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Foreword

This ETSI Technical Report (ETR) has been produced by the Special Mobile Group (SMG) Technical Committee of the European Telecommunications Standards Institute (ETSI).

This ETR presents scenarios for the introduction of the Universal Mobile Telecommunications System (UMTS) and highlights the various aspects of evolution towards UMTS including techno-economics, marketing, regulation and licensing.

This ETR corresponds to SMG specification UMTS 01.04 version 3.0.0

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status.

The Universal Mobile Telecommunications System (UMTS) is a third generation mobile telecommunications system which will provide a wide range of mobile telecommunications services in a variety of environments. It is expected that UMTS operations will start in Europe after year 2000.

Introduction

The third generation mobile communications systems will be introduced in the early years of the 21st century. They will consist of radio interfaces, supporting infrastructure and connections to networks. In this frame, the third generation systems are likely to evolve from existing (also called pre-UMTS) mobile systems and at the same time integrate new system components and concepts. The form of the evolution will be strongly influenced by market considerations. UMTS should be standardised by a managed evolution process starting from GSM and N/B-ISDN, using a generic access part.

At the time of introduction of UMTS, several networks of different degrees of sophistication will exist. The pre-UMTS mobile systems will have a large user base near year 2000. Intelligent Network (IN) technology will have been deployed in the fixed networks and will also have a role in the mobile networks. Pre-UMTS mobile satellite systems will be in service. Massive investments have been made to the different networks. Hence, evolutionary scenarios are an intrinsic part of the work on the UMTS system framework.

Since the start of the UMTS/FPLMTS discussions, the intention has been to provide a standard for a world-wide personal mobile phone, giving the mass market mobile communications with quality equivalent to wireline service and access to a very extensive set of features. Ever since the early days of UMTS/FPLMTS discussions, deployment of pre-UMTS systems have been an enormous success. he growth rate is still very rapid. Considering this growth rate, the number of users of pre-UMTS technologies world-wide will be in the order of several hundred million users by the scheduled introduction of UMTS. Considering this recent development UMTS should primarily be positioned as a wideband extension for existing network platforms and should be integrated with these. Scenarios and considerations for this are presented in this ETR.

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1 Scope

This ETSI Technical Report (ETR) presents scenarios for the introduction of the Universal Mobile Telecommunications System (UMTS) and highlights the various aspects of evolution towards UMTS including techno-economics, marketing, regulation and licensing. These are considered from the user, subscriber, service provider, network operator, regulator and equipment manufacturer points of view.

The objective of this ETR is to identify those issues and considerations that must be addressed in order to facilitate the introduction of UMTS including evolution of pre-UMTS terrestrial and satellite systems to UMTS. This ETR is to provide guidance to the production of the UMTS standards and it can be used for co-ordination with other groups.

2 References

This ETR incorporates by dated or undated references, provisions from other publications. These references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of the publications apply to this ETR only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ETR 309 (UMTS 01.02): " Special Mobile Group (SMG): Vocabulary for Universal Mobile Telecommunications System (UMTS)"

[2] Communication on the Green Paper on Mobile and Personal Communications. Commission of the European Communities.

[3] ETR 271 (UMTS 01.01): "Special Mobile Group (SMG): Universal Mobile Telecommunications System (UMTS); Objectives and Overview".

[4] ETR 291 (UMTS 01.03): " Special Mobile Group (SMG): Universal Mobile Telecommunications System (UMTS); System Requirements".

[5] DTR/SMG-050301U (UMTS 03.01):" Special Mobile Group (SMG): (UMTS); Framework of network requirements, interworking and integration for the Universal Mobile Telecommunications System (UMTS).

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[7] ITU-R, TG 8/1: Draft report on evolution and migration to FPLMTS/IMT-2000

[8] Final report of the ETSI EPII (European Project on Information Infrastructure) Starter Group, March 1996

[9] UMTS Task Force Report.

[10] ETSI PAC EG5 Report: “Global Multimedia Mobility (GMM) A Standardization framework”.

[11] TCR-TR 015:”Special Mobile Group (SMG); Work programme for the standardization of the Universal Mobile Telecommunications System (UMTS)

[12] ETSI TC SMG: ”Technical input to ERC/ERO study on Universal Mobile Telecommunications System (UMTS) frequencies

3 Abbreviations and definitions

For the purposes of this ETR the following abbreviations and definitions apply. ~~More~~ Abbreviations and definitions can be found in the Vocabulary for UMTS [1] .

3.1 Abbreviations

For the purposes of this ETR the following abbreviations apply.

AAL	ATM Adaptation Layer
AC	Authentication Centre
ASCI	Advanced Speech Call items
ATM	Asynchronous Transfer Mode
BCUSM	Basic Call Unrelated State Machine
B-ISDN	Broadband Integrated Services Digital Network
BNCSM	Basic Non Call State Machine
BRA	Basic Rate Access
BSC	Base Station Controller
BSS	Base Station System
BTC	Business Telecommunications Committee
BTS	Base Transceiver Station
CAP	DECT CTM Access Profile
CAMEL	Customised Applications for Mobile network Enhanced Logic
CCAF	Call Control Agent Function
CCF	Call Control Function
CCFP	Central Control Fixed Part
CEC	Commission of the European Communities
CFNR	Call Forwarding on Not Reachable
CS-x	Capability Set x
CLIR	Calling Line Identification Restriction
COLR	Connected Line Identification Restriction
CPN	Customer Premises Network
CT2	Cordless Telephony 2
CTM	Cordless Terminal Mobility
CUSF	Call Unrelated Service Function
DAM	DECT Authentication Module
D-AMPS	Digital Advanced Mobile Phone System
DECT	Digital Enhanced Cordless Telecommunications
DCS1800	Digital Cellular System on 1800 MHz band
ECU	European Currency Unit
EFR	Enhanced Full Rate Codec
EII	European Information Infrastructure
EIISG	EII Study Group
EIR	Equipment Identity Register
ERC	European Radio Committee
ERMES	European Radio Messaging System
ERO	European Radio Office
ETR	ETSI Technical Report
EU	European Union
FDD	Frequency Division Duplex
FP	(DECT) Fixed Part
GAP	DECT Generic Access Profile
GIP	DECT-GSM Inter-working Profile
GPRS	General Packet Radio Services
GSM	Global System for Mobile communications
HIPERLAN	High Performance Radio Local Area Network
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data
IC	Intelligent Card
IMT	International Mobile Telecommunications (IMT-2000 equals FPLMTS)
IN	Intelligent Network
INAP	Intelligent Network Application Protocol
ITU-R	International Telecommunication Union, Radio Sector

ITU-T	International Telecommunication Union, Telecommunication Sector
IWF	Interworking Function
LAN	Local Area Network
LE	Local Exchange
MAP	Mobile Application Part
ME	Mobile Equipment
MES	Mobile Earth Station
MS	Mobile Station
MSC	Mobile Service and Switching Centre
MSS	Mobile Satellite System
NA	(ETSI TC) Network Aspects
N-ISDN	Narrowband Integrated Services Digital Network
ONP	Open Network Provision
OSI	Open Systems Interconnection
PBX	Private Branch Exchange
PCMCIA	Personal Computer Memory Card Industry Association
PCS	Personal Communications System
PDC	Personal Digital Cellular System
PHS	Personal Handy Phone System
PP	(DECT) Portable Part
PRA	Primary Rate Access
PSTN	Public Switched Telephone Network
PTN	Private Telecommunication Network
RAP	DECT Radio Local Loop Access Profile
RFP	(DECT) Radio Fixed Part
RLL	Radio in the Local Loop
RLP	Radio Link Protocol
RP	Radio Part
SCP	Service Control Point
SCUAF	Service Control User Agent Function
SDP	Service Data Point
SES	Satellite Earth Station
SIM	Subscriber Identity Module
SMG	Special Mobile Group
SMSC	Short Message Service Centre
S-PCN	Satellite Personal Communications Network
SSF	Service Switching Function
STC	(ETSI) Sub Technical Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
TE	Terminal Equipment
TETRA	Trans European Trunked Radio
TINA	Telecommunication Information Networking Architecture
TMN	Telecommunications Management Network
UIM	UMTS Identity Module
UMTS	Universal Mobile Telecommunications System
UPT	Universal Personal Telecommunications
WARC	World Administrative Radio Conference (now: WRC)
VHE	Virtual Home Environment
VLR	Visitor Location Register
WRC	World Radio Conference (previously WARC)

3.2 Definitions

For the purposes of this ETR the following definitions apply.

Adaptivity of terminals: A concept which offers adaptation to a variety of radio interfaces and service related coding schemes.

Evolution towards UMTS: A process of change and development of a telecommunications system towards the capabilities and functionality's of UMTS.

Generic Access Network: A revolutionary UMTS radio access subnetwork, capable of being integrated with mobile as well as fixed transport network infrastructure and capable of supporting all UMTS Service capabilities.

Migration to UMTS: Movement of users and/or service delivery from existing telecommunications systems to UMTS.

Pre-UMTS: A system introduced before the introduction of UMTS (not defined by UMTS standards).

Virtual Home Environment (VHE): A system concept for personalized service portability across network borders.

4 Assumptions for telecommunications in year 2000-2005

4.1 General

Europe is turning mobile and cordless, changing habits and creating new needs for services. It can hence be expected that the personal and business use of mobile services will significantly exceed today's level in the years 2000-2005. In some regions, almost all the population may be mobile or cordless in some of their user roles. Therefore, technical limitations that limit the possible penetration level should not be made.

Service provision after year 1998 will, due to potential European Union (EU) regulations, be network and technology independent, including no strict division between mobile and fixed networks. This implies a leap forward towards service integration and personal telephony, as far as service provision is concerned. UMTS will be the first system that includes (and supersedes) the wide range of features previously found in a multiplicity of fixed, cordless, mobile and satellite systems. UMTS will as such an integrated system be in a pole position in the Common Market around the year 2000, if the introduction can be managed on a base of existing infrastructure investments.

Speech services only can not be expected to motivate a new wireless wideband system as UMTS, although it may be the dominating service for the mobile communications market as a whole. Pre-UMTS mobile and cordless systems can fulfil significant portions of the anticipated user needs at the time of UMTS introduction, even if these systems were not originally designed to manage broadband service capabilities.

In areas with older telecommunications infrastructure, the migration concept is expected to be a cost efficient way to provide speech, data and mobility services, as well as service integration.

The business sector is likely to push for wideband services in office and certain public environments, with computer LAN access, video and multimedia as very demanding and driving applications. This also opens up for wideband entertainment services outside of office hours.

Widespread use of computing in the home will provide a hardware base for teleworking and entertainment.

One major characterisation of UMTS is integration of fixed and mobile services and flexible service provision.

Pre-UMTS systems will evolve to provide new advanced capabilities and services. Even so, there is likely to be a need for a new generation wireless wideband system with e.g. the following characteristics: video, multimedia, flexible service provision, around 128 kbits/s for wide area, universal coverage and up to 2 Mbits/s for local area coverage.

Market-driven definition of UMTS should be driven by service aspects. The commercial viability of UMTS relies on the take-up of the services it supports. In the following sections, services in different pre-UMTS systems in year 2000-2005 will be considered.

4.2 Assumptions for services in fixed networks

Public Switched Telephone Network (PSTN) and Narrowband Integrated Services Digital Network (N-ISDN) are, and will be, wide-spread fixed networks for low and moderate bitrate services. Except for speech, fax and general cost-cut domestic use, these systems are limited with regard to introducing new services, in the period of 2000-2005. N-ISDN has gained popularity, and appreciated new services as Internet, video and multi-media are heightening the users' expectations on what telecommunications can do for them.

Universal Personal Telecommunications (UPT) and cordless access add personal and terminal mobility to fixed networks. The standards for the Intelligent Network (IN) Capability Sets will enable enhanced service concepts.

Digital Enhanced Cordless Telecommunications (DECT) access to N-ISDN and PSTNs will form one of the two main platforms for the evolution towards UMTS.

B-ISDN (based on ATM) will be publicly available in developed regions, especially in the business sector. UMTS can be used as an integrated mobile access part.

4.3 Assumptions for services in mobile networks

In Europe, mobile speech and data services are offered by analogue networks, GSM and DCS1800, as well as through cordless access systems as DECT, CT2 and HIPERLAN.

GSM/DCS1800 will be the dominating cellular network. Also, since European operators will not be constrained to a specific technology, existing operators may introduce UMTS technology as a means of enhancing their services, within the regulatory framework. GSM Phase 2+ encompasses among other work items GPRS for wide-band data services and CAMEL as an evolutionary path towards service portability. There are, however, a few impediments to the evolution of GSM which must be overcome, before UMTS service offering can be made based on GSM infrastructure.

Handset technology, in particular GSM/DCS1800 and DECT, will have evolved with decreased size, weight and factory-gate costs. Multi-mode handsets will have appeared based on a combination of standards (e.g. GSM/DCS1800/DECT/UMTS). The user will have increased possibilities to select networks and services.

One of the major characteristics of UMTS will be that it can be positioned as a high-end extension to evolved pre-UMTS systems.

4.4 Assumptions for services in Satellite Personal Communications Network (S-PCN)

To provide world-wide coverage, satellite systems are and will be installed. Today, mobile terrestrial networks and satellite networks are generally not linked together.

S-PCN concepts will provide mobility between pre-UMTS terrestrial networks and satellite networks. Dual mode terminals will facilitate that feature.

4.5 Assumptions for services in UPT context

In the end of 1994, UPT Phase 1 was specified and UPT Phase 2 is under work. UPT Phase 1 is based on the use of DTMF. UPT Phase 2 is to introduce the use of the smart card. The support of UPT is also a work item of GSM Phase 2+, so UPT may also be provided in the evolutionary GSM/DCS1800 networks.

4.6 Assumptions for European Information Infrastructure (EII)

UMTS should be recognized as a mobile access to EII [8], providing radio access and mobility to services requiring bit rates up to 2 Mbits/s, and on the same providing enhanced user control and portability of services. The network function definitions for UMTS mobility services emerge, most likely, with relevant modifications from the existing mobility management principles and procedures of GSM. The implementation of mobility within (EII) other types of networks can thus be built on the basis of UMTS network standards, irrespective of whether the services belong to UMTS/GSM mobile services or ”EII” services requiring higher bitrates than what UMTS can provide.

As a potentially important element of EII, UMTS includes also the procedures for private use and networks as well as roaming between various types of networks.

Other radio technologies than GSM/UMTS (e.g. DECT, HIPERLAN) can be used as wireless access to EII. A re-use of GSM/UMTS mobility should be carefully studied before entering potentially duplicating developments of mobility functions and standards.

5 Non-technical aspects

5.1 Economic aspects

5.1.1 Investments in pre-UMTS systems

Massive investments, by operators and users, have been made to pre-UMTS systems prior to year 2000-2005. This motivates scenarios where evolution of pre-UMTS technology (fixed, cordless, mobile and satellite) provides the base for UMTS. Hence, the life of existing systems capable of evolving towards UMTS can be maximized without compromising UMTS objectives and service requirements.

5.1.2 Introduction of UMTS services

At the time of UMTS introduction, it must be realised that a significant portion of the user needs can be fulfilled by pre-UMTS systems. Nor can all operators be expected to provide a complete set of UMTS services in all user environments. Completely new and UMTS-specific service *capabilities* will be offered according to market needs, and evolved pre-UMTS system components may, to the edge of their inherent limitations, be used to provide UMTS services.

To ensure that UMTS will be a market success, economical realities must be carefully analyzed. The most important aspect that must be fulfilled for UMTS is:

UMTS cannot, for comparable services, be more expensive, than competing networks.

The availability of new types of services and a reduction in the price of equipment and service compared with pre-UMTS will stimulate users to migrate. To ensure low cost UMTS terminals the key aspect is to get large series in production.

5.2 Regulatory aspects

Europe is moving towards a more liberalised and competitive market-place. Around year 2000-2005, mobile telecommunications licences are unlikely to be constrained to a particular technology and multiband operation will be allowed subject to efficient use being made of radio spectrum. This is indicated by the CEC Green Papers on Mobile Communications [2] and on Infrastructure and Interconnection [6]. Contrary to the present situation, in the future there will be more extensive competition on both network operator level and service provider level. Regulation has a strong influence on the competition aspects of UMTS.

The regulators allocate frequency bands to each network operator. For a network operator, the allocated frequency bands constitute a resource. A scarce frequency resource can inhibit competition between operators. Current multiband operation trend allows the network operator enhanced possibilities to provide service capabilities to the service providers.

Various Open Network Provision (ONP) directives likely to be implemented in 1998 will help European countries to establish effective competition between public telecommunication operators. There is also trend towards harmonization of licensing terms in Europe.

