized for data transmission. New transmission methods allow flexible, dynamic data transmission with extremely high data rates. The VHE concept provides a flexible service definition with global availability of the services.

UMTS Phase 2

As of about 2005, homogeneous UMTS networks in UMTS Phase 2 are to provide even greater flexibility and performance. The GSM frequencies are to be made available for use by UMTS in stages ("refarming").



In Phases 1 and 2 GSM allows data transfers at rates of only 0.3 to 9.6 kbit/s. Three different principles are introduced in GSM Phase 2+ for increasing the data rate: HSCSD, GPRS and EDGE.

HSCSD in theory allows up to 8 physical channels of a carrier to be bundled together (multilinking) to a single subscriber. In praxis, however, only up to 4 channels are bundled together. The maximum transfer rate per physical channel was increased from 9.6 kbit/s to 14.4 kbit/s with the introduction of a new codec. As a result, up to 57.6 kbit/s can be reached (or theoretically, 115.2 kbit/s). HSCSD, like conventional GSM, only transfers circuit-switched (CD) data. Only minor modifications to the GSM network are required to introduce HSCSD.

GPRS also allows bundling (multilinking) of up to 8 physical channels to a subscriber. Four new coding methods enable transfers at rates of 9.05 /13.4 / 15.6 / 21.4 kbit/s per physical channel. GPRS introduces packet-switched (PS) data transmission, which allows efficient use of resources and direct access to packet data networks

(PDN). New network elements and protocols are being introduced that will pave the way for UMTS. GPRS is therefore of major importance for UMTS launching.

EDGE (Enhanced Data Rate for the GSM) introduces a new modulation method over the radio interface – 8PSK (8-Phase Shift Keying). In theory, this allows transfer rates three times faster than those for the conventional GSM modulation method, GMSK (Gaussian Minimum Shift Keying). In this way, EDGE increases the performance of GPRS and HSCSD, and transmission at up to 69.2 kbit/s per physical channel is possible. A maximum rate of 553.6 kbit/s is possible with 8 channel multilinking.

UTRA(N): UMTS Terrestrial Radio Access: (Network): Fully new transmission methods (WCDMA, ATM) are used in UMTS for the UTRA radio access and the UMTS Terrestrial Radio Access Network (UTRAN). New network elements and a new protocol architecture are needed. The maximum transmission rate via the radio access will approach 1920 kbit/s.

Evolution statt Revolution

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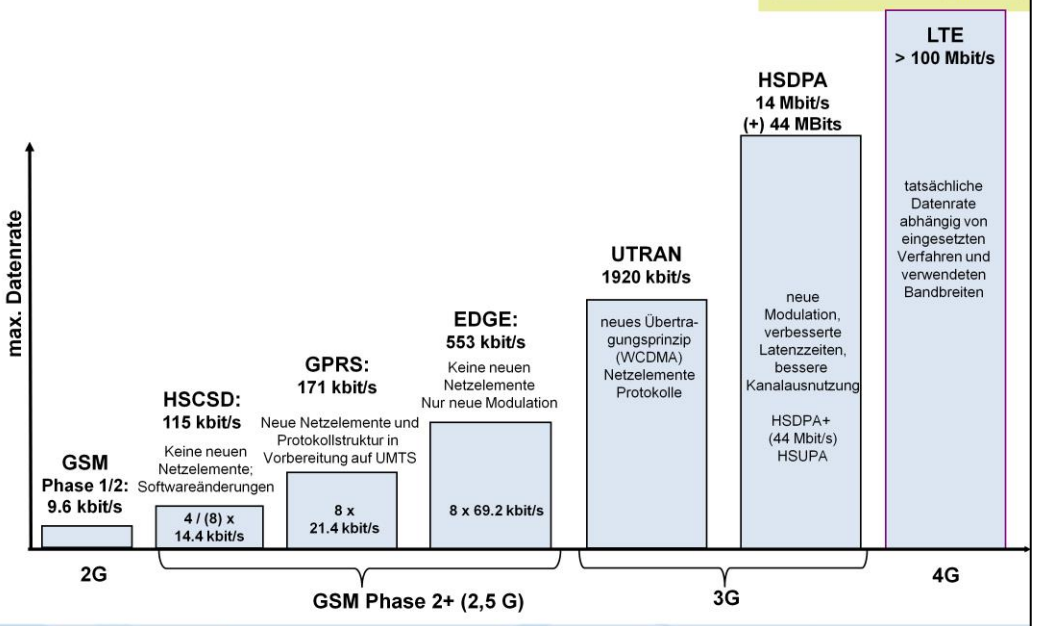

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HSCSD: High Speed Circuit Switched Data
GPRS: General Packet Radio Services
EDGE: Enhanced Data rates for the GSM Evolution

UTRA: UMTS Terrestrial Radio Access
LTE: Long Term Evolution

Potential User Density

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Operation environments	Density of potential user/km²
1. CBD/Urban (in building)	180 000
2. Suburban (in building or on street)	7 200
3. Home (in building)	380
4. Urban pedestrian	108 000
5. Urban vehicular	2 780
6. Rural in- & out-door	36

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CBD Crowded Business District

Source: UMTS Forum

Services Characteristics

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Services	User net bit Rate [kbit/s] (1)	Coding Factor (2)	Asymmetry Factors (3)	Effective Call duration [s]	Service bandwidth* [kbit/s]
High interactive MM	128	2	1/1	144	256/256
High MM	2000	2	0.005/1	53	20/4000
Medium MM	384	2	0.026/1	14	20/768
Switched data	14	3	1/1	156	43/43
Simple messaging	14	2	1/1	30	28/28
Speech	16	1,75	1/1	60	28/28

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Note* - service bandwidth is a product of columns (1), (3) and (3)

MM Multi Media

Source: UMTS Forum

Busy Hour Call Attempt

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Services	2005			2010		
	CBD Urban	Urban in building	Urban on street	CBD Urban	Urban in Building	Urban on street
High interactive MM	0.12	0.06	0.004	0.24	0.12	0.008
High MM	0.12	0.06	0.004	0.12	0.06	0.004
Medium MM	0.12	0.06	0.004	0.12	0.06	0.004
Switched data	0.06	0.03	0.002	0.06	0.03	0.002
Simple messaging	0.06	0.03	0.002	0.06	0.03	0.002
Speech	1	0.6	0.6	1	0.85	0.85

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Source: UMTS Forum

Bearer Services UTRA (without HSDPA)

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	Classe A LDD Low Delay Data	Classe B LDD-VBR Low Delay Data – Variable Bit Rate	Classe C LCD Low Constraint delay	Classe D UDD Unconstrained Delay Data
Time constraints	Real Time	Real Time	Not Real Time (Circuit)	Not Real Time (Packet)
Data rate	8-384kbps	16-2048kbps Variable bit rate	64-2048kbps	64-2048kbps
Delay	20-50ms	50ms	300ms	No Delay Constraint