5.3 User aspects

The service offered in conjunction with the cost/quality ratio is the decisive factor in the choice of service provider. For the user, it is quite unimportant which technology is used to provide the services. The choice of network and technology is indirect.

From the user point of view, continuity of service availability is of vital importance. A wireless user expects the terminal to carry on supporting existing services, but might be prepared to upgrade for new services. The concept of Virtual Home Environment is considered an important tool to provide service migration for users.

5.4 Service provider aspects

From the service provider point of view, UMTS is viewed as a set of service capabilities, not as a network. UMTS service capabilities can be provided by using different technologies and/or networks. When UMTS quality and service requirements are fulfilled, UMTS services are offered.

Today, market research indicates that the majority of mass market mobile users want high quality, low cost voice telephony. At present, the data market for mobile communications represents a niche market sector. By year 2000, there may be a significant market for video telephony and multimedia services, but nevertheless the vast majority of mobile users still want high quality, low cost telephony. Hence, other services should be provided in such a way that the cost of the basic telephony is not increased.

To provide a complete set of UMTS services (narrowband and wideband), it is not necessary to roll out coverage with a new system for all services. A fully established GSM/DCS operator can offer cost effective narrowband services and has a suitable frequency band in which that can be done. However, it is a requirement to be able to provide wide-band capabilities, and that is the primary objective for new service provision.

5.5 Network operator aspects

A lot of different types of operators using different types of networks such as GSM, N-ISDN, B-ISDN and Internet are interested in implementing UMTS as their future system. None of them can accept that UMTS capabilities are adopted to the existing implementations of competing network types only and therefore giving them an evolution advantage. UMTS must therefore for them be positioned as a compromise so that all types of operators can have access to it. This would be in line with the CEC directives to open up the telecommunication market.

The GSM/DCS operators today have an enormous growth in their networks. This results in congestion in hot spots. In order to use spectrum more efficiently, hierarchical cell structures and GPRS are introduced. However, if the growth will continue there is a need for new frequencies around the turn of the century for high bitrate services. It is a complex task to put together a completely new standard, which must supersede GSM; ISDN, and N/B-ISDN, and build products within the time frame of four to five years. To be able to accomplish this, an evolutionary path, re-using today’s networks, is needed.

Data and multimedia traffic will in the introduction phase, and may also in the longer perspective, not be a dominant part of the carried traffic in the mobile networks. Voice may for quite some time be the dominant source of income also for the mobile operators, as it is for the GSM/DCS operators today, but it should not be the driving force for UMTS. UMTS should be positioned as a completely new access and facilitate an evolution track from existing networks in order to be able to cater for all services.

It will be more expensive to build a wide-area coverage from scratch for an UMTS operator compared with an already existing operator. An idea to reduce the cost is to open the interfaces towards the access network so many operators (fixed and mobile) can share the same access network infrastructure.

Another interesting aspect of having an open interface towards the access network relates to the problem of finding the driving application for UMTS, such as voice has been for GSM. By allowing many types of operators access to a wide-area mobile access network a market place is created and the winner will be the operator that finds the driving application.

5.6 Introduction options

A number of scenarios are described in the following subclauses which illustrate various different approaches to the introduction of UMTS.

5.6.1 Introduction of UMTS with no pre-UMTS legacy network

In this scenario of a new operator with no pre-UMTS technology, there is no legacy system to influence investment and deployment decisions. This new operator may decide to enter the market with a stand-alone UMTS deployment. During this UMTS deployment there is no mandatory requirement to have any specific compatibility with pre-UMTS equipment.

5.6.2 Introduction of UMTS supporting complementary services

In this scenario, an operator of a pre-UMTS network can deploy a parallel stand-alone UMTS solution which offers a different and complementary set of services from those already provided by the operator's pre-UMTS network. The existing pre-UMTS network is not modified by the introduction of the parallel UMTS network. Over time, the operator can choose to migrate services and users from the pre-UMTS system to UMTS.

5.6.3 Introduction of UMTS Offering Complementary Coverage Area

In this scenario, an operator of a pre-UMTS network can deploy a complementary UMTS solution which offers a different and complementary coverage area from that already provided by the operator's pre-UMTS network. The UMTS equipment may be implemented as a stand alone network or may be integrated with the pre-UMTS network to some degree. Over time, the operator can choose to increase the coverage area of the UMTS equipment and reduce the coverage area of the pre-UMTS equipment. This has the effect of migrating coverage area away from the pre-UMTS network to UMTS. As a result of migrating the coverage area in this fashion, the overall telecommunications activity will also migrate towards UMTS over time.

6 Radio Frequency Spectrum aspects

6.1 FPLMTS frequencies after the WARC'92 and WRC'95 decisions

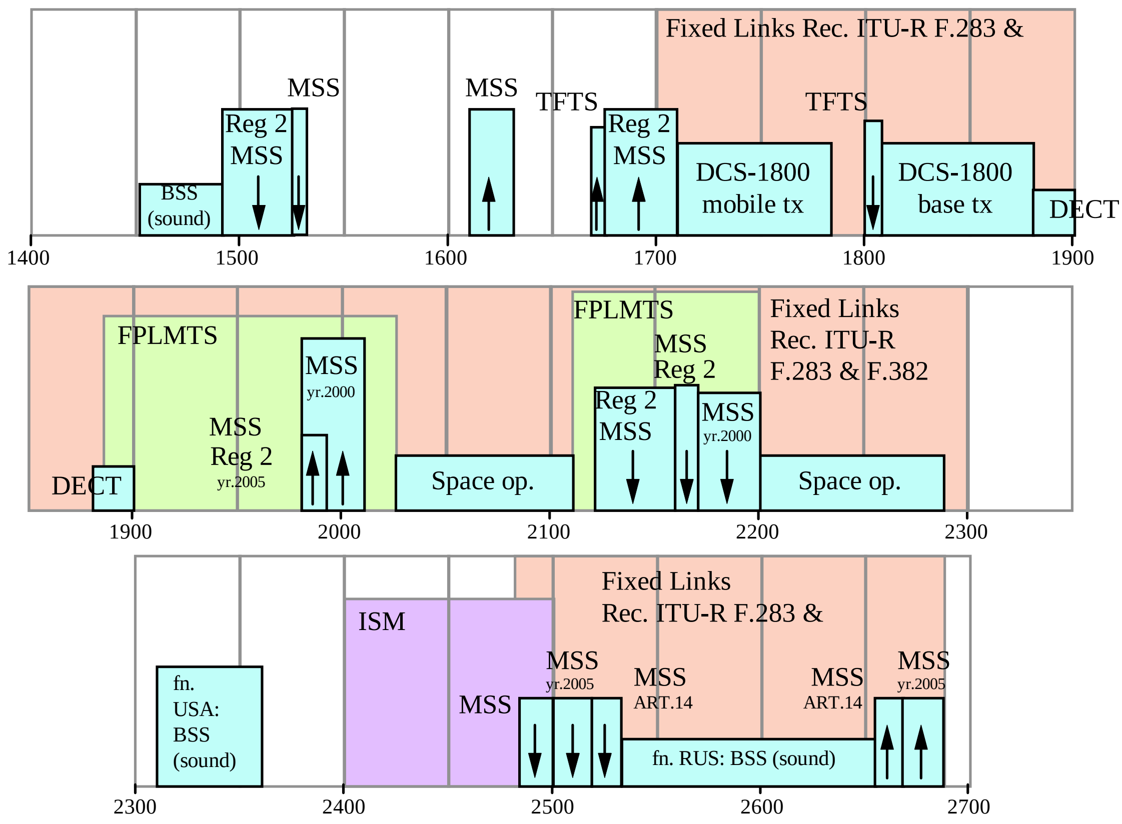

Figure 1: Detailed Spectrum Situation following WRC'95 [12].

At WARC'92, 230 MHz of spectrum (1885 - 2025 and 2110 - 2200 MHz) was identified for use by FPLMTS systems. In Europe, the spectrum was identified for UMTS, but by this time, DECT had been allocated the band 1880 - 1900 MHz. The MSS parts (1980 - 2010 and 2170 - 2200 MHz) of this spectrum were reviewed at WRC'95. The spectrum situation following WRC'95 may be summarised with reference to Figure 1.

6.2 Evolution and migration aspects of frequency bands

Modern mobile communication systems, deployed in various frequency bands, are likely to remain in operation after the introduction of UMTS. These pre-UMTS systems may evolve towards the service capabilities of UMTS as far as their technologies allow. Evolving systems need to be backwards compatible on the radio interface, in order to serve their existing customer base, which implies that there will be limitations in the potential evolution of pre-UMTS systems and that the frequencies used by pre-UMTS will remain in-use well beyond the introduction of UMTS.

Pre-UMTS radio transmission technologies should therefore not be confused with a revolutionary UMTS radio transmission technology. There is no possibility for evolution from a pre-UMTS radio transmission technology to a revolutionary UMTS radio transmission technology. This does not preclude the offering of UMTS service capabilities using pre-UMTS radio transmission technologies in bands outside the UMTS band.

Market developments may lead to an opportunity to use UMTS technology in both the existing pre-UMTS and new UMTS bands, as an integrated part of their overall UMTS service. pre-UMTS technology should only be used in parallel with UMTS within the pre-UMTS frequency bands. The UMTS terrestrial band should be reserved for UMTS mobile services. However, the prevailing regulatory environment may demand that a full UMTS service offering should be provided by a UMTS operator in that UMTS band. Independently of the regulations relating to the UMTS bands, pre-UMTS operators may wish to introduce UMTS technology into their existing pre-UMTS bands as a means to enhance their service capabilities.

In Europe and many other countries, GSM/DCS 1800 will be the dominating cellular network, in which operators and manufactures will have invested billions of ECU's. A new radio interface design will be required to provide all of the UMTS services, although existing infrastructure and in particular the current spectrum will be key components in providing personal communication services of the future.

For marketing reasons, and recognising that within Europe the planned abolition of existing restrictions on GSM 900 licensees concerning access to DCS-1800 and on DCS-1800 licensees concerning access to the GSM extension bands, it is recommended that regulatory bodies and standards makers take due account of multi-band operation when considering the development and introduction of Third Generation Mobile Systems such as FPLMTS/UMTS.

6.3 Coexistence of pre-UMTS systems and UMTS FPLMTS frequency band segment

Unless other pre-UMTS systems are introduced into the UMTS FPLMTS frequency band segment, DECT compatibility with UMTS need only be considered.

6.4 Technology Independent Licensing of the UMTS Spectrum

For the period of the introduction of UMTS, it is possible that frequency licensing will not be constrained to a particular technology, although there will be a reference to ETSI Standards. This opens up a possibility for offering UMTS services in other frequency bands depending on the decision of National Authorities.

6.5 Common Global Spectrum Allocations

It is generally accepted that global terminal mobility is a goal of FPLMTS (IMT-2000) with which UMTS will be compatible. It can be seen from figures 1 and 2, however, that there little opportunity for a uniform frequency band plan which can be applied in all regions for both the satellite and terrestrial components of FPLMTS (IMT-2000).

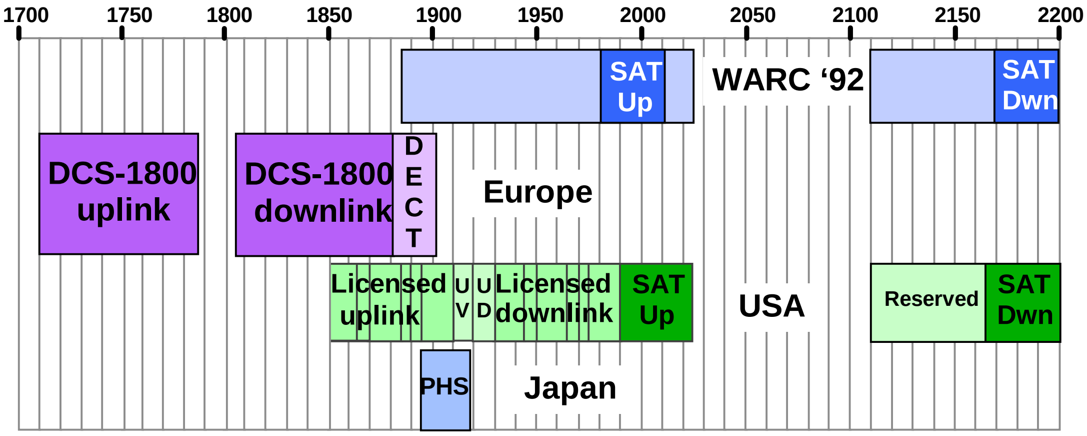

Figure 2: Summary of the Mobile and Personal Communications System Frequency Allocations in the Different Regions.

Recent studies have indicated that global terminal mobility may also be achieved through adaptation of the terminal functionality in order to match the various terrestrial radio interface standards offered in the different regions. However, in the interests of low cost MS/MESs with mass-market appeal, it is desirable to minimise the degree of adaptation which is required in those MS/MESs, particularly in the radio frequency hardware. One particularly desirable characteristic therefore in frequency band planning is that the number of frequency division duplexers (or up and downlink band changes) which are necessary in an MS/MES in order to ensure that it is capable of global terrestrial access should be minimised. In other words, FDD separations should be made common if possible.

6.6 Migration strategies

The identified spectrum for the terrestrial part of UMTS is not sufficient to provide all narrow- and wideband UMTS services to all the anticipated users. Until more spectrum has been allocated (e.g. 180+180 MHz was proposed by the UMTS Task Force [9]), strategies to ensure the introduction of new mobile wideband services in Europe will need to be taken into account.

Considering the investments made in pre-UMTS systems and the insufficient terrestrial spectrum allocation for UMTS, the following evolution/migration strategies should be applied:

- The UMTS radio interface and the UMTS (terrestrial) frequencies shall be used primarily to introduce new wideband services (64 kbits/s-2 Mbits/s).

- DECT/GSM/DCS/UMTS multi-standard operation via multimode terminals will provide an integrated wide and narrowband service offering, mobility management, integrated billing etc.

7 Candidates for the evolution towards UMTS

During the next decade, a number of systems and technologies will evolve towards the capabilities originally intended for UMTS. The standards for these systems and technologies will evolve, as well as the networks in operation.

The following types of evolution are relevant for consideration in this ETR:

- system evolution;

- service evolution;

- system component evolution;

- standards evolution.

7.1 GSM/DCS1800/DCS1900

A discussion about evolution towards UMTS must take into account the ongoing development of GSM, both commercially and technically. At the beginning of 1996 the GSM MoU had 170 members from 91 countries. The GSM system, started as European system, has now evolved to become almost a true Global System for Mobile communications.

The GSM technology (within Europe) is now used in two frequency bands (GSM 900 and DCS 1800), and in the USA the 1900-band is used. The GSM system will offer almost global coverage at the end of the century. GSM will in the near future offer multi band capability (900/1800/1900) including handover between frequency bands, which is an important factor to combine high capacity and good coverage within one and the same network.

GSM/DCS-terminals are expected to have multimode and multiband capabilities with a wide range of systems: DECT, S-PCN, etc.

The maximum bit rate supported by GSM is expected to be about 100 kbit/s non transparent data, using multislot techniques, optimised RLP (Radio Link Protocol) and error correction schemes.

GSM will offer a good and acceptable speech quality (enhanced full rate codec, EFR, standard is likely to be approved in 1996). The availability, price and variety of mobile stations shows that the GSM system, including DCS 1800 and 1900, can offer low cost terminals.

7.1.1 Service aspects

GSM will have a wide range of new services before year 2000. The services listed below are currently being specified within the framework of GSM Phase 2+ within ETSI TC-SMG.

- ASCI (Advanced Speech Call Items) will introduce a number of new speech services such as: Voice Broadcast service, Voice Group call service and priority call set-up service.

- GPRS (General Packet Radio Services) will introduce a new type of data service, utilising the burstiness of data traffic and the less stringent requirement on delay and delay variations. GPRS will be specified for bitrates up to around 100 kbits/s.

- CAMEL (Support of operator specific services when roaming). To be competitive as an operator, it becomes more and more important to be able to offer some extra services in addition to the standardised GSM services. The function which will be introduced by CAMEL is that an operator will be able to offer a subscriber these services even if the subscriber roams outside his home network.

- Data compression based on V42bis will be included in the GSM standard. The V42bis algorithm has the capability to compress normal text 2-3 times.

- HSCSD (High Speed Circuit Switched Data). The aim of this work item is to introduce circuit switched data services with bitrates up to around 100 kbits/s.

7.1.2 Network management aspects

The current ETSI standards for the GSM network management are based on the ITU-T M.3100 series where the TMN principles are presented. Also the OSI management specifications, ISO/X.700-series, are used. The management of current GSM networks covers the Network Element (NE) management layer and Service Management layer according to TMN logical management layers.