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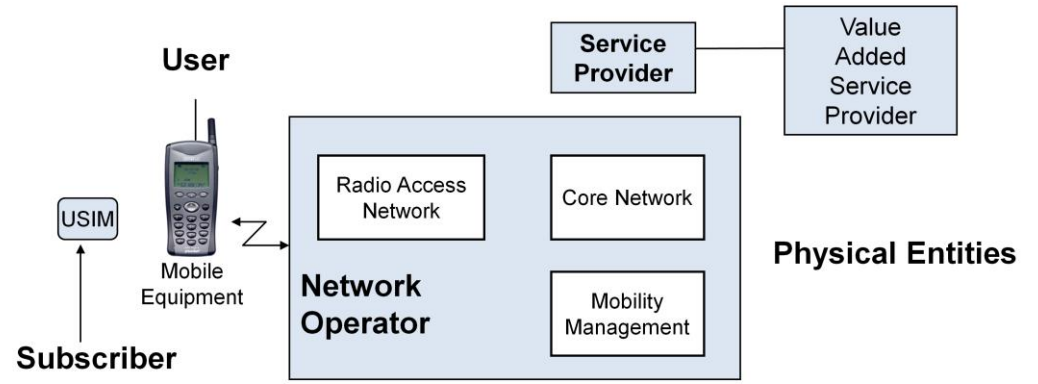
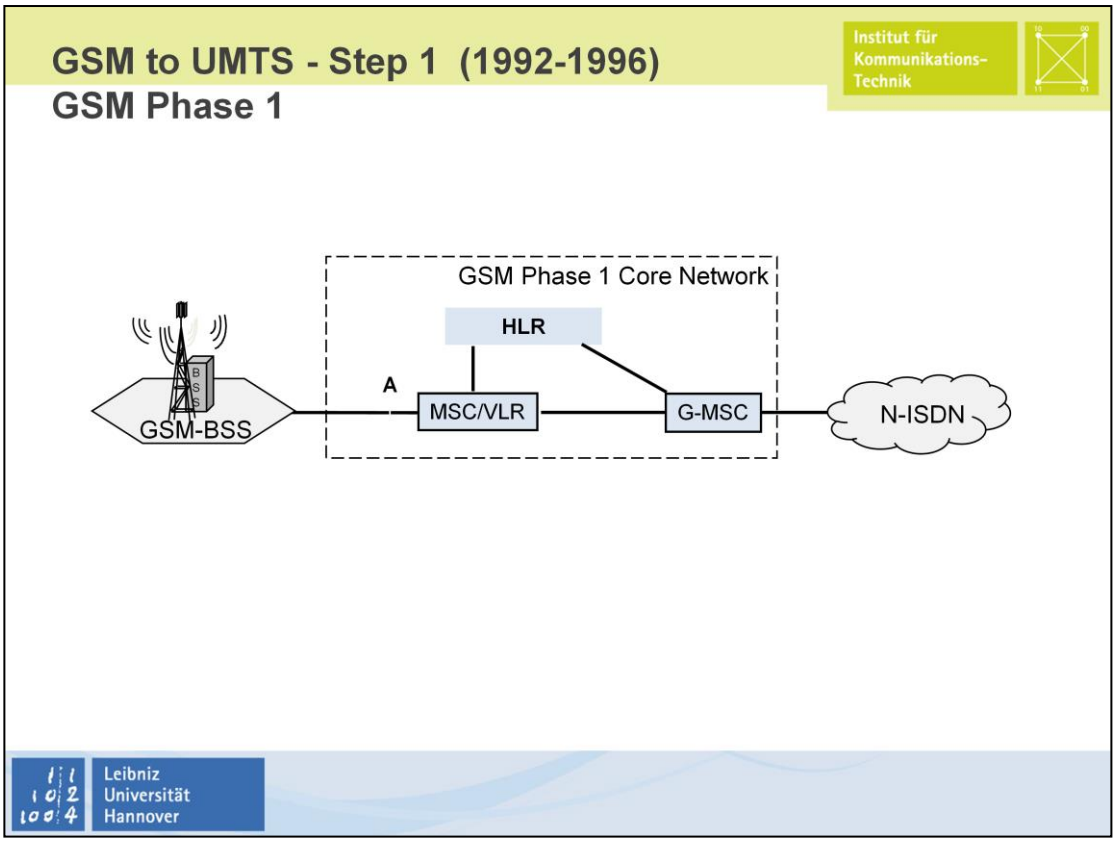
UMTS-Network architecture



targets:

- Network is able to support any radio access infrastructure
- Joint usage of the infrastructure, interfaces, protocols und procedures
- Logical separation of functions depending and not depending on the radio access infrastructure



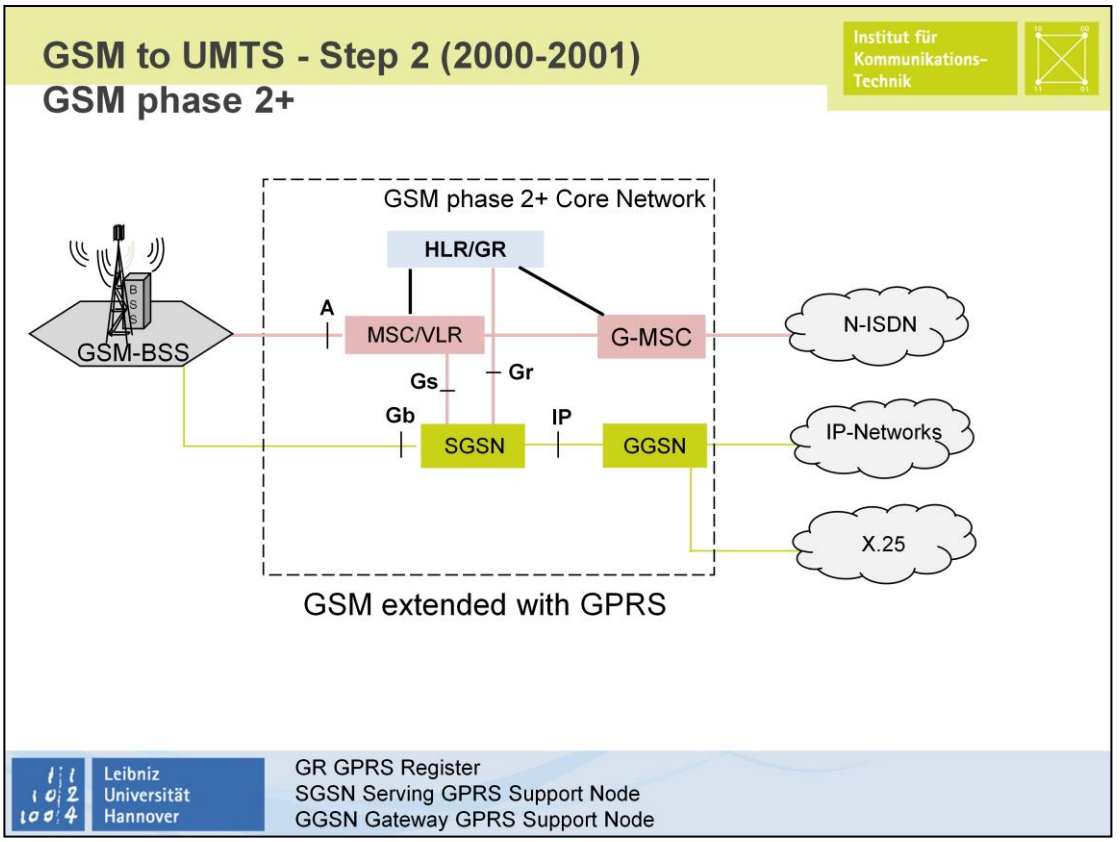
The GSM PLMN is subdivided into the following component:

A radio component called the Radio SubSystem RSS (= BSS + MS) A switching component called the Network Switching Subsystem (NSS) An operation and maintenance component called the Operation SubSystem (OSS)

The Network Switching Subsystem (NSS) consists of the following: Mobile Services Switching Center (MSC). An MSC represents the circuit-switched switching node of a GSM PLMN. It performs switching functions such as routing, signaling (with MS's, BSS, registers and other MSC's), processing of GSM features and collection of charging information. In addition it is also responsible for the Mobility Management (MM) of the MS's in its service area. An MSC with contact to external networks (ISDN, PSTN) is known as a gateway MSC (GMSC).

Home Location Register (HLR). An HLR is used for permanent storage of subscriber data (in so-called subscriber profiles). A number of temporary subscriber data types (e.g., current VLR identity) are also stored. Visitor Location Register (VLR). A VLR temporarily stores the subscriber profiles (requested by the HLR) of the MS's registered in the associated MSC service area. The VLR initiates authentication procedures, for example, for these MS's and saves their location areas. Authentication Center (AC). An AC saves confidential subscriber data and generates parameters for authentication and encryption.

Equipment Identication Center (EIR). An EIR saves the International Mobile Equipment Identity (IMEI) of the Mobile Equipment (ME). The EIR checks the ME and can block unapproved or stolen ME.

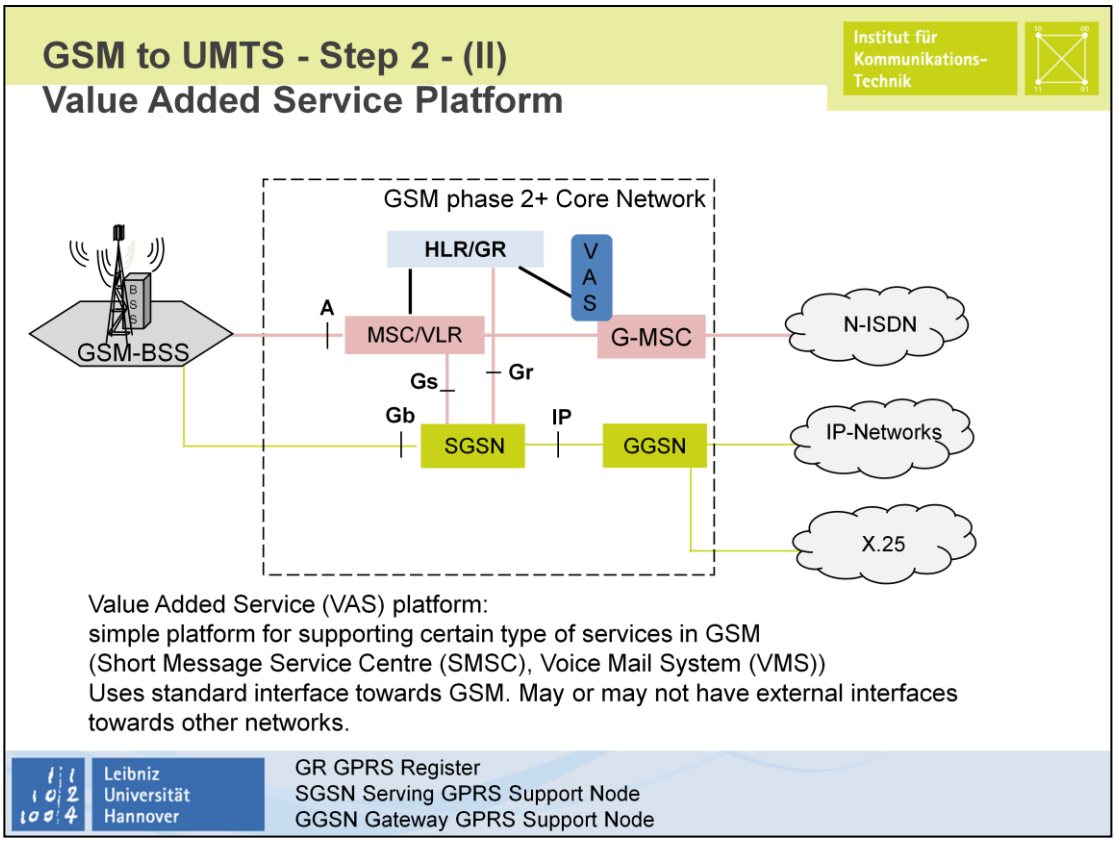


This phase specifies the extensions from pure GSM towards GSM and GPRS
GR GPRS Register: centralized database, containing customer data for GPRS users (comparable to the HLR for GSM subscribers)
SGSN Serving GPRS Support Node: Router with copied GR functionality (same relation as HLR/VLR)
GGSN Gateway GPRS Support Node: Router with Gatewayfunctionality The core extension of GSM for the introduction of UMTS is GPRS. The introduction of GPRS makes it possible to transfer packet-switched (PS) data in GSM. This is of great importance for UMTS because UMTS is optimized for PS data transfers.GPRS allows the following, among others:

Direct contact of a GSM PLMN to Packet Data Networks (PDN – e.g., Internet, intranets, X.25). This shortens erection times, reduces costs (for transfer networks) and enables PS data transfer at high data rates. High transmission rates (max. 171.2 kbit/s) also over the radio interface Um (bundling of 1 – 8 physical channels, new coding schemes: 9.05 / 13.4 / 15.6 / 21.4 kbit/s per physical channel). Optimized use of the transmission resources. This has particular relevance with regard to the very limited capacity of the radio interface. Reduced costs for subscribers (charging according to data volume instead of

connection time).
• Short Message Services (SMS) of unlimited length (until now: max. of 160 alphanumeric characters). New functional units must be provided to introduce GPRS:

- Gateway GPRS Support Node (GGSN). A GGSN is used as a gateway from a GSM PLMN to packet data networks. The GGSN converts protocols (external – internal), has routing functionality and can collect charging information and screen unwanted information.
- Serving GPRS Support Node (SGSN). An SGSN is the central exchange for PS data in GSM. It has the same hierarchical position as an MSC. An SGSN switches PS data (user data and signaling data), has routing functionality, is responsible for Mobility Management (MM) of the MS's in its service area, collects charging information, etc. (comparable functions to MSC's). In addition, SGSN's temporarily store the subscriber profiles and location information of the MS's (routing area / cell) of their service areas and coordinate the authentication activities (comparable functions to VLR's).



This phase specifies the extensions from pure GSM towards GSM and GPRS
GR GPRS Register: centralized database, containing customer data for GPRS users (comparable to the HLR for GSM subscribers)

SGSN Serving GPRS Support Node: Router with copied GR functionality (same relation as HLR/VLR)
GGSN Gateway GPRS Support Node: Router with Gatewayfunctionality The core extension of GSM for the introduction of UMTS is GPRS. The introduction of GPRS makes it possible to transfer packet-switched (PS) data in GSM. This is of great importance for UMTS because UMTS is optimized for PS data transfers.GPRS allows the following, among others:

Direct contact of a GSM PLMN to Packet Data Networks (PDN – e.g., Internet, intranets, X.25). This shortens erection times, reduces costs (for transfer networks) and enables PS data transfer at high data rates. High transmission rates (max. 171.2 kbit/s) also over the radio interface Um (bundling of 1 – 8 physical channels, new coding schemes: 9.05 / 13.4 / 15.6 / 21.4 kbit/s per physical channel). Optimized use of the transmission resources. This has particular relevance with regard to the very limited capacity of the radio interface. Reduced costs for subscribers (charging according to data volume instead of