7.1.3 IN

Operator specific services and services not defined within the GSM standards can be introduced to GSM networks e.g. by interconnecting IN nodes (SCP) to selected MSC. From these MSCs, the IN services will be triggered when needed.

Another IN-related aspect is the use of operators specific services when roaming outside the home network. To support this, a GSM Phase 2+ work item called Customised Application for Mobile network Enhanced Logic (CAMEL) is being developed.

7.2 S-PCN

The satellite and terrestrial components of UMTS in general complement each other by providing service coverage to areas which either alone may not economically serve. Each component has particular advantages and constraints. The satellite component can provide coverage to areas which may not be within the economic range of the terrestrial component - this applies especially to rural and remote regions. Additionally, the satellite component may, in more densely populated areas, precede and encourage later deployment of the terrestrial component. The evolution of S-PCNs should take these things into account.

Satellite systems do not evolve in the same way as terrestrial systems. Terrestrial systems can evolve in small increments by upgrading the hardware and software. However, once launched, it is practically impossible to change a satellite. Satellite systems therefore evolve in quantum leaps as each generation of satellite is launched.

There are a number of S-PCNs that are currently being planned to be in operation around the year 2000-2005. These include (in alphabetical order) Ellipso, Globalstar, Inmarsat-P, Iridium and Odyssey. The way in which the forthcoming S-PCNs will influence the design of the satellite component of the UMTS will depend on the experience with each of them and the level of integration of them and the pre-UMTS systems.

Some S-PCNs plan to use pre-UMTS mobile system techniques for routing, switching and mobility management, and dual-mode terminals are foreseen to be used for S-PCN and pre-UMTS systems. Hence, migration from GSM to UMTS terrestrial component would assist S-PCN migration towards UMTS satellite component.

7.3 DECT

The DECT access technique, using for example GSM, PSTN or ISDN as core network, is together with the GSM-family a most interesting starting point for migration towards UMTS within Europe.

DECT makes use of dynamic channel selection (DCS), so there is no need for frequency planning. DCS makes DECT easy to deploy with the use of very small cells, thus providing a very high traffic capacity at a low cost.

The DECT frequency band is adjacent to and part of the FPLMTS frequency band identified by WARC92.

7.3.1 Service aspects

A number of DECT profiles defining specific functional capabilities have been developed or are under development in ETSI/RES3. These profiles will provide DECT systems with capability to support a wide range of services.

- DECT- Generic Access Profile (GAP) consists of the minimum mandatory requirements that allow a 3,1 kHz teleservice (telephony and any other 3,1 kHz voice service) connection to be established, maintained and released between a DECT fixed part and a portable terminal with the appropriate access rights, irrespective of whether the Fixed part provides residential, business or public access services. GAP is the basis for all other DECT access profiles, supporting a 3.1 kHz speech service.

- DECT-GSM Inter-working Profile (GIP) describes the DECT FP and PP interworkings/mappings necessary to ensure that GSM Phase 2 services can be provided via a DECT access system. Interworking is currently specified for the attachment of the DECT FT to the MSC using the A-interface. DECT subsystems attached to GSM can provide extended mobility to DECT users, as well as giving operators possibility for overall capacity and quality improvement of their networks.

- DECT-Data Services Profile give DECT a protected net sustainable data rate of up to 307/384 kbits/s (with single/double slot) and 563/704 Kbits/s for symmetric and asymmetric connections, respectively.. Possible applications are fax (group 3 and 4), file transfer, e-mail, and Internet access in a LAN or public access environment.

- DECT-ISDN Inter-working Profile (IIP) specifies how ISDN services may be provided over DECT systems. The ISDN bearer services covered are: speech, 3,1 kHz audio and unrestricted digital information 64 Kbits/s data.. DECT can either be the end system or act as an intermediate system. In both cases the DECT system is fully ISDN transparent. For a DECT end system, either one or more BRA or one PRA are supported as ISDN interfaces

- DECT-CTM access profile (CAP), currently under development, describes how CTM phase 2 services may be supported over a DECT access system.

- DECT-Radio Local Loop Access Profile (RAP) will define the minimum requirements to allow the use of DECT common interface for Radio Local Loop applications. RAP is based on DECT GAP and will provide a minimum of service level; i.e. POTS services and optional extensions including 64 Kbits/s bearer services, ISDN services and a limited set of broadband packet services.
  Development of services based on DECT applications may take place in other fora as well, like ETSI/CTM:

- Cordless Terminal Mobility (CTM) is a mobility service based on IN for cordless terminals. Through providing roaming to different access networks, telecommunications services of the supporting networks are made available at different locations.

7.3.2 User aspects

The low output power of the portable gives DECT long standby and talking times. The low power need makes it possible to manufacture simple light-weight handsets. Dual mode DECT/GSM handsets will allow the access to GSM services in DECT coverage islands.

Built-in, plug-in or PCMCIA based DECT terminals will cater for flexible data communications. One of the first DECT products that was released was a wireless LAN. Public access to data networks at airports, hotels and city areas will be a way to provide a mobile office to travelling professionals.

7.4 Fixed network

A requirement for the 21st century is provision of a unified presentation of services to the user in wireless and wired environment. For the 21st century user there should be no distinction in service capability between mobile or fixed network access.

Evolution of the fixed network towards a mobile system requires an addition of a radio access system and wide area mobility management. Relevant fixed network standardisation activities include

- IN CS-1, 2 and 3;
- CTM phase 1 and 2;
- N-ISDN;
- B-ISDN;
- UPT.

It is important that sufficient interaction between these activities take place to ensure they will provide UMTS mobility.

IN and Object Oriented Techniques can provide mobility management in the future. Other developments including TINA are also relevant.

DECT and CT-2 will also play a major role in providing wireless access to the fixed networks.

The fixed network evolution towards UMTS can be divided into the following four domains: ”Radio access”, ”service”, ”mobility control” and ”backbone network”. In the backbone network development, N-ISDN is the dominating part in the initial phases, while B-ISDN is becoming more important later as the demand for high bitrate services increase.

IN is evolving through new capability sets, influenced by CTM for mobility features and it is likely that these standards in the end will be harmonised. It is therefore of great importance that there is sufficient interaction between the development of these standards in order to gain support for e.g. the mobility functionality in the B-ISDN.

CTM phase 1 and phase 2 will be developed in parallel to N-ISDN, IN and DECT/CT2 radio access, and will have an influence on the development of these standards.

7.4.1 CTM

The “evolution” of the CTM service will be an important issue for the fixed network evolution towards UMTS. It will be a driving force for enhancing the IN capabilities with support for terminal mobility. The integration of mobility management functionality in IN will make the provision of mobility services more independent of the backbone network.

CTM phase 1 and phase 2 have influence on evolution of the defining standards - N/B-ISDN-ISDN, IN, DECT/ CT2 cordless access - through the addition of new capabilities to support mobility features.

7.4.2 IN

Many operators already base services on IN platforms. This enables an easier introduction of new services, and a costly upgrade of the local exchanges can be avoided. By implementing the mobility management functionality at the IN level, the provision of mobility services are more independent of the core network used as long as it supports IN. There are of course dependencies between the backbone network and IN that must be taken into account in the further development in the standardisation bodies.

The schedule for IN standardisation is:

February 1996: The ITU IN CS2 Recommendation are put in a frozen state.

The new functionality relevant for the support of mobility function is the Non-Call associated interaction between users and service processing.

1996: First issue of ETSI IN CS2 INAP

(Protocol specification including a first set of mobility features)

1998: The ITU IN CS3 Recommendations are put in a frozen state

(Planned for use with B-ISDN, TMN and UMTS)

Relevant capabilities:

Support of distributed databases;

Support of distributed control (the SCF-SCF relationship is also available in the CS2, but only for interworking functions);

Direct control of the bearers by the SCF.

7.4.3 UPT

UPT will be supported as a service by the fixed network. It is also a GSM Phase 2+ work item. It is an objective that UMTS will support UPT. Close links between the development of UPT and IN exist.

7.4.4 ISDN/B-ISDN

B-ISDN and UMTS might be mature in the same time frame and integration of UMTS into B-ISDN may be a possible choice. If UMTS is integrated into B-ISDN the B-ISDN protocols and functions will be used where possible completed with the UMTS specific protocols and functions. B-ISDN should therefore take UMTS aspects into account when developing protocols. There is still the possibilities to influence the B-ISDN standardisation process. The end results could be that certain B-ISDN protocols would be useable ‘as it is’ for UMTS. This solution requires co-operation between the B-ISDN and UMTS development groups, and can be considered as one possible integration scenario with B-ISDN.

The time schedule for the B-ISDN is:

1994: CS1 approved

mid 1996: CS2.1 defined and approved

mid 1997: CS2.2 defined and approved

end 1998: CS3 defined and approved

8 UMTS characteristics and functionality

8.1 UMTS specific characteristics and functionality

This section contains considerations that will facilitate the identification of items relevant for evolution and whether further work is required.

What characteristics and functionality`s will distinguish UMTS from today's mobile communications systems?

For each characteristic and functionality identified, the following questions are also answered in this section:

Is this characteristic or functionality currently identified within the UMTS ETRs as an objective?

Is this characteristic/functionality revolutionary or evolutionary?

These identified characteristics and functionality`s, along with the answers to the subsequent questions, all require further work:

Table 1

Characteristic/functionality	Identified objective	Revolutionary or evolutionary?
higher bit rate capability	yes	revolutionary from the radio perspective
higher service quality, in particular voice	yes	evolutionary
global standard	yes	revolutionary
world-wide roaming based on terminal mobility	yes	evolutionary
intelligent network (IN) based service creation and service profile management based on ITU-T Q.1200 series of Recommendations	no	evolutionary
integrated satellite/terrestrial networks	yes	evolutionary
multimedia support	yes	evolutionary
wider range of operating environments, including aeronautical and maritime	yes	revolutionary
bigger marketplace leading to lower costs	yes	evolutionary
world-wide, off-the-shelf compatible equipment	yes	revolutionary idea, evolutionary process
world-wide common frequency band	yes	revolutionary
additional security	yes	evolutionary
flexibility for evolution, both from pre-UMTS and for post-UMTS	yes	evolutionary
coherent systems management based on ITU-T M.3000 series of Recommendations	yes	evolutionary
caters to needs of developing countries	no	evolutionary
improved ease of operation	yes	evolutionary
flexible radio bearer, leading to improved spectrum efficiency and lower cost per Erlang	no	evolutionary
the role of the service provider	yes	evolutionary
the distinction between the user and subscriber	yes	evolutionary
handover between networks during communication	yes	revolutionary

8.2 Advanced characteristics and functions covered also by other networks

Substantial parts of the planned UMTS features will actually appear before or at the time of UMTS introduction. Some examples include:

- High speed packet data (such as GPRS in GSM)
- Merging cordless and cellular functionality`s (such as DECT/GSM)
- Interworking of terrestrial systems (such as GSM) and Mobile Satellite System
- SIM card roaming with US PCS and Japanese PDC
- Provision of non-standardised services outside the home network; UMTS Virtual Home Environment (such as GSM CAMEL)
- IN, and mobility such as UPT or CTM in the fixed network.

8.3 Global roaming

UMTS should provide capabilities for global roaming. Some basic solutions for roaming should be considered for UMTS/FPLMTS evolution from different regional systems, even if not the same terrestrial radio interfaces are used in the different regions:

- SIM/UIM-roaming;

- Mobile Satellite Services;

- Dual mode terminals;

- Support of UPT, even though the concepts should not be mixed.

Many current and planned pre-UMTS and pre-FPLMTS systems include a removable user identity module. With a removable user identity module, a user is able to access the telecommunications services at different terminals, even if these terminals offer different characteristics, including the radio interface. The removable user identity module offers an element of functional commonality which can be used to smooth over other elements of incompatibility. Even if you cannot provide terminal roaming, a removable user identity module may let you access services in visited networks.

The UMTS satellite segment is another solution for areas where no compatible terrestrial system is available.

9 Evolution paths

9.1 Starting points and migration methodology

9.1.1 General

By year 2000, a range of telecommunications technologies will be in use in Europe including GSM, DCS1800, HIPERLAN, DECT, ERMES, TETRA, N-ISDN, B-ISDN, S-PCN, Internet, UPT and IN.

To be successful, a new standard must offer considerably greater capabilities and service quality than preceding systems, and permit these things to be accomplished at a competitive price.

Dual or multi-mode terminals will soften system borders for users, offering access to services over different access networks. The trend is towards even more intelligent terminals, which could form a building block for migration to UMTS.

By re-using parts of pre-UMTS systems and adding some new modules a fast introduction of UMTS services can be accomplished very cost effectively.

Migration can be made more feasible by applying the concept of building blocks in UMTS design. Examples of building blocks are transmission system, radio interface or mobility management protocol. Any combination of European pre-UMTS technology and added new technologies such as a new UMTS radio interface can be chosen by each operator individually. As such, UMTS may be positioned as high-end extension (wide band capabilities) to evolved pre-UMTS systems.

The challenge for the introduction of UMTS is:

- To find financially viable ways to fulfil the expanding needs and expectations of users and subscribers in a timely manner and with the minimum impact for the users and subscribers.

9.1.1.1 Ways from various systems towards UMTS

Various evolutionary tracks towards UMTS exist. Two important examples are:

- GSM/DCS, DECT/GSM, IN. The further evolution can comprise the introduction of a new (UMTS) radio interface, increased bit-rates and enhancements of the MAP to fulfil UMTS system requirements. Potentially also new base station system technologies might be introduced. Gradually GSM evolves and in the end UMTS services can be offered.

- Adding B-ISDN, IN-capabilities with mobility support and radio access subsystems to the fixed networks forms the second main track towards UMTS. CTM is one such example.

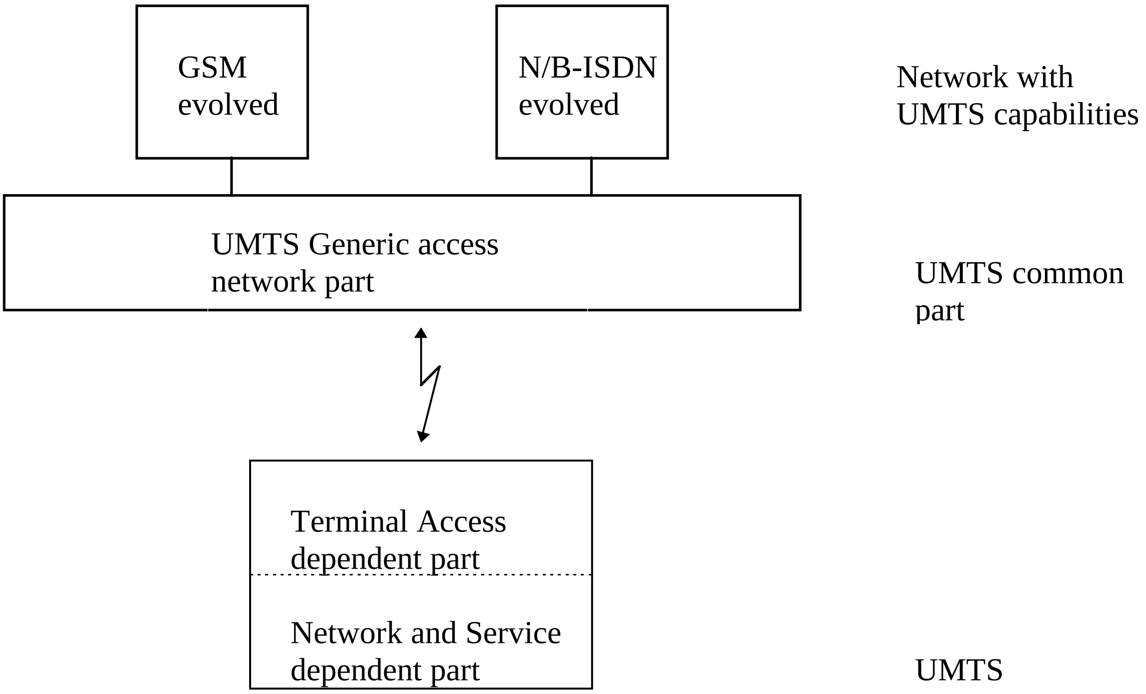

Figure 3. The division of UMTS into access and core network parts

The figure shows the division of the UMTS network into an UMTS Generic Access part and a Network part. The UMTS Generic Access part handle all radio related functionality and provides the wide area coverage of radio access services to the different network service types. The generic access part and terminal access dependent part can contain a number of different radio interfaces.