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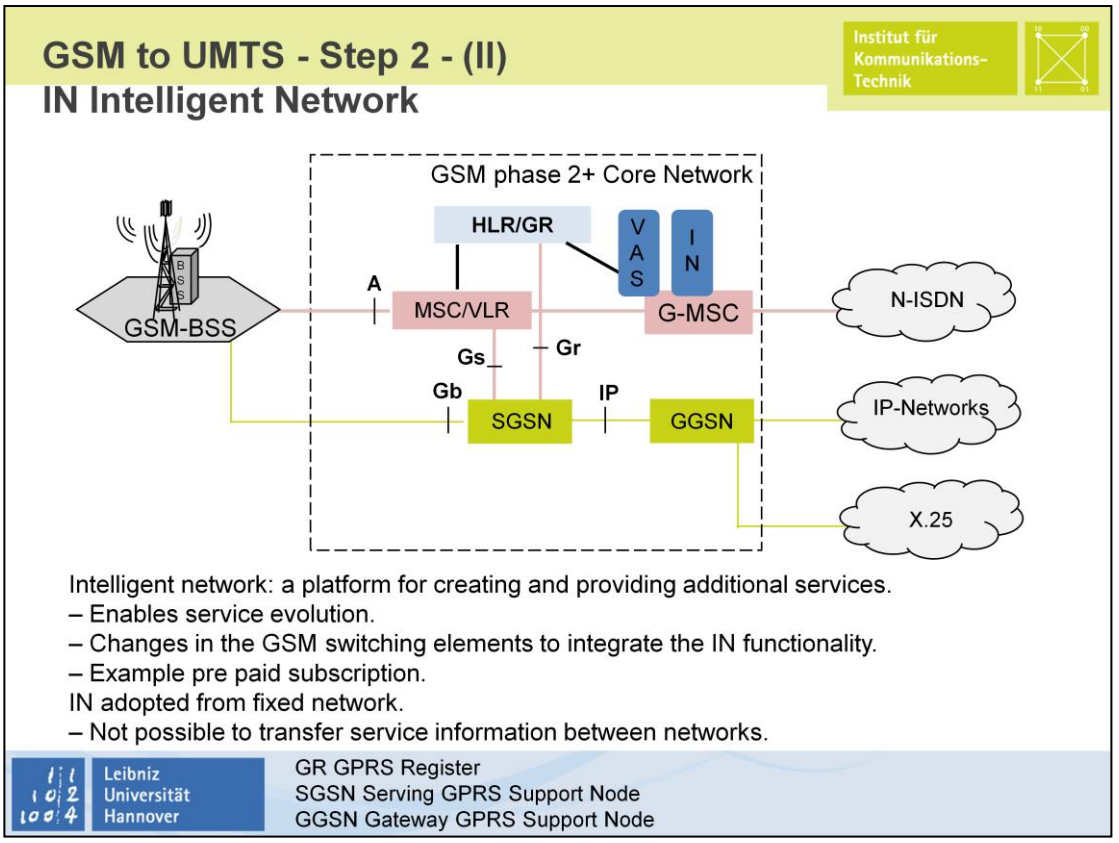

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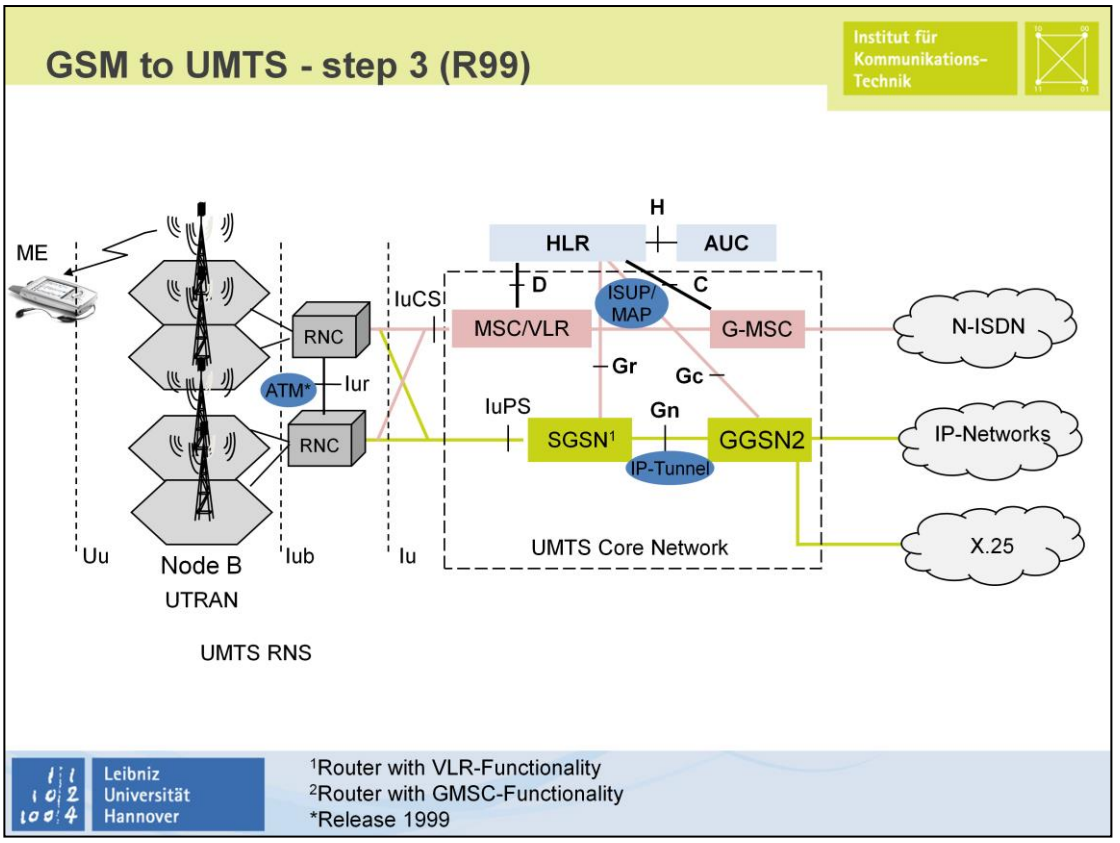


RNS: Radio Network System

RNC: Radio Network Controler

UTRAN: UMTS Terestrial Radio Access Network

UMTS CN: UMTS Core Network

SGSN Serving GPRS Support Node

GGSN Gateway GPRS Support Node

GMSC: Gateway Mobile Switching Centre

HLR: Home Location Register

VLR: Visitor Location Register

The UMTS PLMN as defined in UMTS Rel. '99 consists of the following:

Core Network functional units from GSM Phases 1/2 (MSC, VLR, HLR, AC, EIR) GPRS functional units (GGSN & SGSN), CAMEL functional units: CSE (gsmSSF & gsmSCF)

The radio component, UMTS Terrestrial Radio Access Network (UTRAN).

UMTS-Specific Extensions / Modifications

The Core Network (CN) needs only minor modifications to introduce UMTS. A number of protocols need to be extended, for example, to enable transfer of the new UMTS subscriber profiles. In a similar manner, the corresponding registers have to be extended in order to save the data. Another modification is the relocation of the transcoding TC function (for speech compression) in the CN. The TC function is needed together with an interworking function (IWF) for protocol conversion between the A and Iu interfaces.

The main differences between GSM (Phase 2+) and UMTS are due to the new principles of radio transmission (WCDMA instead of FDMA/TDMA). UTRAN, as the radio transmission component of UMTS, is therefore the main modification. UTRAN is connected to the Core Network (CN) via the Iu interface. Circuit-switched data is transferred by UTRAN via the Iu(CS) interface to the MSC/VLR, while packet-switched data is transferred via Iu(PS) to the SGSN.

The UTRAN network elements are as follows:

Radio Network Controller (RNC). UTRAN is divided into individual areas known as Radio Network Systems (RNS). Each RNS, to which a flexibly definable number of UMTS cells belong, is controlled by a RNC. An RNC is a central unit for switching data in UTRAN and for formatting the data for transport over the UMTS radio interface. An RNC is also solely responsible (independent from the CN) for all radio-based decisions: autonomous Radio Resource Management (RRM). The functionality of an RNC is comparable with that of a GSM BSC. However, its functions are designed for greater autonomy and are adapted for compliance with the new radio interface.

Node B. One or more Node B's are controlled and addressed by an RNC. A Node B is a physical unit for implementation of the UMTS radio interface. As a central transmission and reception site, it serves one or more UMTS cells (an omni cell with 360° service or, for example, 2, 3 or 6 sector cells with 180°, 120° and 60° service respectively).

The UTRAN interfaces are as follows:

Uu interface: The Uu interface provides the UMTS radio interface and connects Node B with the UMTS user equipment (UE). Iu interface: The Iu interface connects an RNC with the CN – i.e., with the MSC/VLR and SGSN.

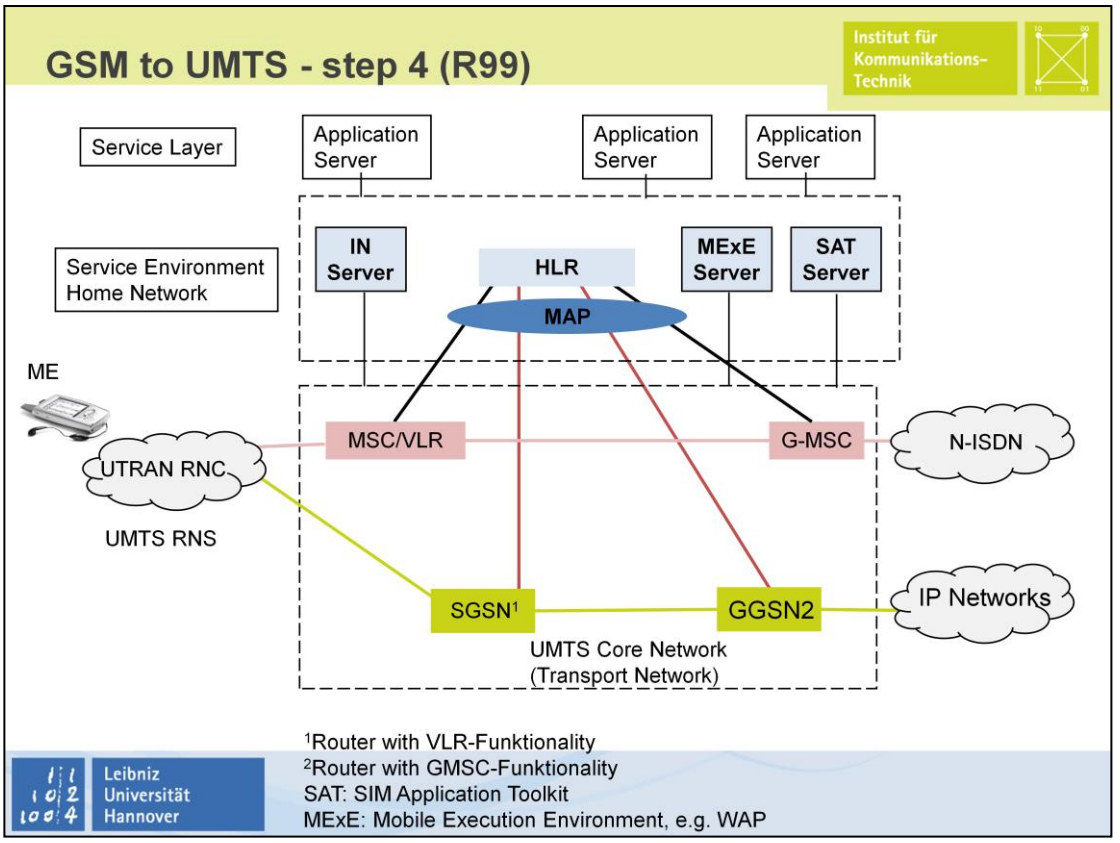
Iub interface: Connects an RNC with the Node B's that it controls.

Iur interface: Connects different RNC's together. It has no equivalent in GSM and

is due to a handover method (known as soft handover) not typical in GSM.

Uu, Iu, Iub and Iur are open interfaces – i.e., specified in the UMTS

Recommendations. They use different transmission methods from GSM.



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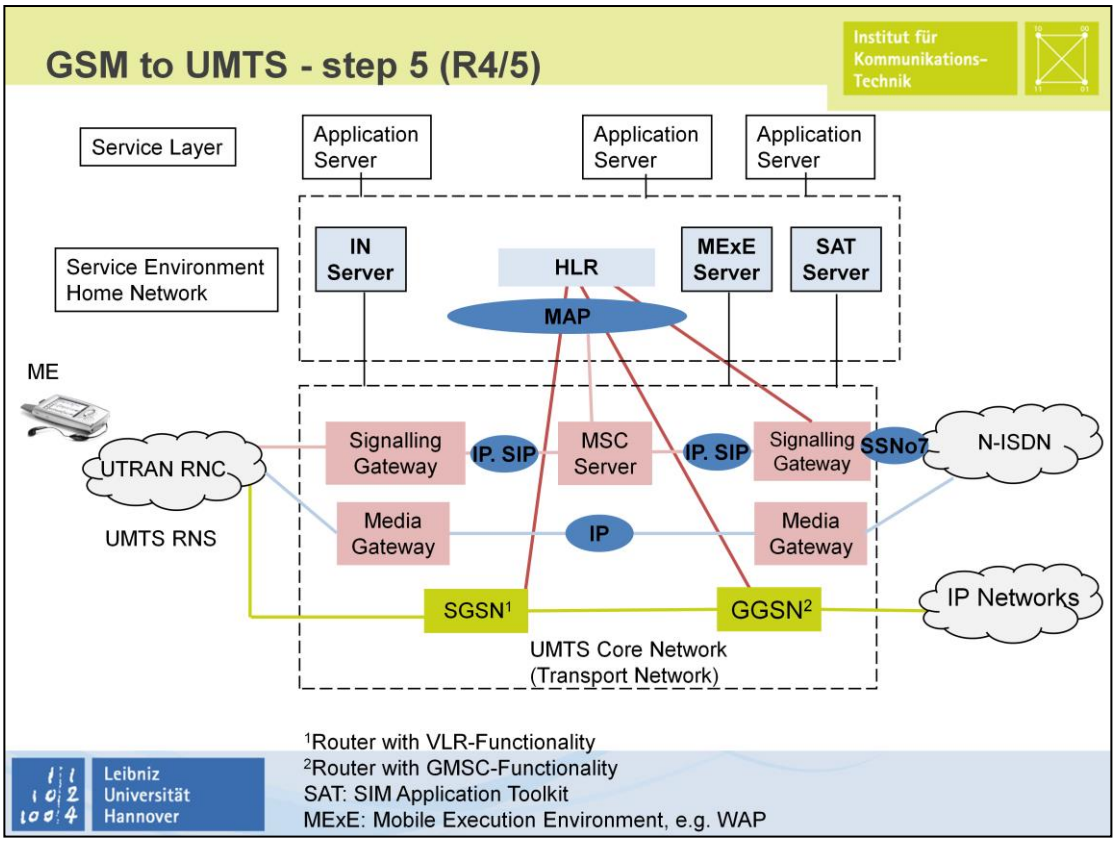
HLR: Home Location Register

VLR: Visitor Location Register

WAP: Wireless Application Protocol



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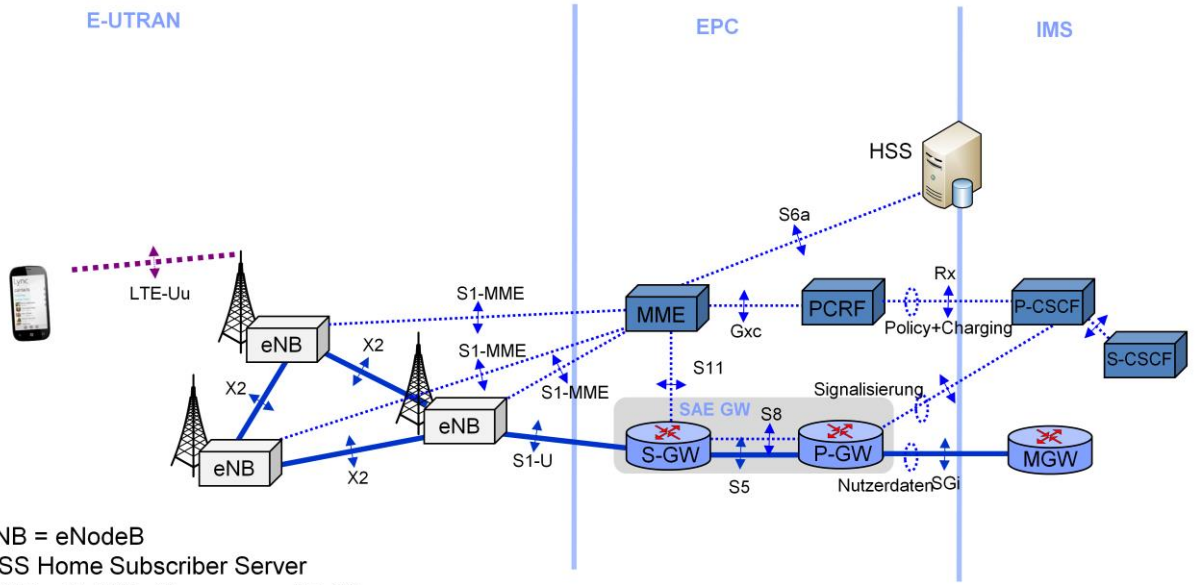
LTE und EPC System Overview