9.1.2 The four level and three step model

Evolution and migration for each system is visible at 4 levels due to three main evolutionary steps. At level 4, the system may keep their main inherited characteristics (thus, multiple components of the target UMTS).The steps may occur at different times for different operators

The subclauses 9.2 and 9.3 including figures 6-9 and 11-14 describe the foreseen features commercially available to end-users at each evolution level. It is up to the individual service providers and network operators to choose which features to implement i.e. how to progress on the evolution path towards UMTS.

9.1.2.1 LEVEL 1

Examples: GSM Phase 1 and Phase 2, D-AMPS, PDC, PHS, IN CS-1, B-ISDN CS-1, CTM phase 1, etc. - mid '90s technology.

9.1.2.2 STEP A

The evolution from level 1 to 2.

9.1.2.3 LEVEL 2

Examples: GSM Phase 2+ and further developments, US-PCS, Advanced PDC/PHS, IN CS-2, B-ISDN CS-2.1 and CS-2.2. Brings technology and services into pre-UMTS systems originally intended for UMTS/FPLMTS, to the edge of pre-UMTS limits (IN. higher bit rates...). Old terminals work in all parts of the system but cannot use new services.

Examples of level 2 functionality's:

- GSM Enhanced full rate codec;
- Multi-band mobiles. GSM/DCS provides more capacity for the user;
- Multi-mode terminals. GSM/DECT provides more capacity, indoor/outdoor coverage, higher bitrates etc.;
- High bitrate capabilities give users new services;
- UPT;
- IN (proprietary, standardised);
- Service delivery across multiple networks;
- Service providers separated from network operators.

9.1.2.4 STEP B

The change from level 2 to 3

9.1.2.5 LEVEL 3

UMTS during the introduction phase, limited capability sets, partly re-use of pre-UMTS technology. IN CS-3 and B-ISDN CS-3 are available. Level 3 adds a new frequency band, a new radio interface, a new integrated access and a new service concept. Pre-UMTS terminals can still be used where pre-UMTS exist but might in due time be phased out. New coverage and services areas introduced at this stage can not be used, except for those who invest in new terminals. At level 3 multimode terminals exist that can access service logic through a number of radio interfaces, including UMTS as well pre-UMTS radio interfaces. UMTS at level 3 is a subset of the full set of UMTS standards.

9.1.2.6 STEP C:

The evolution from level 3 to 4

9.1.2.7 LEVEL 4:

Target UMTS: no technical limitations or bottlenecks for a full implementation of UMTS. Market demands on high quality and high bitrate services will push the rapid deployment of UMTS. Interworking with previous generation systems is maintained. A level 4 UMTS system should conform to the full set of UMTS standards.

New UMTS technology introduced at level 3 (and fully operational at level 4) will comply with all UMTS objectives/specifications and it will facilitate access to services in visited networks segments across regions. Also the user mobility provided through UIM (User Identity Module) functionality will provide service accessibility in visited networks during the intermediate phases.

9.1.2.8 Example of timescale

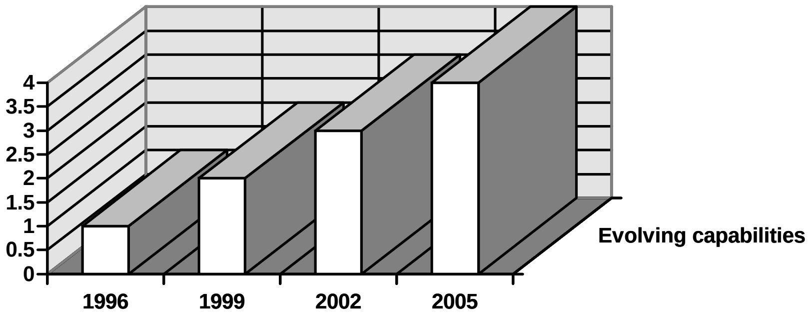

Figure 4 Examples of starting years for network operation and capability sets for the four levels

9.1.3 Modularity

Consider evolution of pre-UMTS systems towards UMTS, using a modular approach. Then each independent module or subsystem may evolve at it's own pace.

Any pre-UMTS module or subsystem can be considered as being taken into UMTS operation, when complying with UMTS standards and when connected to other subsystems also complying with UMTS standards.

Comparing the states before and after the introduction of a module into UMTS, it can either be maintained (no modification), enhanced (be modified) or changed (be replaced). There may be individual choices for discrete components within each module or subsystem.

The following scenario is an **example** of dividing a system into modules and an **example** on how this system may evolve into UMTS: The

- *user data* (user identity module, subscription...) is likely to be maintained or enhanced;
- *terminal* is likely to be enhanced or changed;
- *access subsystem* is likely to be maintained, enhanced or changed;
- *transport subsystem* is likely to be maintained, enhanced or changed;
- *service subsystem* is likely to be enhanced or changed;
- *mobility subsystem* is likely to be enhanced or changed;
- *security subsystem* is likely to be enhanced or changed;
- *network management subsystem* is likely to be enhanced or changed.

These modules or subsystems may be distributed over several network elements.

Some general guidelines can be drawn on how UMTS can make use of specific pre-UMTS modules. The actual path, for any individual system in operation, has however to be planned by the individual operator in each case.

9.1.3.1 Requirements on evolving subsystems

It should be possible to enhance a subsystem to provide additional capabilities without affecting any other subsystem, e.g. provide a new transport subsystem or service control subsystem. In some cases, enhancements may be needed to a number of different subsystems before the system is able to provide a new service to an application. It should be possible to implement/deploy individual subsystem enhancements in any order, to facilitate system upgrading and network operation/evolution. Such enhancements should be possible if functional models of UMTS are implementation independent. Any enhancement in a subsystem boundary, e.g. to make available the new subsystem capabilities to other subsystems, must be backwards compatible with the previous version, i.e. the new version of the subsystem must be able to emulate the previous version, so avoiding the need for a synchronised updating of all subsystems concerned. When all other subsystems (which interact with the upgraded subsystem) have themselves been upgraded to use the enhancements, then the need to emulate the previous version no longer exists.

Similarly, it should be possible to add entirely new subsystems to take care of evolving needs (e.g. add mobility), without adversely affecting the other subsystems.

9.1.3.2 UMTS Generic Access Network

UMTS will live in a changing telecommunication environment. The changes will affect network technology, services and regulatory issues. Furthermore, the future mobile telecommunications systems are more likely to be operated more integrated with the fixed network, i.e. the sharp boundary between mobile and fixed services is likely to diminish. It is therefore necessary to identify the current and future key technologies in the mobile and fixed networks and to discuss how these will affect and interact with UMTS.

The role of the access network is presently being handled differently depending on the fixed or mobile evolution paths. The UMTS Access Network can be connected to any Network Part (e.g. N/B-ISDN or GSM), see Figure 5. An interesting aspect of the UMTS access network is that it provides the means for each network part to use their own access protocol. This means that an ISDN user will get access to all his services also in a UMTS environment. Service transparency is ensured.

The UMTS Access Network shall provide bit transport services which are used by the core Network for signalling and user information transfer.

The UMTS Access Network should provide the following functionality to one or more Network Parts, independently of the chosen access method or the chosen fixed network:

- Offer the network part operator a wireless access.

- Offer the user access to any network or service.

- It should not handle any type of subscription.

- A generic bit transport services on OSI-level 2 (comparable with AAL within ATM).

- Mobility functionality, e.g. paging and handover functionality, maintaining the relation between the terminal and the fixed network.

- No permanent registers about users or terminals.

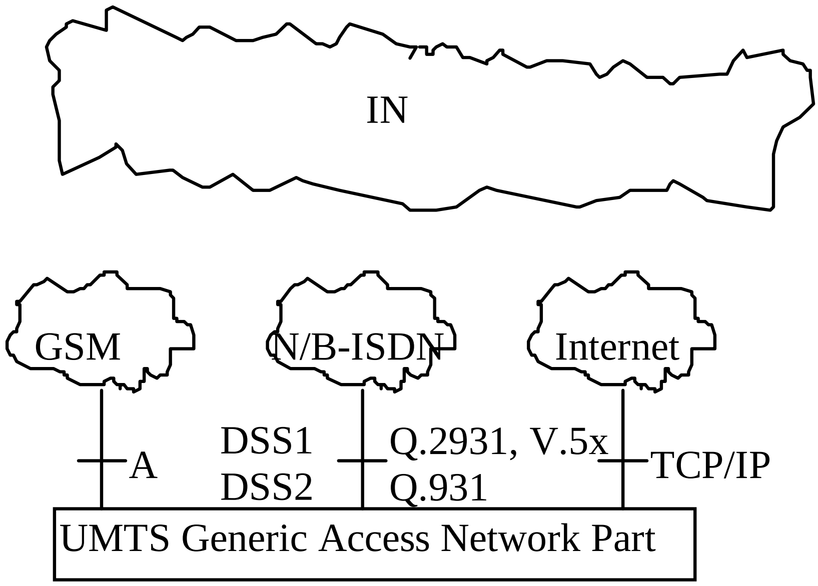

Figure 5: The UMTS Generic Access Network and possible interfaces to networks.

The interfaces are only examples. For the GSM the A interface has been used. It can be seen as level 2 in the GSM evolution path. Further on the GSM access network will evolve to fulfil more capabilities of UMTS and hence the interface is likely to be changed. For N-ISDN the access protocol DSS1 is used together with the I V5.x . The same applies of course for B-ISDN and the Internet. Cable operators will also offer new services in short term but the access protocols to be used are still to be defined. The IN layer in the Figure provides functionality common to the different networks, see also Figure 17. The type of functionality that will be placed in this layer depends on market requirements.

The role of the UMTS access network should be given more attention in a generic context, in the sense that it should be scaleable and possible to implement efficiently in different environments

9.2 Evolution from a mobile network perspective

GSM and its equivalent at higher frequency band DCS1800 are widely deployed in Europe and other parts of the world. In addition, in the US, PCS 1900 belongs to the GSM family. The evolution path from GSM towards UMTS is based on the enhancement and exploitation of the gradually evolving GSM. The approach taken ensures profitability for new services to be implemented by UMTS or GSM evolution towards UMTS.

In the following, the GSM evolution is described as steps with the timing given only as an indication. The actual times and steps will be defined by the markets. In the GSM-UMTS road map presented, Level 1 is the situation in year 1996, Level 2 the situation in year 1999, Level 3 the situation in 2002 and Level 4 the situation in 2005.

9.2.1 Levels and evolution steps

The GSM system can be defined as the functions and interfaces of SIM, terminal, access system and network subsystem.

The SIM/ME interface is essential since it enables personal mobility between terminals. Respectively, the radio interface between the terminal and the access system is needed for terminal mobility. The radio interface also enables terminals of different manufacturers to be used within the same network. The interface between the access system and the network subsystem enables operators to use access systems of different vendors and network subsystems of different vendors in their network.

Timings given in all scenarios are only examples of possible relationships between time and available standards. The actual situation these years may prove to become different, depending of standardization progress, regulations and individual operator situations. The scenarios may include elements not (fully) covered by the GSM standards at the time(e.g. SMSC and its applications, SCP or PBX) but still closely coupled with or applicable in the GSM system. By separately analyzing the evolution of each GSM system component – together with the services and features offered – the evolution of the GSM system becomes more visual. Implementation of the increments depicted is up to each operator's decision while fulfilling the regulatory requirements.

The examples below do not imply a choice of a certain network architecture.

9.2.2 Level 1

Level 1 corresponds to the status of the GSM system in year 1996 (GSM Phase 2). Level 1 GSM system is depicted in Figure 6.

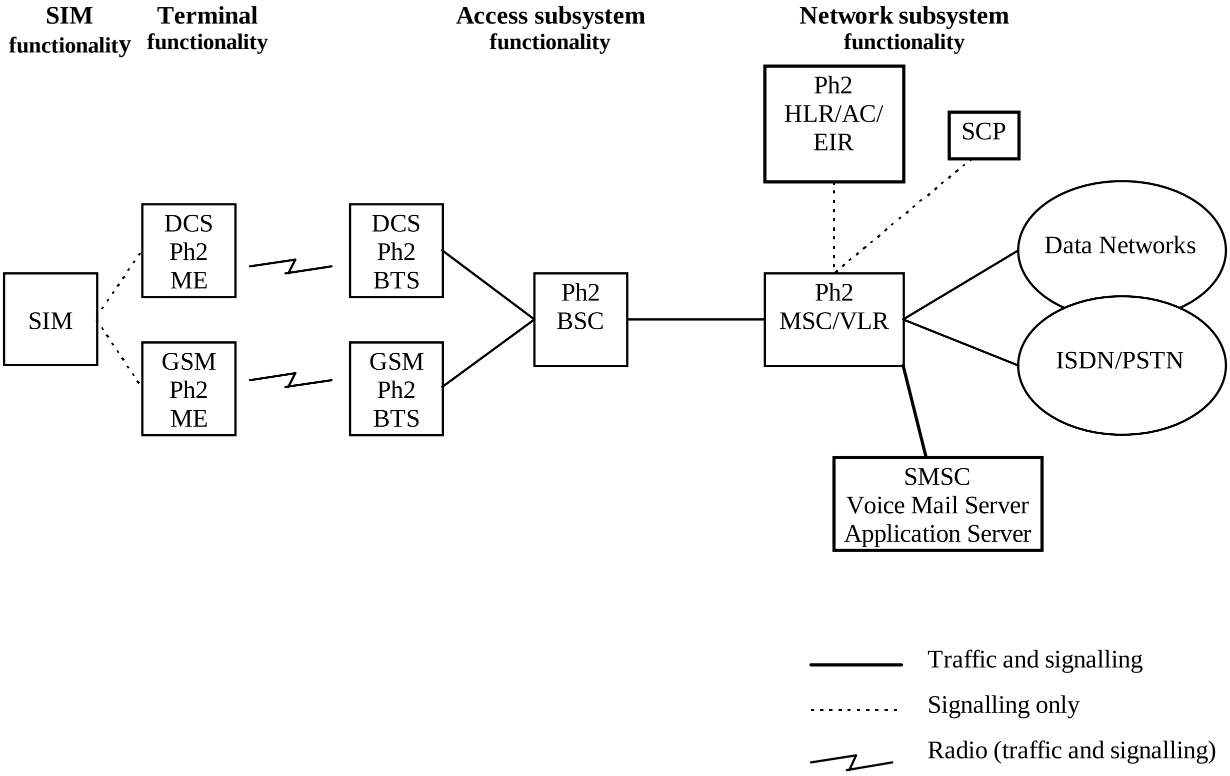

Figure 6: Level 1 GSM system.

9.2.2.1 Basic Features of Level 1

In the following, the basic features of Level 1 GSM system are depicted with regard to the different parts of the GSM system.

SIM

The same Subscriber Identity Module (SIM) can be used in both GSM and DCS terminals.

Terminal

Single-mode GSM Phase 2 terminal with 900 MHz radio interface and single-mode DCS Phase 2 terminal with 1800 MHz radio interface are used.

Access system

The access system comprises GSM Phase 2 BTSs and DCS Phase 2 BTSs attached to the same Phase 2 BSC. The BSC is interconnected to the MSC/VLR via the A interface.

Network subsystem

Phase 2 HLR/AC/EIR is attached to the MSC/VLR with MAP interface. Core INAP is used for SCP access. The SCP has been standardized outside of the GSM standard. Other elements are Short Message Service Centre (SMSC), voice mail server and TCP/IP support for data applications.

Services and features

The main teleservices of Level 1 GSM are: telephony, emergency calls, alternate speech and facsimile group 3, automatic facsimile group 3, short message service (mobile originated, mobile terminated, cell broadcast). Provision of teletex and videotex is possible when needed.

The different bearer services of Level 1 GSM cover bit rates from 300 to 9600 bps.

Level 1 GSM provides versatile supplementary services including multi-party call, calling line identification presentation/restriction, call waiting, call hold, call transfer and a range of different call forwarding and barring services.

Level 1 GSM provides multiband operation by single operator (same BSC and MSC for both GSM and DCS BTSs) and same user access (SIM) to both GSM and DCS terminals.

The supplementary services provided consist of GSM Phase 2 and CS-1 supplementary services. Voice mail box and TCP/IP support for data services are additional features provided but not standardized within the GSM standard.

9.2.3 Level 2

The main characteristics to be identified in Level 2 (year 1999) are the differences compared to Level 1 i.e. evolution step A. The analysis of Level 2 is done according to the same division into components as in the previous section. Level 2 GSM system is shown in Figure 7.

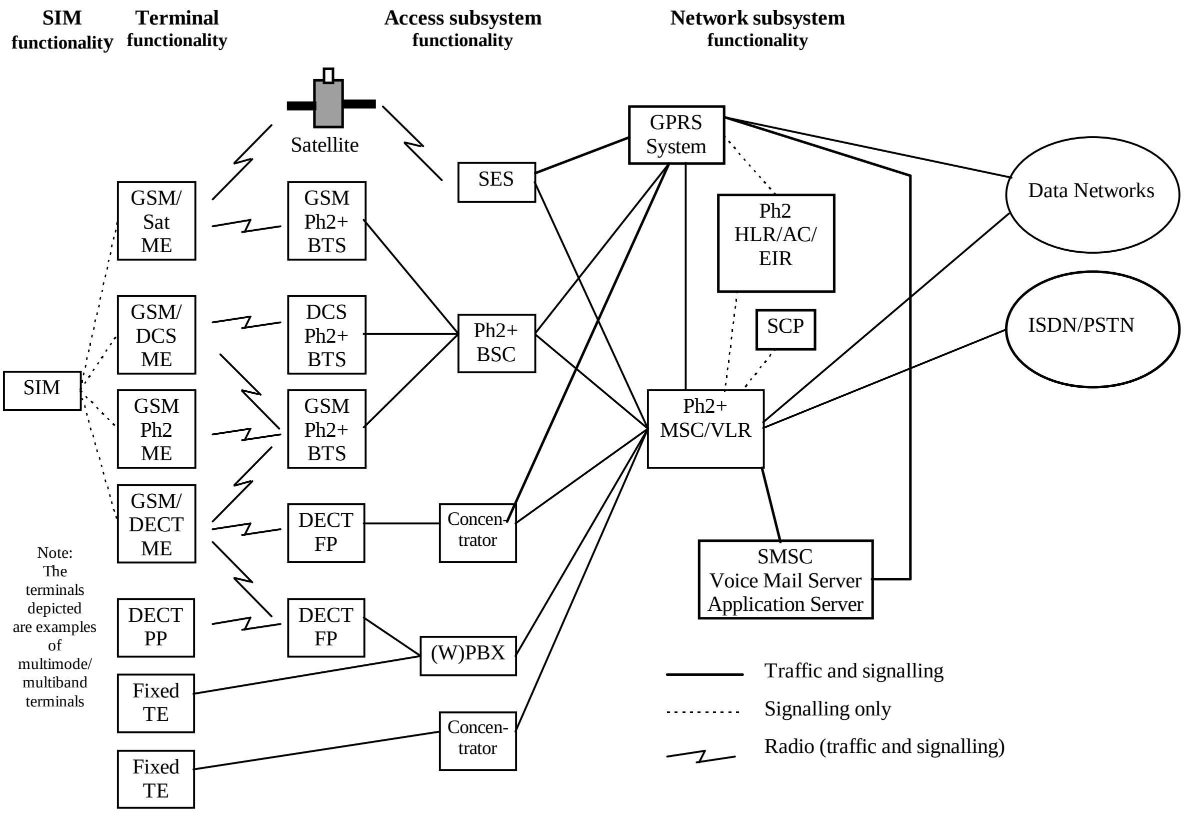

Figure 7. Level 2 GSM system.

9.2.3.1 Evolution step A (Δ Level 1 -> Level 2)

The changes since Level 1 is described in the following:

SIM

In addition to GSM and DCS Phase 2+ terminals, the same GSM/DCS SIM can be attached to a DECT Portable Part (PP).

Terminal

GSM and DCS Phase 2+ terminals and DECT terminals with DECT/GSM interworking capabilities. In addition, multimode/multiband terminals e.g. dual mode GSM/DCS, GSM/DECT, GSM/Satellite and DCS/Satellite terminals are available. Also a fixed terminal connected to a Private Branch Exchange (PBX) or concentrator can be used.

Access system

GSM and DCS Phase 2+ BTSs are attached to a Phase 2+ BSC.

A further way to differentiate services and increase system capacity is interconnection of DECT Fixed Parts (base station systems) with DECT/GSM interworking capabilities to the MSC (modified A and/or modified DSS.1 interface). The DECT/GSM system supports roaming between DECT subsystems and GSM backbone network. In addition to wireless DECT terminals, the WPBX can also have fixed terminals. It is also possible to interconnect a fixed PBX without DECT subsystems to the MSC.

A new access to the Packet Switched Public Data Network (PSPDN) is realized by the General Packet Radio Service (GPRS) system.

Access to a satellite system providing interworking with GSM/DCS brings true global and cost-effective coverage to a GSM/Sat or DCS/Sat user. The interface between the Satellite Earth Station (SES) and the MSC/VLR is based on the A interface of GSM. The satellite system uses HLR and VLR for mobility management.

Network subsystem

The MSC/VLR and HLR/AC/EIR are upgraded to Phase 2+ capabilities. A SCP is connected to the MSC with a CAMEL/CS-2 interface.

A new interface for satellite applications is established from MSC/VLR. These satellite services are pre-UMTS applications.

The GPRS system is connected to MSC, HLR and the different access systems.

Services and features

The Enhanced Full Rate (EFR) codec improves the speech quality.

Level 2 introduces new Phase 2+ services including high bit rate data services General Packet Radio Service (GPRS) and High Speed Circuit Switched Data (HSCSD). Both GPRS and HSCSD make use of the multislot technique which – together with V.42bis data compression – enable bit rates up to 100 kbit/s.

By attaching both GSM and DCS BTSs - even DECT subsystems - to its network, a single operator can increase the capacity of its network and differentiate services. This constitutes also the first step on the evolution path towards combination of private and public service environments.

Further new Phase 2+ features include Customised Applications for Mobile network Enhanced Logic (CAMEL) and Advanced Speech Call Items (ASCI). The CAMEL feature provides the mechanisms to support services of operators which are not covered by standardised GSM services even when roaming outside the HPLMN. ASCI services include PMR-like services e.g. group and priority calls.

9.2.4 Level 3

In Level 3 (year 2002), the UMTS frequency band is taken into use and the first parts of the UMTS standard are implemented. Part of the planned set of UMTS services is provided. Level 3 includes the changes of evolution step B i.e. changes between Level 2 and Level 3. Figure 8 illustrates Level 3 GSM/UMTS system.

GSM evolution level 3 will have the most significant changes in the radio access. The management might have separate systems for the different radio accesses. The management standards will be modified accordingly. They will cover the fault and configuration management of all new or modified GSM elements and management will be implemented at the network level. Charging function has to cope with the new services such as packet data by providing capabilities to charge according to the actual usage. The combination of GSM and DECT equipment will enlarge the number of managed resources. However, if the interfaces are standardised, the management of equipment from different manufacturers will not complicate management systems too much.

In addition, operators will have to administer a large amount of user/subscriber service profiles in different databases and registers introduced for the various services (e.g. HLR, GPRS register, IN SDP, CAMEL specific server, Mobile Internet binding caches etc.). To facilitate the handling of and access to these databases, they will gradually be interconnected. This also aids in coping with feature interaction due to the multitude of services provided. The database or register architecture will be *prepared* to allow evolution to a heterogeneous fully distributed wide area database (DDB in the sense of commercial distributed database manufacturers). This keeps the door open for further evolution of parts of the GSM/UMTS system in a direction proposed e.g. by TINA (telecommunication information networking architecture).

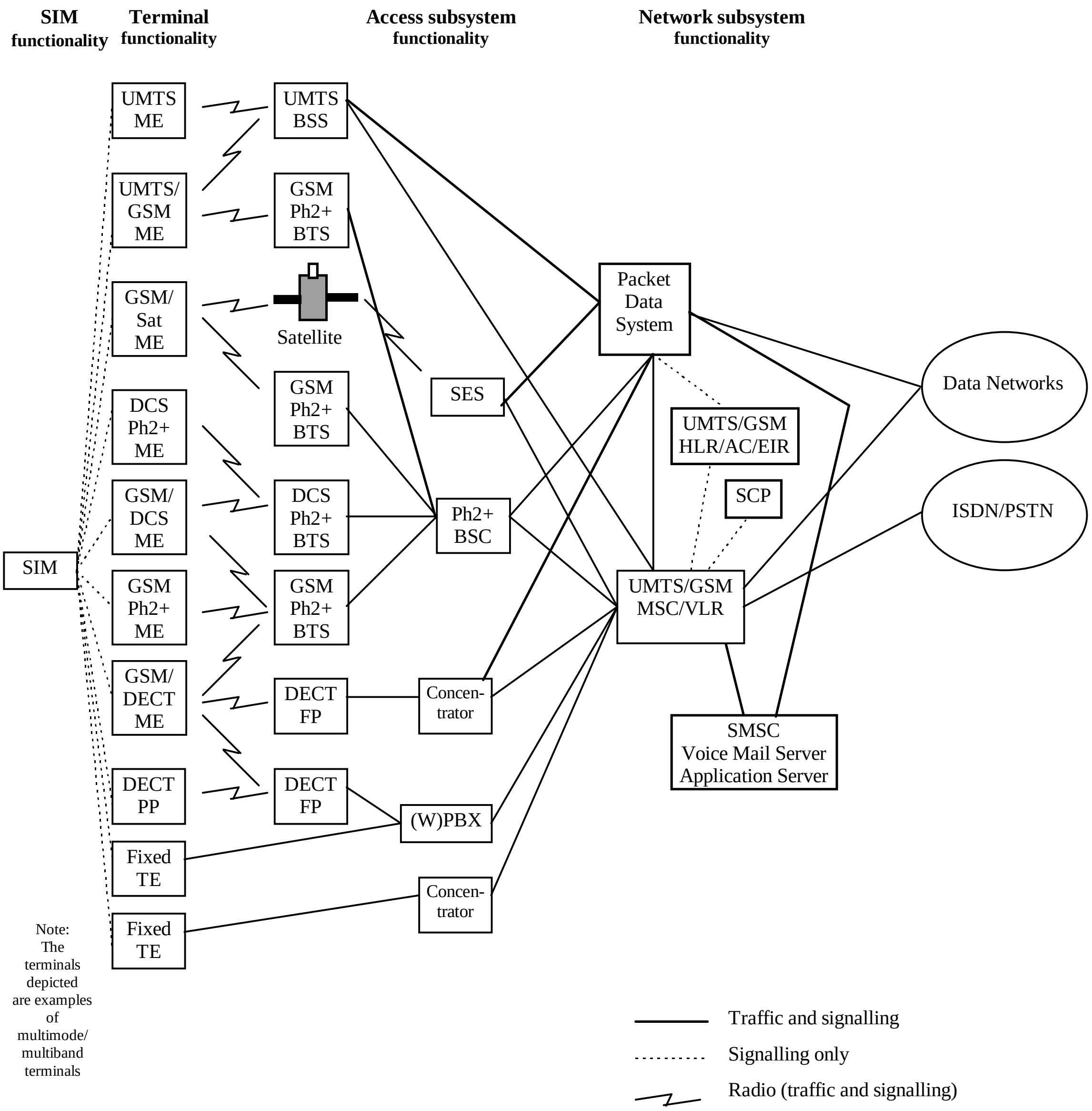

Figure 8. Level 3 UMTS/GSM system.

9.2.4.1 Evolution step B (Δ Level 2 -> Level 3)

The changes since Level 2 is described in the following:

<u>SIM</u>

The SIM card can be attached to UMTS terminals bringing UMTS services to the user.

SIM roaming is feasible between GSM/DCS and UMTS, even between mobile and fixed terminals. SIM roaming might also be offered between evolutionary GSM systems and other mobile systems. Furthermore, the SIM could possibly also be attached to fixed terminals.

Terminal

Single-mode UMTS terminal with terrestrial UMTS radio interface(s) only.

New UMTS/x/y (UMTS/GSM, UMTS/DCS, UMTS/DECT, UMTS/GSM/DCS, UMTS/GSM/DECT) multimode terminals are likely to be used for utilizing the ubiquitous GSM/DCS coverage together with the restricted UMTS coverage.

Furthermore, adaptive (download of software etc.) terminals may be used for achieving more flexibility when roaming between networks using different radio technologies.

Access system

New UMTS base station subsystem which supports terrestrial UMTS radio interface(s). The access to MSC is realized by a new modified interface. The interface might support the use of ATM.

Network subsystem

The new UMTS/GSM MSC/VLR has separate access facilities for UMTS. The MSC/VLR might also support ATM resources and therefore may take advantage of new enabling technologies.

New modified HLR/AC/EIR and a combined CAMEL /CS-3 subset for SCP access. The supported mobility management procedures are an evolution from the mobility management procedures of GSM Phase 2+. The interface between HLR/AC/EIR and SCP might be useful for certain applications. It might be introduced as a preparatory step to pave the way towards a heterogeneous distributed wide area database which will then act as a further enabling technology. Even when this “Level 3 network of databases” employs different database access protocols, the internal inter database node protocol should be chosen to be future proof and allow upgrade of this database network to a future DDB compliant database network

Packet Data System evolved from GPRS is connected to UMTS BSS.

Services and features

Level 3 will support part of the services (such as multimedia and videotelephony) planned for UMTS. The first parts of UMTS standards will incorporate the features of the preceding levels. SIM as well as terminal roaming is supported between GSM/DCS and UMTS.

Virtual Home Environment (VHE) is a concept which allows the user to perceive the service offering of any network under the UMTS umbrella as the one available at his/her Home PLMN. Functionally, the VHE concept can be seen as evolution from CAMEL.

UMTS provides additional capacity to the GSM/DCS network. UMTS standards should be capable of supporting services of pre-UMTS systems.

9.2.5 Level 4

Level 4 (year 2005) will provide the full set of UMTS services including the broadband (up to 2 Mbits/s) services via the UMTS radio interface to limited coverage areas. Level 4 UMTS systems will fulfil all UMTS requirements and is depicted in Figure 9.

Level 4 will bring new service providers and UMTS network operators. New management interfaces between these new stakeholders might be needed.

The Level 4 UMTS system evolved from GSM has high potential to allow sharing of network components with other UMTS systems as e.g. fixed network evolution level 4. This allows to meet requirements of operators who take advantage of a then different regulatory environment (e.g. fixed and mobile operators). This potential sharing of components on different planes (e.g. content plane, application service plane, network service plane: mobility management,..., transport plane) will even *allow* a diversification of the market into new types of providers like content providers, network providers, etc. In this case, the demand for a drastically reduced set of management and administration methods will develop for a given plane.

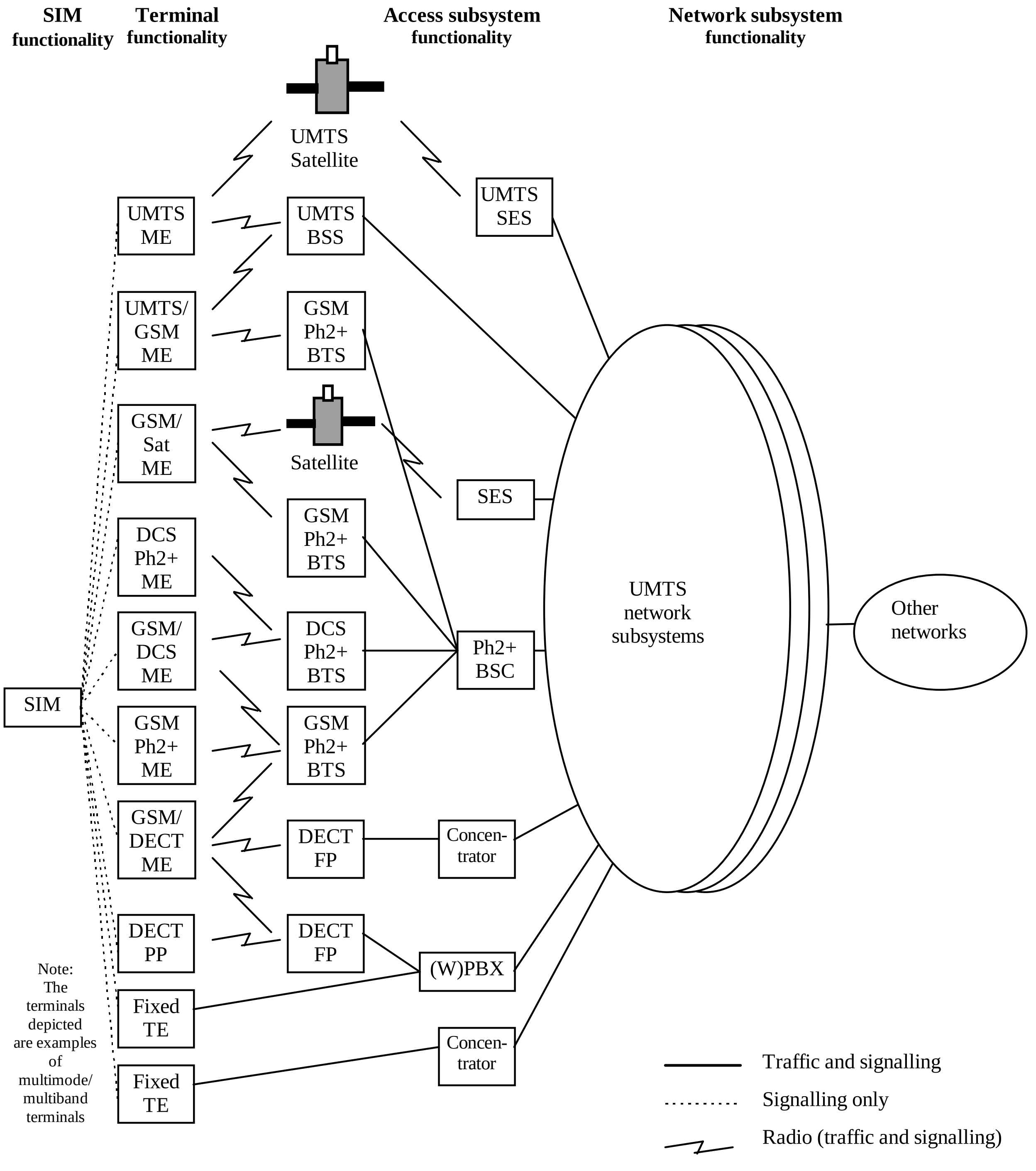

Figure 9. Level 4 UMTS system, evolved from GSM.