Institut für Kommunikations-Technik



eNB = eNodeB
HSS Home Subscriber Server
MME = Mobility Management Enitity
PCRF = Policy and Charging Rule Function
S-GW Serving Gateway

HSS Home Subscribe Server: HLR, Authentication, Authorisation, Accounting

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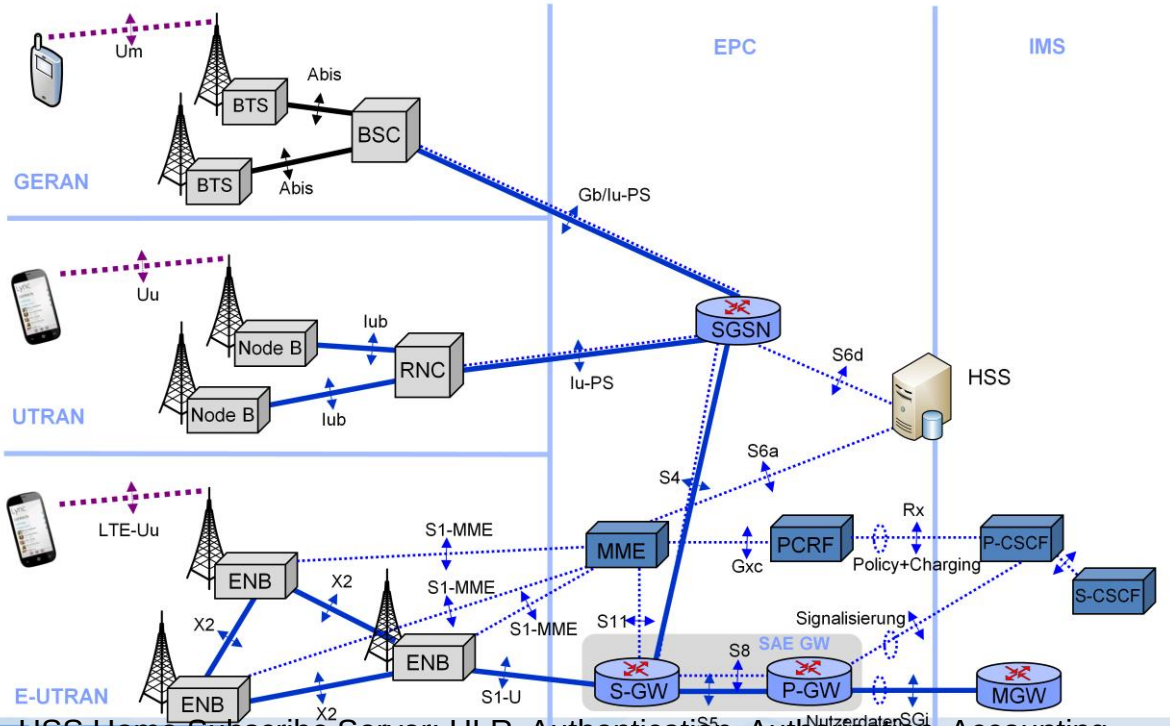
System architecture with mixed 3GPP-Networks



HSS Home Subscribe Server: HLR, Authentication, Authorisation, Accounting

Outline

Institut für Kommunikations-Technik

1. GSM to UMTS
2. History and Milestones
3. 3GPP
4. Standardisation
5. Licenses and Frequencies
6. GSM-UMTS Evolution
7. Overview Infrastructure
8. Further Concepts

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Bearer Concept

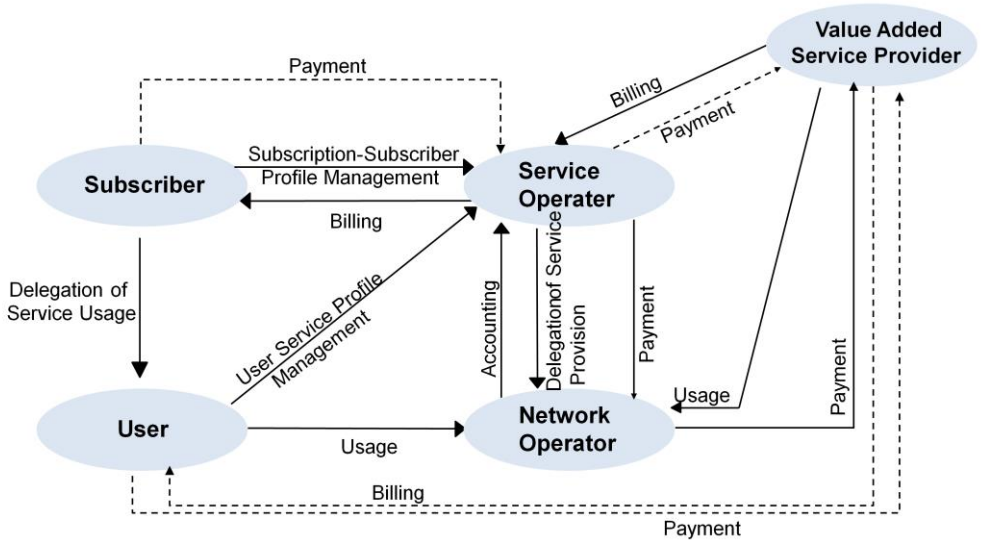
Bearer

- a bearer capability of defined capacity, delay and bit error rate etc. (as defined in the 3GPP specs)

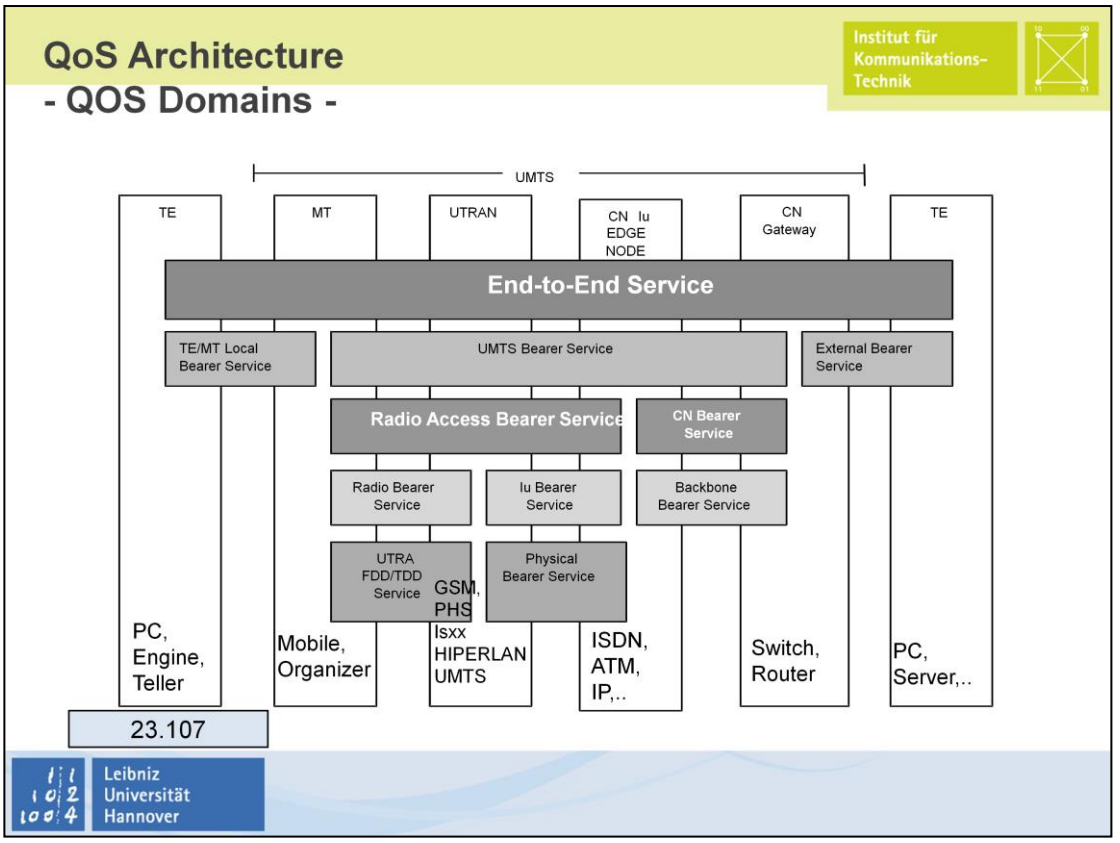
Bearer is a flexible concept designating a kind of "bit pipe"

- at a certain network level
- between certain network entities
- with certain QoS attributes and capacity

Services in UMTS



What is the difference between accounting, billing and payment?