9.2.5.1 Evolution step C (Δ Level 3 -> Level 4)

The changes since Level 3 is described in the following:

SIM

UMTS satellite subscription added to SIM.

Terminal

The UMTS terminal can support access to the UMTS satellite component.

Access system

The UMTS satellite component will be deployed. New Customer Premises Networks (CPN) further diversify the plethora of the service environments of the UMTS system.

Network subsystem

Several different UMTS network subsystems are presented in Figure 9, since it is unclear which architecture a UMTS network subsystem will have. The Network subsystem can support ATM switching. It should be possible to integrate the UMTS satellite component with the terrestrial component of UMTS. The increased complexity introduced by new network features will be coped with by providing transparency in different *parts* of the UMTS system. Candidates are e.g. the register/database architecture for network internal services (e.g. routing including mobility management) and the processing architecture for application services. Distributed database characteristics can be realized in parts of the system by introducing a single database access protocol (e.g. a derivative of INAP or MAP) and a single internal inter database node protocol. The network subsystems will provide interworking capabilities to other (access) systems to provide services according to the market demand. The network subsystems will also have interfaces towards other networks established according to market requirements.

Services and features

New multi-layer service environments may be introduced in the system thus further enhancing the combination of various evolutionary GSM, DCS and DECT service environments of Level 3.

Broadband data and multimedia services are offered within limited coverage areas.

9.2.6 Summary

The road map from GSM to UMTS introduced describes the gradual development of the GSM infrastructure and terminals towards UMTS. The GSM-UMTS road map consists of four levels and three evolution steps, each analyzed towards the following distinct parts or subsystems of the GSM system: SIM, terminal, access system and network subsystem. In addition to these, the services and features offered were identified.

The SIM evolution comprises the modification of SIM to match the requirements of the new DECT and UMTS users and a fixed user with or without UPT functions.

The terminal evolution introduced DECT terminals with DECT/GSM interworking capabilities, fixed domestic or (W)PBX terminals, terrestrial and/or satellite UMTS terminals and adaptive multi-mode terminals combining the GSM, DCS, DECT, satellite, UMTS terrestrial and UMTS satellite technologies.

The access system evolved as new phases of BTS and BSC equipment, finally leading to the introduction of the terrestrial UMTS BSS. The UMTS satellite component was introduced first during the last evolution step. Fixed PBX, Wireless PBX, DECT Fixed Part and GPRS system complemented the intermediate steps on the way towards the true UMTS access.

The network subsystem evolved as upgrades of MSC/VLR and HLR/AC/EIR. The new MSC/VLRs had to support each of the new access systems attached to it. The interface between the MSC/VLR and the SCP changed from CS-1 to a CS-3 subset together with the in parallel advancing CAMEL. Moreover, the capabilities of MSC/VLR were enhanced by non-standard elements such as SMSC, voice mail server, application server, data gateway (TCP/IP) and satellite gateway. The evolutionary MSC/VLR is also likely to support the use of ATM resources and ultimately ATM switching.

The set of services and features offered will be developed from the existing set through e.g. high bit rate data services (HSCSD, GPRS) and combination of private and public environment (DECT access, GSM/DCS picocells) to a much wider set of novel services and features including multimedia, videotelephony, wide/broadband data services, multi-layer service environments, Virtual Home Environment and satellite access.

9.3 Evolution from a fixed network perspective

9.3.1 CTM evolutionary scenario

CTM evolution is an important aspect of the fixed network evolution towards UMTS. Current IN standards do not have sufficient support of terminal mobility. One important aim of CTM is to add mobility features like roaming and location handling to the fixed network using the capabilities of IN.

9.3.1.1 Level 1

Level 1 of this scenario has it’s starting point at the finalised CTM phase 1 standard.

At this point, only CTM phase 1 is being defined by ETSI. The CTM service is being described by NA1, the IN architecture for the support of CTM is being defined within NA6, while the mobility procedures and the protocol aspects are being specified in SPS3, SPS2 and SPS5 respectively. It is expected that standards for CTM phase 1 will be completed during 1996.

CTM Phase 1 service addresses:

- incoming and outgoing calls of telephony (3,1 kHz) teleservice,
- speech bearer service and 3,1 kHz audio bearer service,
- roaming and location handling within and between residential, business and public access,
- intra-cell and intra-cluster handover (at Fixed Termination FT Level),
- emergency call,
- Call Forwarding on Not Reachable (CFNR) supplementary service,
- possibility for permanent mode of Calling Line Identification Restriction (CLIR) and Connected Line Identification Restriction (COLR) supplementary services, and,
- possibility for service profile interrogation and modification.

The functional network model that has been defined for the support of CTM phase 1 service is depicted in next figure. It shows the separation between call-related (CCAF, CCF/SSF) and call unrelated (SCUAF, CUSF) service functions. To handle call unrelated terminal mobility associated events, a new State Machine (BCUSM) is used, instead of non-call related out-of-channel user interactions associated events (BNCSM), as in present IN CS-2 ITU model. SCF should include co-operation between several intra- and inter-network service logic instances (relationship "c"), including ISDN- ISDN and PTN- ISDN interworking.

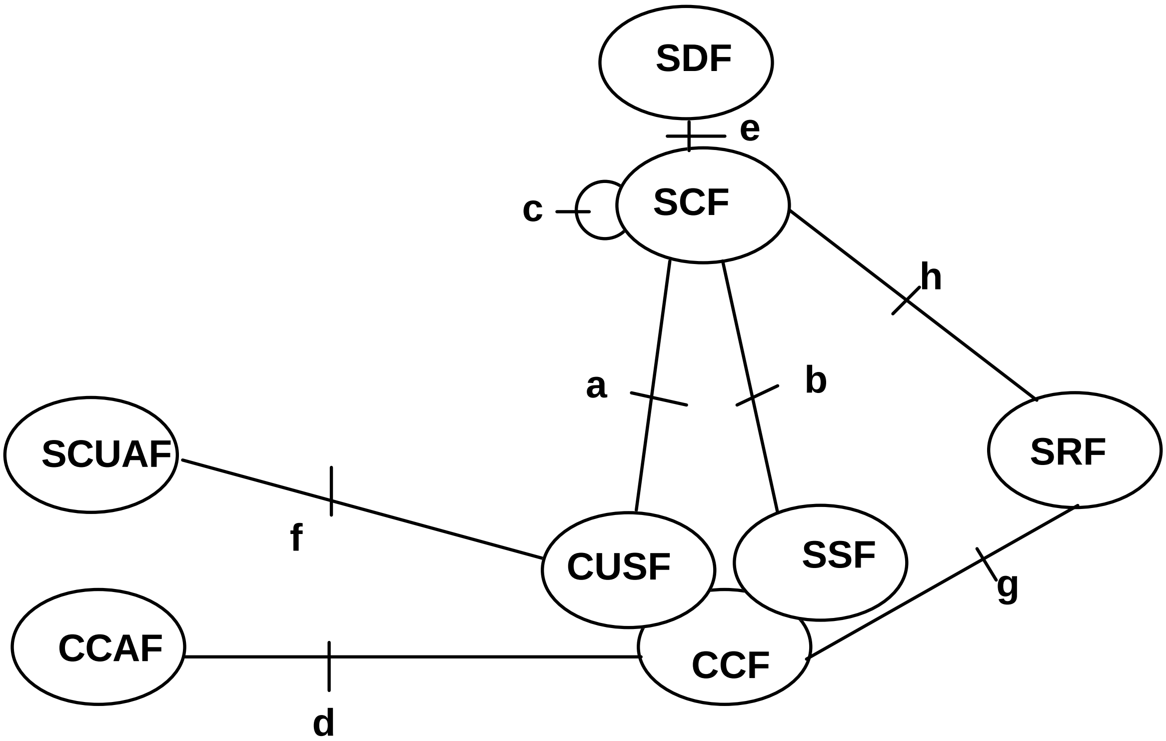

Figure 10: Relationships

Figure 10: Relationships "b" ,"e", ”g” and ”h” are assumed to be CS-1 IN Core INAP. Relationships "a" and "c" are assumed to be IN CS-2. Relationship "d" is based on ISDN access protocol (DSS1). Relationship "f" is being defined as an extension of DSS1.

Figure 11 is showing a physical architecture example consisting of DECT, CT2, Satellite and Fixed access to an IN structured fixed network.

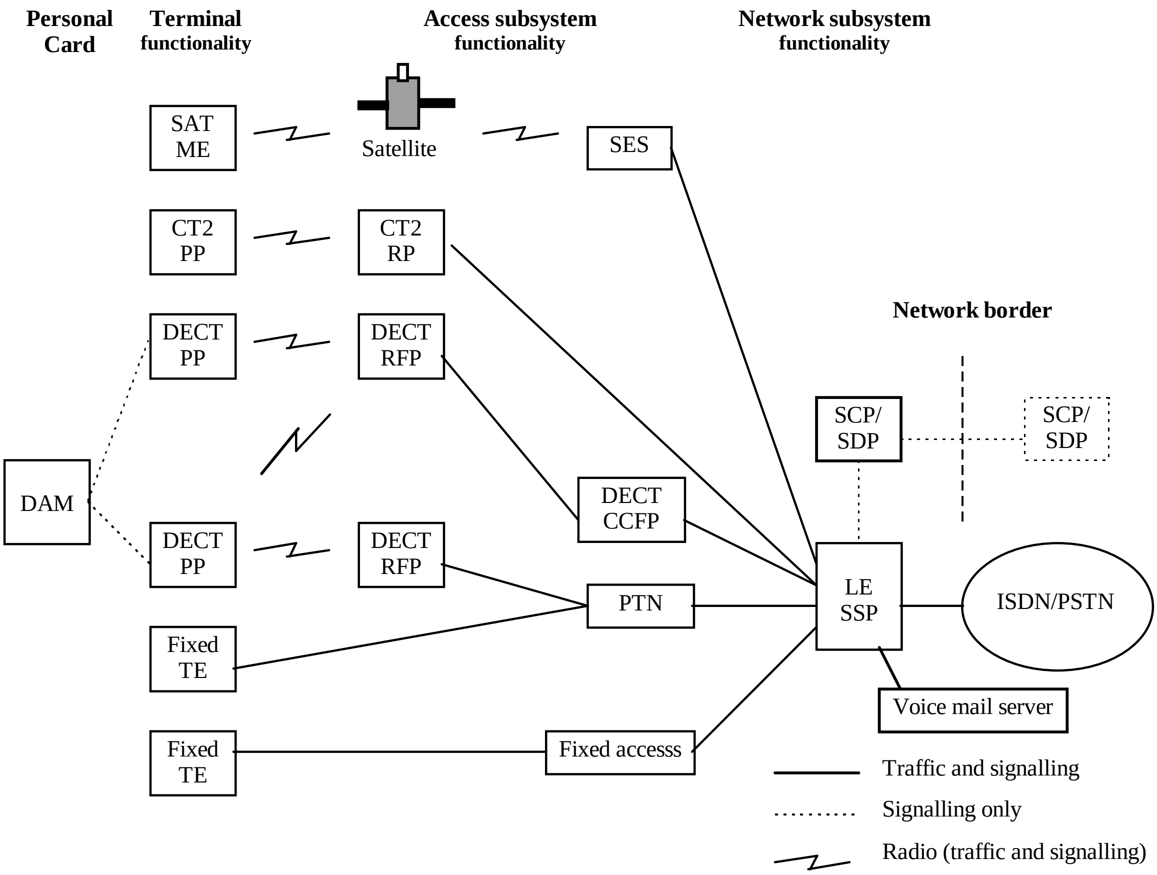

Figure 11. Fixed network evolution level 1

9.3.1.1.1 Basic Features of Level 1

Personal Card

The DECT Authentication Module (DAM) is similar to the GSM SIM. In addition the fixed network provides roaming between different terminals types trough a UPT subscription.

Terminal

DECT terminals supporting GAP will be used. The same terminal can then be used to access different DECT networks. Fixed terminals are available through a PTN (PBX) or connected to the LE through a fixed access unit. Satellite access is available through existing satellite systems.

Access subsystem

DECT Radio Fixed Part (RFP) are controlled by the Central Control Fixed Part (CCFP). The CCFP is connected to a local exchange (LE) using ISDN PRA interface, supporting an enhanced DSS1 protocol. Terminal mobility with handover is provided within the area of the CCFP, roaming between DECT islands is also provided, but handover between base stations connected to different CCFPs is not standardised in level 1. Personal mobility can be provided from any fixed and mobile terminal. The satellite access will be a separate system (not a S-PCS) with its own mobility control.

Network subsystem

The IN SCP is attached to the LE/SSP using the INAP protocol. CTM phase 1 is implemented on the current IN platform (CS-1), extended in line with the IN CS-2 protocols. An enhanced DSS1 protocol is used for the interworking with the private network, and roaming between public CTM networks as well as between public and private CTM networks is provided. Voicemail is provided by a separate voice mail server.

Services and features

This Level 1 is able to provide all those teleservices and supplementary services offered by ISDN and IN-CS1, including UPT phase 1. Additionally, those teleservices, bearer and supplementary services offered by CTM phase 1 will be available in the Cordless Access Networks.

9.3.1.2 Level 2

The level 2 is positioned in time to the finalisation of the CTM phase 2 standard. At this time, UPT phase 2 service will be full standardised and operational.

Standardisation of CTM Phase 2 will be undertaken by ETSI , as soon as definition of CTM phase 1 is mature enough. STC NA1 and BTC1 have started activities on CTM phase 2 service requirements, covering the following areas:

- bearer services;
- teleservices other than telephony;
- Supplementary Services;
- handover at network level, and;
- TMN.

The functional architecture to support CTM phase 2 will depend on final service requirements and standardized level of IN capabilities. Basically, it will be based on IN CS-2, with separation of call-related and non-call-related service functions from the user terminal. The radio interface between the user terminal and the fixed network part should be updated in order to support that separation (specific CTM access profile).

Figure 12 shows a functional architecture example for this evolution level.