Vier verschieden QoS-Klassen (or traffic classes):

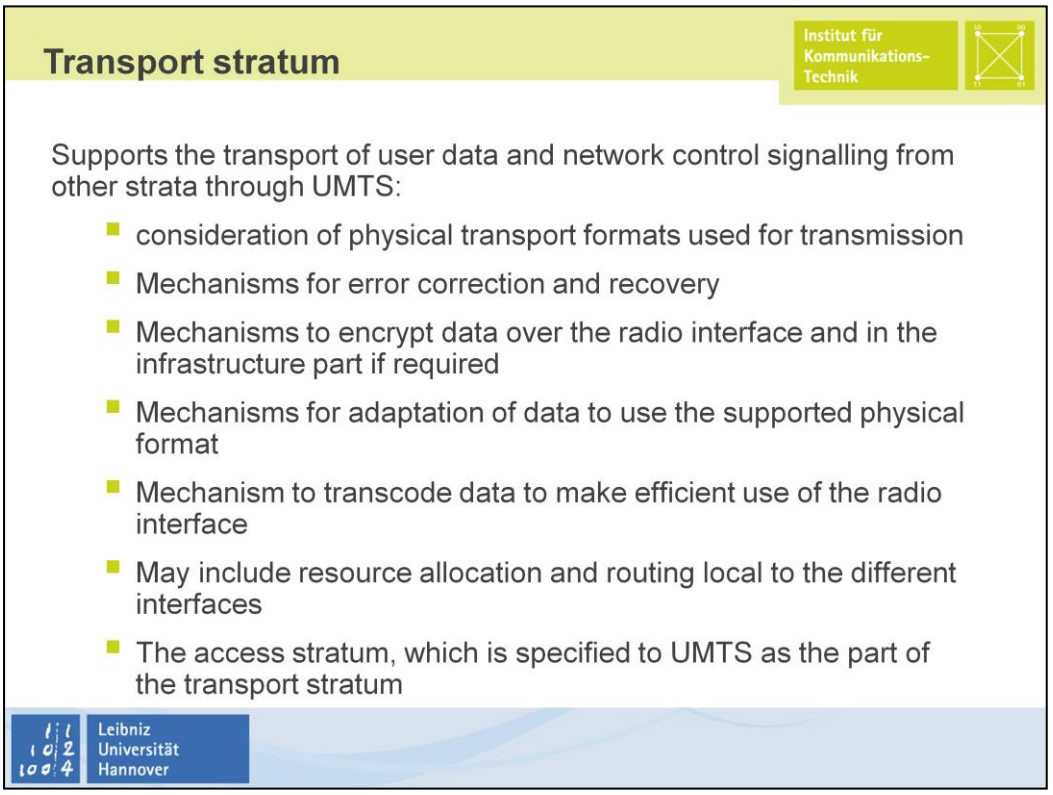
- conversational class;
- streaming class;
- interactive class und
- background class.

Stratum Concept

Stratum: Group of protocol parts used for the same service (several OSI layers are used)

UMTS Strata

- Transport (Error Correction, Ciphering, Coding, Ressourcen Allocation, Access Stratum)
- Serving (End-to-End Service, USIM-Mobile Termination)
- Home (functions to handle subscriber data)
- Application



Access stratum

Consists of User Equipment (UE) and infrastructure parts, as well as access-technique specific protocols between these parts.

Provides services related to the transmission of data over the radio interface and the management of the radio interface to the other parts of UMTS.

The access stratum includes the following protocols:

Mobile termination - Access network (MT- AN) protocol supporting transfer of detailed radio- related information to coordinate the use of radio resources between MR and AN.

Access network - Serving Network (AN - SN) protocol supporting the access from the SN to the resources provided by the AN. It is independent of the specific radio structure of the AN.

Serving stratum

Consists of protocols and functions to route and transmit user of network generated data/ information form source to destination. The source and destination may be within the same of different networks. It contains functions related to telecommunication services, and includes:

USIM - Mobile termination (USIM - MT) protocol supporting access to subscriber- specific information to allow functions in the user equipment domain.

Mobile Termination - Serving Network (MT -SN) protocol supporting access from MT to the services provided by the serving network domain.

Terminal Equipment - Mobile Termination (TE -MT) protocol supporting exchange of control information between the TE and the MT.

Home stratum

Consists of protocols and functions related to the handling and storage of subscription data and possibly home network specific services.

Functions to allow domains other than the home network domain to act on behalf of the home network.

Functions related to subscription data management and customer care, as well as billing and charging, mobility management and authentication.

The home stratum include the following protocols:

USIM - Home Network (USIM - HN) protocol supporting co- ordination of subscriber- specific information between USIM and HN.

USIM - Mobile Termination (USIM - MT) protocol providing the MT with access to user specific data and resources necessary to perform actions on behalf of the home network.

Mobile Termination - Serving Network (MT - SN) protocol supporting user specific data exchange between the MT and the SN.

Serving Network - Home Network (SN - HN) protocol providing the SN with access to HN data and resources necessary to perform its actions on behalf of the HN.

Transport stratum

It represents the application process itself, provided to the end user.

It includes end- to- end protocols and functions making use of services provided by the home, serving, and transport strata and necessary infrastructure supporting services and/ or value added services.

The functions and protocols within the application stratum may adhere to GSM/ UMTS standards or may be outside the scope of the UMTS standards.

End- to- end functions are applications consumed by users at the edge of/ outside the overall network.

Authentication and authorised users may access the applications by using any variety of available user equipment.

A
AAL ATM Adaptation Layer
AC Authentication Center
ACCH Associated Control CHannel
ACE Antenna Coupling Equipment
ADC Analog to Digital Converter
AGCH Access Grant CHannel
AMR Adaptive MultiRate speech
AMX ATM MultipleXer
AMPS Advanced Mobile Phone Services
ANSI American National Standards Institute (USA)
AP Application Part
ARFCN Absolute Radio Frequency Channel Number
ARIB Association of Radio Industries and Business (Japan)
ARQ Automatic Repeat reQuest
ASCI Advanced Speech Call Items
ASN ATM Switching Network
ATM Asynchronous Transfer Mode
AUC AUthentication Center
B
BA BCCH Allocation
BCC Base transceiver station Color Code
BCCH Broadcast Control CHannel
BCH Broadcast Channel
BER Bit Error Rate
BMC Broadcast / Multicast Control
BPSK Binary Phase Shift Keying
BS Base Station
BSC Base Station Controller
BSIC Base transceiver Station Identity Code
BSS Base Station System
BSSAP Base Station System Application Part
BSSMAP Base Station System Management Application Part
BTS Base Transceiver Station BS Sende-/Empfangsstation
C
CA Cell Allocation
CAMEL Customized Applications for Mobile network Enhanced Logic
CAP CAMEL Application Part
CATT China Academy of Telecommunication Technology (China)
CC Call Control
CC Country Code
CCH Control Channel
CCITT Comité Consulatif International Téléphonique et Télégraphique
CCS7 Common Channel signaling System No. 7
CCU Channel Coding Unit
CDMA Code Division Multiple Access
CEPT Conference Europèene des Postes et Telecommunication
CGI Cell Global Identity
CI Cell Identity
CN Core Network
CP Call Processing
CS Coding Scheme
CUG Closed User Group
D
D-AMPS Digital AMPS
DCS1800 Digital Cellular System in the 1800 MHz band
DECT Digital Enhanced Cordless Telephone
DL Down Link
DRNS Drift RNS
DRX Discontinuous ReceptionDS-CDMA Direct Sequence CDMA
DTAP Direct Transfer Application Part
DTX Discontinuous Transmission

E
EFR Enhanced Full Rate speech
EIR Equipment Identification Register
ERC European Radiocommunication Committee
ERMES European Radio MEssage System
ESA European Space Agency
ETSI European Telecommunications Standard Institute

F
FAC Final Assembly Code
FACCH Fast Associated Control Channel
FB Frequency correction Burst
FCCH Frequency Correction Channel
FDD Frequency Division Duplex
FDMA Frequency Division Multiple Access
FEC Forward Error Correction
FN Frame Number
FPLMTS Future Public Land Mobile Telecommunication System
FR Frame Relay
FR Full Rate speech
FRAMES Future RAdio wideband MultiplE access Systems

G
GGSN Gateway GPRS Support Node
GMM Global Multimedia Mobility
GMPCS Global Mobile Personal Communication Systems
GMSC Gateway MSC
GMSK Gaussian Minimum Shift Keying
GP Guard Period
GPRS General Packet Radio Service
GSM Global System for Mobile communications
GTP GPRS Tunneling Protocol

H
HCS Hierarchical Cellular Structures
HLR Home Location Register
HO(V) HandOver
HPLMN Home PLMN
HSCSD High Speed Circuit Switched Data

I
IAM Initial Address Message
ICO Intermediate Circular Orbits
ID Identification
ID Identity
IMEI International Mobile Equipment Identity
IMSI International Mobile Subscriber Identity
IMT-2000 International Mobile Telecommunications-2000
IN Intelligent Network
Inmarsat INternational MARitime SATellite
IP Internet Protocol
ITU International Telecommunication Union
IP Internet Protocol
IP Intelligent Peripheral
ISDN Integrated Services Digital Network
ISP Internet Service Provider
ISUP ISDN User Part
IWE InterWorking Equipment
IWF InterWorking Function
IWUP InterWorking User Part

J
JD Joint Detection
JDC Japanese Digital Cellular

K
Kc cipher Key
Ki individual subscriber authentication Key

L
LA Location Area
LAI Location Area Identity
LAN Local Area Network
LAPDm Link Access Protocol on the Dm channel
LEO Low Earth Orbital
LES Land Earth Station
LIC Line Interface Circuit
LMT Local Maintenance Terminal
LR Location Register

M
MAC Medium Access Control
MAP Mobile Application Part
MARISAT MARItime SATellite
MBS Mobile Broadband System
MCC Mobile Country Code
ME Mobile Equipment
MExE Mobile station application Execution Environment
MM Mobility Management
MMI Man Machine Interface
MML Man Machine Language
MNC Mobile Network Code
MOC Mobile Originating Call
MS Mobile Station
MSC Mobile services Switching Center
MSISDN Mobile Station international ISDN number
MSP Multiple Subscriber Profile
MSRN Mobile Station Roaming Number
MSS Mobile Satellite Systems
MT Mobile Termination
MTP Message Transfer Part
MTC Mobile Termination Call
MTP Message Transfer Part
MUX MultipleXer

N
NB Normal Burst
NBAP Node B Application Part
NCC Network Color Code (PLMN color code)
NDC National Destination Code
NMT Nordic Mobile Telephone
NSS Network Switching Subsystem

O
O&M Operation and Maintenance
OACSU Off Air Call Set Up
ODMA Opportunity Driven Multiple Access
OFDMA Orthogonal Frequency Division Multiple Access
OMC Operation & Maintenance Center
OMC-B Operation & Maintenance Center for BSS
OMC-S Operation & Maintenance center for SSS
OSS Operation SubSystem
OVSF Orthogonal Variable Spreading Factor codes

P
PA Power Amplifier
PACS Personal Access Communication System
PC Power Control
PCM Pulse Code Modulation
PCU Packet Control Unit
PDA Personal Data Assistant
PDC Personal Digital Cellular (Japan)
PDCP Packet Data Convergence Protocol
PDN Packet Data Network
PHS Personal Handy System (Japan)
PIN Personal Identification Number
PLMN Public Land Mobile Network
PMR Private Mobile Radio
PP Point-to-Point
PSTN Public Switched Telephone Network

Q
QOS Quality Of Service
QPSK Quaternary Phase Shift Keying

R
RA Rate Adaptation
RACH Random Access Channel
RANAP Radio Access Network Application Part
RAND RANDom number
REQ REQuest
RES RESponse
RF Radio Frequency
RFC Radio Frequency Channel
RFCH Radio Frequency CHannel
RFCN Radio Frequency Channel Number
RLC Radio Link Control
RNC Radio Network Controller
RNS Radio Network Subsystem
RNSAP Radio Network Subsystem Application Part
RRC Radio Resource Control
RRM Radio Resource Management
RSS Radio SubSystem
RX / Rx Receiver

S
SACCH Slow Associated Control Channel
SAP Service Access Point
SAPI Service Access Point Indicator
SB Synchronization Burst
SCCP Signaling Connection Control Part
SCE Service Creation Environment
SCH Synchronization CHannel
SDCCH Stand- alone Dedicated Control CHannel
SF Spreading Factor
SFH Slow Frequency Hopping
SGSN Service GPRS Support Node
SIM Subscriber Identity Module
SM Security Management
SMG Special Mobile Group
SMP Service Management Point
SMS Short Message Service
SN Subscriber Number
SN Switching Network
SP Signaling Point
SP Switching Point
SS Supplementary Services
SSF Service Switching Function
SSP Service Switching Point
STP Signaling Transfer Point

T
T1 Standards Committee T1 Telecommunications
TA Terminal Adapter
TAC Type Approval Code
TACS Total Access Communication System
TB Tail Bit
TCAP Transaction CApability Part
TCH Traffic Channel
TCP Transmission Control Protocol
TD-CDMA Time Division CDMA
TDD Time Division Duplex
TDMA Time Division Multiple Access
TE Terminal Equipment
TETRA TErrestrial Trunked Radio Access
THSS Time-Hopping Spread Spectrum
TIA Telecommunication Industry Association
TMN Telecommunication Management Network
TMSI Temporary Mobile Subscriber Identity
TRAU Transcending and Rate Adaptation Unit
TRX Transceiver
TS Tele ServiceTS TimeSlot
TTA Telecommunications TechnologyAssociation (South Korea)
TTC Telecommunication Technology Committee (Japan)
TX / Tx Transmitter

U
UDP User Datagram Protocol
UE User Equipment
UL UpLink
UMTS Universal Mobile Telecommunications System
UP User Part
USIM UMTS Subscriber Identity Module
UTRA UMTS Terrestrial Radio Access
UTRAN UMTS Terrestrial Radio Access Network
UWC-136 Universal Wireless Communication

V
VAD Voice Activity Detection
VBR Variable Bit Rate
VBS Voice Broadcast Service
VHE Virtual Home Environment
VLR Visited (visitor) Location Register
VMSC Visited MSC
VoIP Voice over Internet Protocol
VPLMN Visited PLMN

W
WAN Wide Area Network
WAP Wireless Application Protocol
WARC World Administrative Radio Conference
W-CDMA Wideband CDMA
WLL Wireless Local Loop