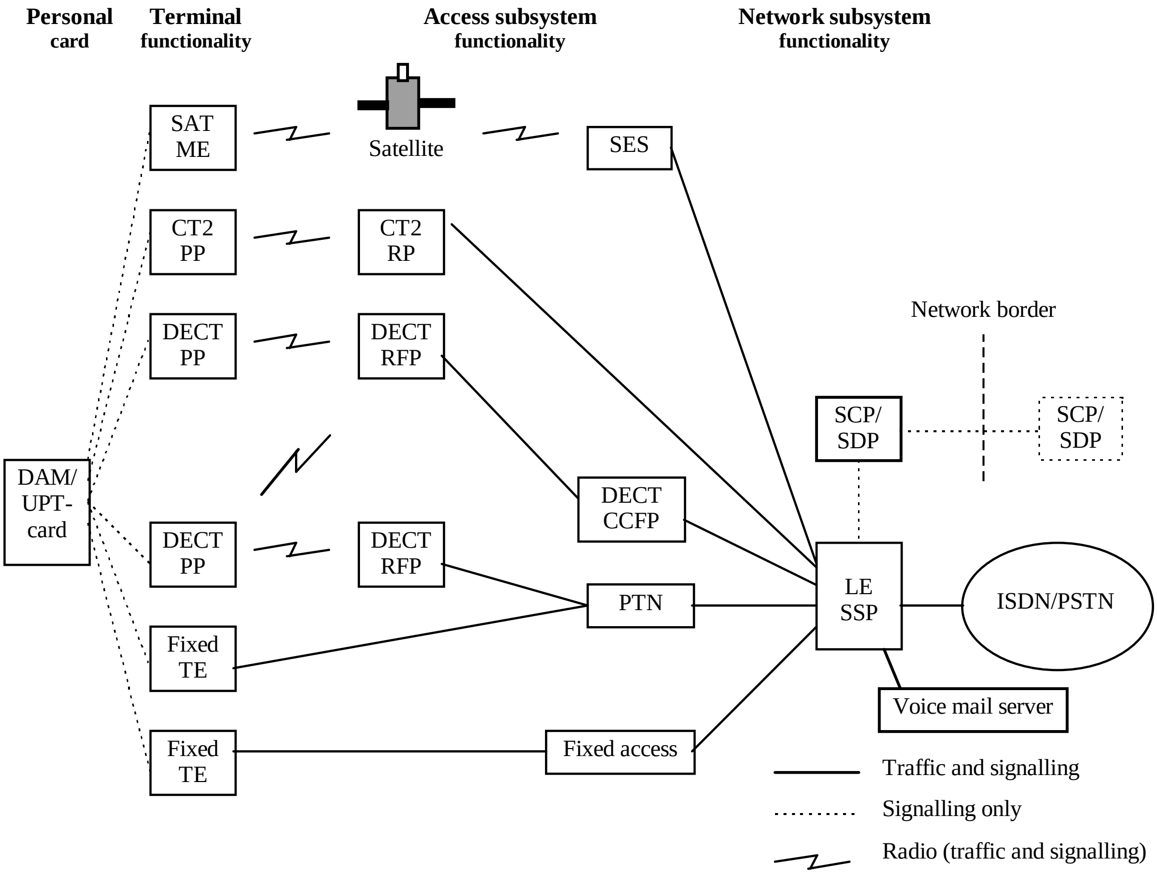

Figure 12. Fixed network evolution level 2

9.3.1.2.1 Evolution step A (∆ Level 1 -> Level 2)

The changes since Level 1 is described in the following: **Personal Card**

A card for UPT and CTM is introduced. This card could be combined UPT and CTM card. This means that personal card roaming is provided, and the card can be used with DECT/CT2 terminals as well as with fixed terminals.

Terminal

DECT terminals supporting CTM access profile will be available. Dual mode terminals will also be available and a CTM service can be complemented with GSM to increase the coverage. (The dual mode terminals are not shown in the figure.) The interworking with the GSM network is also left out of the figure, but a possible way of doing this could be to have a signalling link from the SCP to the HLR.

Access subsystem

The capabilities of CTM phase 2 with the DSS1+ protocol makes it possible to provide handover between DECT base stations connected to different LEs (Local Exchanges). ISDN will be offered transparently through the access subsystem to the end user. This will enable additional supplementary services and high rate data services. The satellite system takes advantage of advanced service capabilities of IN through triggering in the LE, but still the satellite system has its own mobility management.

Network subsystem

IN CS-2 together with CTM phase 2 will provide a common platform for service and mobility control.

IN-CS2 includes, in addition to IN-CS1 capabilities:

- capabilities allowing the implementation of mobility services: personal and service mobility will be fully standardised, terminal mobility will be defined but protocol standardisation (stage 3) will be delayed to IN-CS3;

- Private Network (VPN) evolution;

- service features outside the range of “single ended” or “single point of control” (multi-party services, multiple points of control);

- telecommunication services;

- capabilities allowing implementation of service management services and service creation services.

It is characterised by consideration of call unrelated events, support of out-of-band signalling, extended set of services and inclusion of SCF-SCF and, probably, SDF-SDF relationships

Services and features

At this time, level 2 of Fixed network evolution is able to provide those services offered by IN-CS2, including UPT phase 2 and evolved CTM phase 2.

A likely evolution of the CTM service is to give capabilities for personal and service mobility within and between networks supporting cordless mobility. This will imply personalization of cordless terminals, enhancement of IN capabilities and extension of ISDN protocols in order to support personal and service mobility functionality in addition to terminal mobility functions.

Service mobility allows the provision of home network’s services to users from any access point/terminal.

Personalization of cordless terminals will be most likely provided through the use of smart cards to allow the user information (e.g. user identification) contained in cordless terminals, to be changed to allow user mobility between cordless terminals. At a later date the same smart card may be used in fixed terminals using the same access mobility management protocols to provide user mobility between cordless and fixed terminals and between different fixed terminals. Thus, the protocol used for CTM service could form a basis in ISDN for a common access protocol for cordless terminal mobility and for personal mobility between cordless terminals, between cordless and fixed terminals and between fixed terminals.

The implications of this are that harmonized service logics can be developed and the same instances of the same location data bases can be used to support both terminal and personal mobility within ISDN without getting into complex relationships between users and terminals and their corresponding service control functions and data bases.

9.3.1.3 Level 3

Figure 13 shows several access systems working together in parallel controlled by IN. Broadband and narrowband transport networks are separated, using different protocols.

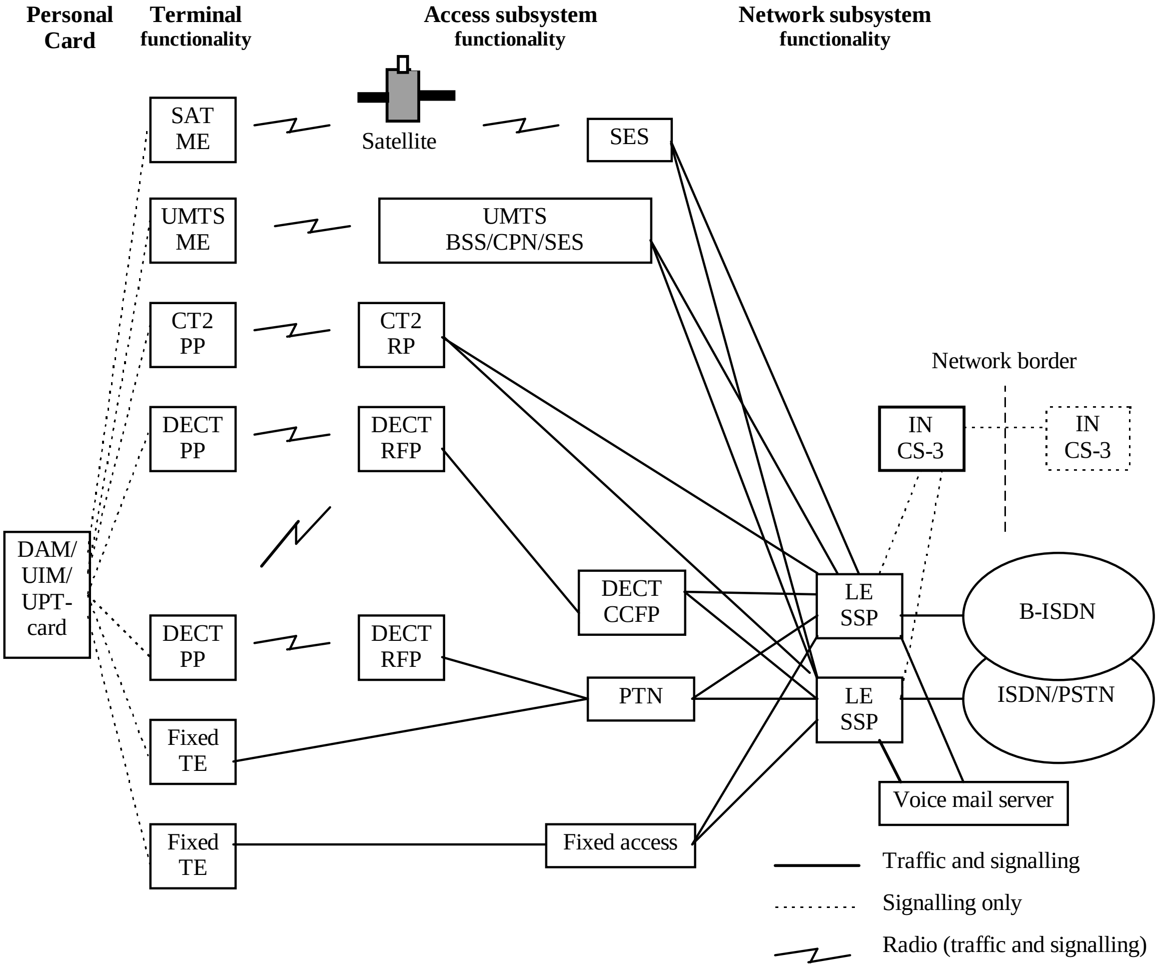

Figure 13. Fixed network evolution level 3

9.3.1.3.1 Evolution step B (Δ Level 2 -> Level 3)

The changes since Level 2 is described in the following:

Personal Card

UMTS UIM is introduced together with the UMTS terminals. This should be possible to use with all the different terminals in the figure. An enhanced DAM card is used with DECT terminals, and UPT is provided on the same card or on a separate card.

Terminal

A new UMTS radio interface and terminal with broadband capabilities is introduced which can handle bit rates up to 2 Mbit/s.

Access subsystem

Separate base station subsystems remains for each of the existing radio interfaces. A new BSS is introduced for UMTS covering both the terrestrial and the satellite access.

<u>Network subsystem</u>

In level 3 broadband capabilities are included, for the moment separated from the narrowband ISDN.

Global Mobility Management capabilities are supported by IN-CS3. The main goal of IN-CS3 is to provide a consistent reference architecture for open telecommunication systems encompassing operational and management services, integrating IN and TMN domains. It will also integrate B-ISDN multimedia multi-party services

The IN architecture was conceived to interact with existing network technology, introducing the required network adaptations to support supplementary services. Therefore, one of the proven advantages of the IN technology is that it can easily be incorporated into the present network infrastructure enhancing its added value. The centralised control proposed by IN-CS1 is not the most adequate for global mobility services. Although the IN-CS2 adopts a more distributed control, the current IN recommendations do not support the property of distribution transparency for the service components. IN-CS3 service architecture should be independent of any underlying network architecture.

The use of Object Oriented techniques and Distributed Processing Environments (DPE) will allow the provision of TINA-like solutions supporting UMTS service capabilities. The use of DPE will hide the underlying network architecture. The SIBs (Service Independent building Blocks) should be generalised to Object oriented techniques and the service control should be defined in terms of computational objects.

<u>Services and features</u>

Level 3 will be able to support part of the UMTS service capabilities.

Personal card roaming among the different access networks will be possible.

Service mobility, supported by IN-CS3, will be provided in the different access networks, only limited by terminal and access subsystem limitations.

9.3.1.4 Level 4

Level 4 (year 2005) will provide the full set of UMTS services including the broadband (up to 2 Mb/s) services via the UMTS radio interface to limited coverage areas. Level 4 UMTS systems will fulfil all UMTS requirements and is depicted in Figure 14.

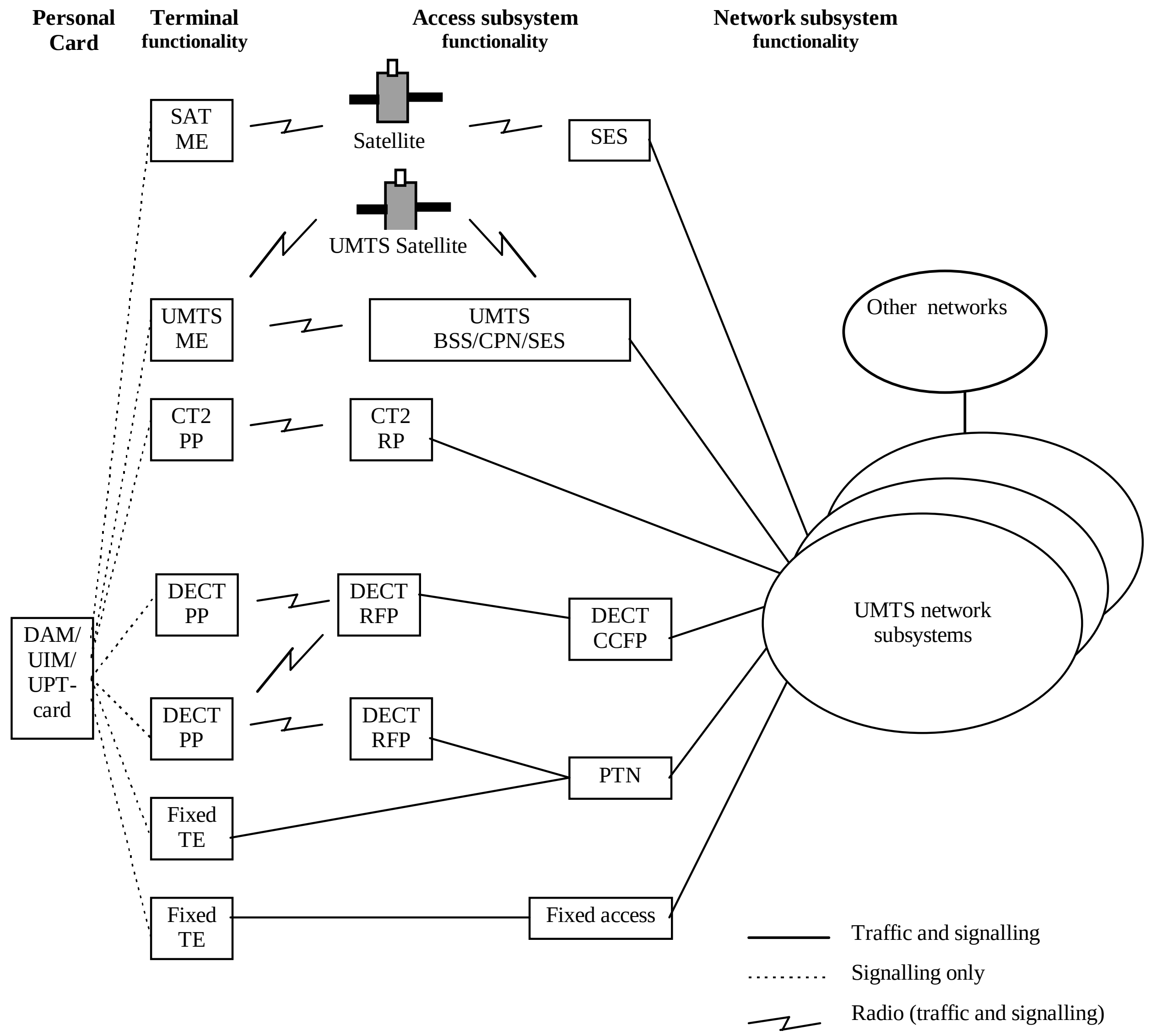

Figure 14. Fixed network evolution level 4

9.3.1.4.1 Evolution step C (Δ Level 3 -> Level 4)

The changes since Level 3 is described in the following:

Personal Card

The description for level 3 is valid also for this scenario.

Terminal

Multimode terminals, supporting two or more of the radio interfaces, will be used.

Access subsystem

A set of radio interfaces may be controlled by the same base station subsystem. The new UMTS satellite access is an integrated satellite system leaving the mobility- and service- control to the IN.

Network subsystem

Several different network subsystems are depicted in the figure , because it is unclear what structure the UMTS network subsystem will have. The network subsystems provide interworking capabilities to enable pre-UMTS access systems to be connected, in addition to the UMTS access subsystem. The mobility management is completely handled within these systems and full mobility with handover between different radio access systems should be possible.

Broadband capabilities including separation of bearer and call control and support for handover of bearers is required. The network subsystems will also have interfaces towards other networks established according to market requirements.

10 Impacts of evolution on users and networks

The migration principles to be defined from GSM, DECT or S-PCS into UMTS services deployed in the 2 GHz band need to be defined carefully, to control the costs for those operators who wish to evolve their existing systems towards UMTS and maintain a support of services deployed during earlier evolution phases. Especially consumer market users will expect to be able to use their terminals even as the systems evolve.

10.1 Definitions for the impact of evolution on users and networks

Compatibility with respect to interworking implies a degree of transparency sufficient to support an acceptable grade of service with respect to a connection which transits the interworking traffic. Full compatibility implies full transparency [ITU-T Rec. Q.300].

Interoperability can be defined as the ability of multiple entities in different networks or systems to operate together without the need for additional conversion or mapping of states and protocols. [ITU-T draft Rec. I.11x] This implies compatible networks interoperating without the need for interworking functions.

Interworking can be defined as the means of supporting communications interactions between entities in networks or systems that are not fully compatible (based on ITU-T draft Rec. I.11x).

10.2 Interworking

10.2.1 Inter-system interworking

The benefits of inter-system interworking are self-evident. Today it is possible to use a mobile phone and place a call to virtually any place in the world. This call may pass through several networks using a variety of technology. The same goes for a call terminating in a mobile network. Clearly UMTS must be capable to provide voice as well as data services to and from other networks.

10.2.2 Intra-system interworking

There is potential for terminal equipment operating within UMTS to obtain services and interoperate with networks, such as GSM, which are based on earlier technologies. On the network side, an equivalent degree of interworking can be provided (e.g. single billing, intersystem handoff).

Intra-system interworking may be of value in a scenario where the earlier system has coverage where UMTS does not. This may, for example, occur during the early phases of UMTS deployment. At that time, the GSM and DCS1800 coverage in Europe will be widespread. A very high percentage of the European population will have the possibility, subject to subscription, to gain access to the services of GSM and DCS1800. In these circumstances, it is reasonable to expect that during the initial limited deployment of UMTS, the widespread pre-UMTS networks could complement UMTS service offerings. Techniques which enable UMTS and pre-UMTS networks to co-operate together for the benefit of users and subscribers would be applicable in the scenario described.

Intra-system interworking may also be of value where a particular deployment of UMTS provides service capabilities which are complementary to those of the earlier system. An example scenario could be where an operator offers digital data services according to the UMTS standards, and uses a pre-UMTS network to provide voice services. In this scenario, UMTS users access services from both the UMTS and the pre-

UMTS network according to the desired service capabilities and user selection. Techniques which enable both networks to co-operate together would be applicable in this scenario.

The identification of specific techniques for intra-system interworking and the level of standardisation of these techniques are for further study.

10.3 Compatibility

UMTS is introduced at level 3. Since UMTS at level 3 may not be supported by a full set of UMTS standards, some limitations or deviations in level 3 compared to level 4 (full set of UMTS standards) may appear. Services/functions introduced at level 3, not covered by the first set of standards and later not conforming to level 4 standards, can be maintained at level 4 by interworking to non-UMTS standard system parts, as long as it is found appropriate to support those services/functions.

After this one can expect UMTS to evolve through level 5, 6.... each level providing new enhancements and service capabilities to the UMTS standards (cf. GSM phase 2, GSM phase 2+ relative to the GSM standard). Each UMTS service provider will decide on which services to offer, when to deploy them and how long to maintain then, within the legal framework.

UMTS should provide full compatibility between Level 3 and future levels, in the sense of preferably not loosing any service capabilities when evolving. If this puts serious restrictions or constraints to the further evolution of UMTS, interworking mechanisms should be seriously considered as an alternative. Full compatibility between UMTS and pre UMTS-systems is not anticipated.

10.4 User aspects - Maintaining access to services deployed in earlier evolution phases while the system evolves

Investments made by the community of users (terminals, applications) should be recognized. The access possibilities to services deployed in earlier evolution phases should be maintained as long they do not put serious restrictions or constraints to the further evolution of the system.

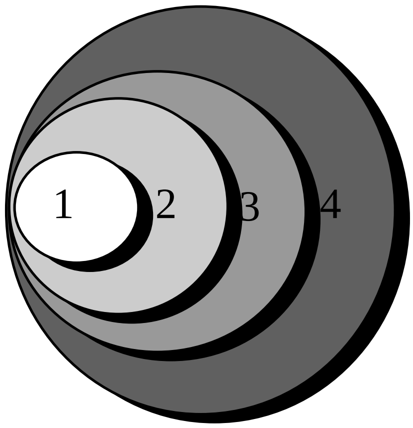

Figure. 15 Service set/service capabilities diagram

The service set diagram, as in figure. 16, illustrates the ideal (user perspective), but possibly not optimal (system perspective), evolution of services and service capabilities, where the level n services will be a subset of consecutive levels. For a description of the four levels, please refer to section 9.1.2.

From a user point of view, a level n terminal will work and offer level n services as long as the level n technology is supported by the network. When level n technology not longer is supported, the corresponding services will be offered by level n+1 or newer technology and the user will migrate.

10.5 Compatibility vs. interworking

Compatibility and Interworking are two different strategies of making systems or system components operate together. The systems can be made compatible, and there will then be no need for mapping of messages and states between them. But in order to achieve compatibility the network protocols have to be similar, and the first system will constrain capabilities of the new system. The other strategy is to let the systems operate together by means of interworking. This implies some overhead in order to perform the mapping from one systems messages and states to the other, but has the advantage that the new system can be designed independently of the previous and the weaknesses and constrains from the former system can be avoided.

UMTS is introduced at level 4 as a finalised new standard. Therefore one has to differentiate between the evolution steps up to level 4 and the evolution steps after level 4 (the same applies for those areas covered by level 3 UMTS standards). From an operators point of view it will be desirable to keep pre-UMTS users when UMTS is introduced. The user must then be able to keep his terminal, services and coverage as long as it is desirable. The UMTS system will provide new functionality and this functionality must not be constrained by the requirements of fully supporting pre-UMTS systems. Interworking between UMTS and the pre-UMTS systems is therefore the desirable solution. The future evolution steps ahead of UMTS should be forwards compatible in order to reduce the investments of upgrading the UMTS system.

The same situation will probably occur when 4th generation systems is to be introduced, interworking with the UMTS systems and compatibility forwards from the 4th generation system will be desirable. The figure below illustrates the relation between compatibility and interworking within and between systems.

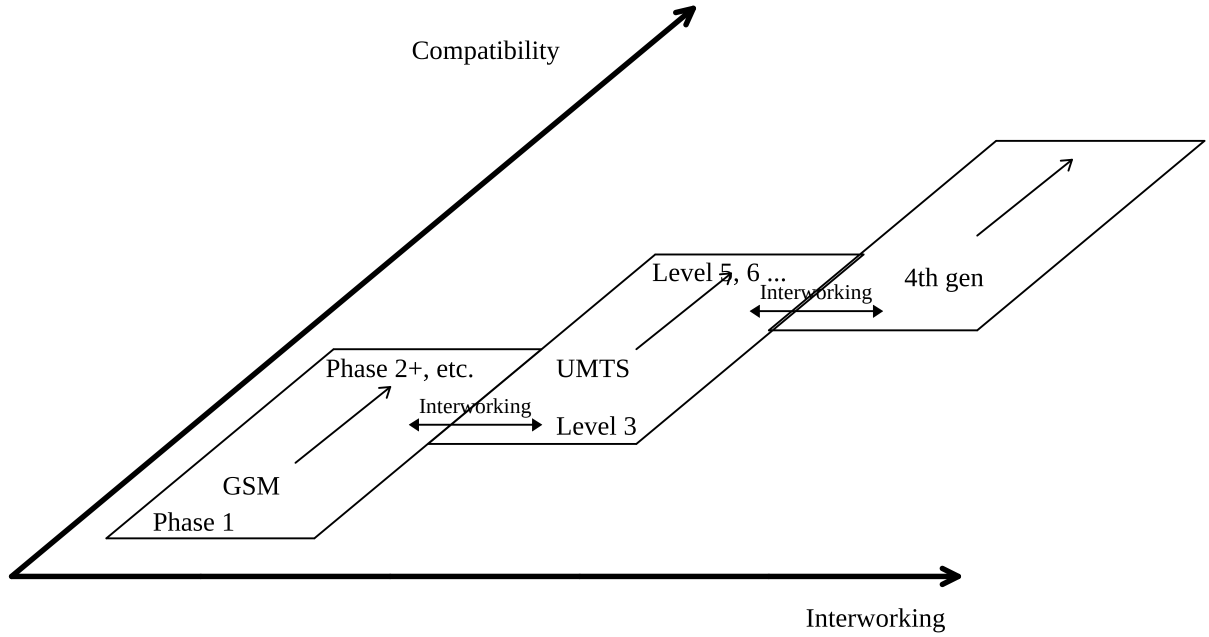

Figure 16 : Interworking and compatibility with respect to evolution

11 New technologies supporting evolution

11.1 Basic means for evolution

- Integration of portions of existing pre-UMTS systems.
- Virtual home environment.
- Service interworking.
- UIM/SIM roaming.
- Adaptivity of terminals. Offers software-driven flexibility for adaptation of a range of radio interfaces and service coding schemes.

11.2 Virtual Home Environment (VHE)

Virtual home environment is a system concept for service portability in UMTS across network borders. Service offerings in a visited network could differ from those of the home network. However, the visited network should be able to emulate for each user their home system, network, in such a way that these users will not notice the fact that they are no longer in their respective home networks.

There is a need to encompass diversification of services and innovation within the mobile systems. However, a user may wish to use services or a personalized set of services, regardless of the access or transport networks involved, subject to possible limitations.

VHE emulates the user's home system or network in such a way that these users will not notice the fact that they are no longer in their respective home networks. The primary aim is to provide the user with a comprehensive set of services, features and tools, which have the same look and feel whether they are used at home or somewhere else. VHE is providing support of:

- service portability between different UMTS networks;
- emulation of pre-UMTS services;
- the means for network operators, service providers and users to re-use existing systems capabilities to define their own specific features/services;
- interoperability between UMTS and pre-UMTS;
- a personalized service set being used via all UMTS networks;
- user personalization of features/services;
- a generic standard set of service network capabilities and including access capabilities (deployment will be network dependent).

The following are some of the key issues (not an exhaustive list) that need to be addressed in the UMTS to support the Virtual Home Environment :

- The standardisation of a set of resource servers, universally accessible from client processes, via open, standard primitives.
- Emulators, to facilitate migration and inter-regional operability.
- Standardised syntax and semantics for control logic (service, access, mobility, etc.) to enable system wide execution.
- Security controls for access to resources, and for inter-process communication, especially across network boundaries.

11.3 Adaptivity of terminals

Adaptive transceivers are now being researched / developed which will enable a single mobile terminal to identify and operate over a range of radio interfaces. Such a terminal should form a keystone of UMTS design, especially for its initial deployment.

The radio interfaces may differ in radio frequencies (e.g. from around 800 MHz to around 2 GHz) and the multiple access principles used covering access to terrestrial as well as satellite components. The required software can be downloaded into the terminal via radio interface, via smart card or by other means.

Similarly, techniques are now being researched / developed to move service control out of the mobile terminal into the UIM, to remotely configure that software over the radio interface and to apply UIM software modifications via the radio interface. This is needed to reduce the amount of control logic in the terminal, thereby reducing cost and the need for reprogramming.

11.4 Distributed storage and processing

Storage architectures in UMTS can benefit from enabling technologies like fully distributed databases. A DDB will be characterized e.g. by

- emulation of a single centralized database, thus easing access to it for queries and administration,
- hardware and operating system independence, thus allowing reuse of different platforms like e.g. HLRs, SDPs,
- data location independence and transparency, e.g. supported by data dictionaries,
- data fragmentation and replication independence.
- providing an access and an internal inter database node protocol.

Processing can be enhanced by introducing distributed processing environments as proposed in TINA. TINA is mainly based on the ingredients of strict object orientation and distributed computing environment.

12 Level 3, the first goal for the evolution towards UMTS

The scenarios in chapters 9.2 and 9.3 indicate that it is possible to evolve into UMTS from a mobile or fixed network. Following an evolution path towards UMTS, the changes in pre-UMTS networks and techniques will come in small increments. However, to fulfil UMTS objectives some revolutionary aspects need to be added before UMTS Level 3 is achieved.

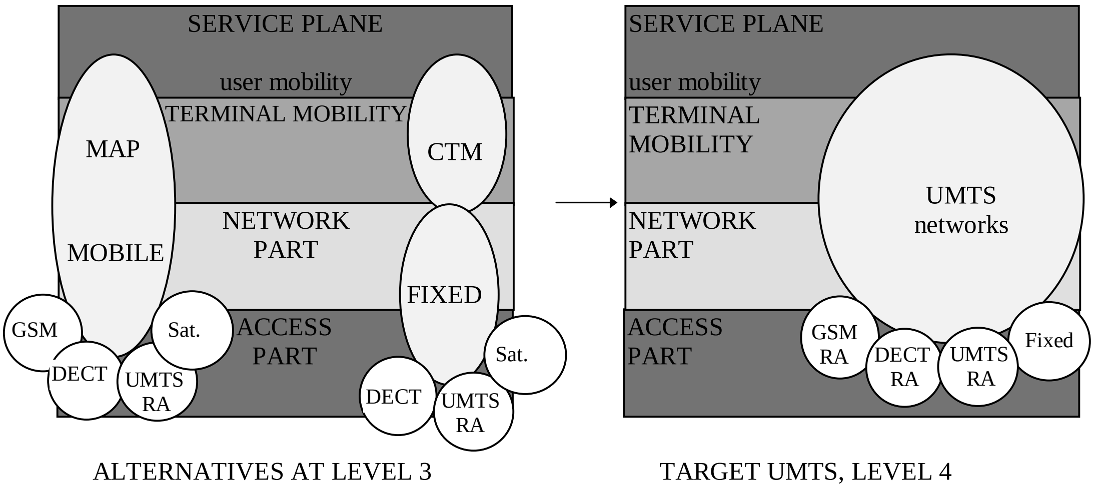

Figure 17: Commonalities between evolution tracks (left hand side) and target UMTS. The access bubbles shown are examples, and include RLL.

At Level 3, the introduction of UMTS, a revolutionary radio access and a revolutionary integrated service concept are introduced. Service plane and access parts are the same in both Level 3 alternatives, transport/network parts and mobility management principles differ.

Towards level 4, the Radio Access (RA) parts will be maintained and re-used as long as there is a market for the use of the specific access technologies. UMTS level 4 will also be able to handle service provision, user mobility and terminal mobility in an integrated way independent of the RA over the network part to be defined.

12.1 Dependence on pre-UMTS systems

The SMG study on UMTS frequencies concludes that no more than 2*60 MHz FDD , 1*15 MHz TDD and 1*20 MHz TDD will be available for the terrestrial part of UMTS. This is significantly less than the allocations for the pre-UMTS systems GSM, DECT and DCS 1800. With less bandwidth than today's narrowband systems, it can not be expected that UMTS on its own can provide both narrow- and wideband services to a growing market, without the support of these pre-UMTS systems.

The UMTS access network should be designed to primarily support bearers with higher bandwidths than DECT and GSM can provide or is optimized to provide. Close interworking mechanisms between DECT, GSM and UMTS will provide the users with a complete set of services, integrated mobility management, integrated billing, etc, subject to regulatory constraints.

12.2 The evolution from Level 3 towards Level 4

Evolution from level 3 to level 4 will depend on market requirements. A possible scenario in the longer term timescale is a convergence of some concepts, adding more and more commonalties between the two identified evolution paths.

13 Impact on ETSI and ITU standardization

This clause states some recommendations for UMTS standardization. Some recommendations are also valid for ITU standardisation.

13.1 Influence on UMTS work programme

13.1.1 Considerations on migration/evolution in UMTS standards

All key decisions regarding UMTS, including all UMTS ETS/ETR/TCTRs, must take into consideration migration/evolution strategies of all relevant pre-UMTS wireless techniques. (pre-UMTS techniques as materialised and evolving as DECT, GSM and DCS1800 in Europe, as cellular and PCS in North America and as PDC and PHS in Japan, and emerging mobile satellite systems.).

TC SMG should ensure the European influence on FPLMTS in regions outside of Europe. This includes to propose a phase approach of FPLMTS, in order to be aligned with UMTS. The first phase should be focused on roaming and service provision between regions using different implementations of FPLMTS.

13.1.2 Re-use of existing standards

Re-use of existing standards in UMTS is an important concept, including standards in and outside the mobile sector that:

- can be used without modification;
- should be modified.

A new ETR containing a list of standards that can be reused for UMTS should be drawn up. Special attention should be given to a future common use of standards currently being developed in different standards bodies.

13.1.3 Level 3 standards

13.1.3.1 Proposal to standardise Level 3

Standardisation of a limited set of UMTS standards for the first introduction of UMTS (Level 3) is needed. It is very important to formally distinguish between describing Level 3 Mobile, Level 3 Fixed and Level 4 UMTS, in order to set clear goals for the individual standardisation activities and avoid differences in focus from the involved parties in the standardisation process. In the UMTS work program Level 3 (scheduled for operation in 2002) and Level 4 (scheduled for operation in 2005) should be shown and clearly separated.

13.1.3.2 Targets for Level 3 standardisation

In the migration study, discrepancies between the two identified main evolution tracks have been seen. There exist however commonalties that could be useful for the standardisation of UMTS Level 3:

- The UMTS access network, as defined in subclause 9.1.3;
- The IN-based service provision as described in clause 12.

NOTE: These standards will fulfil Level 4 requirements, although they will at level 3 not form of a complete set of UMTS standards.

UMTS level 3 should be designed to facilitate interconnection of different access systems(DECT/GSM/UMTS) to different network platforms and provide integrated service offering, mobility management and billing within the relevant network platform .

From a migration point of view, service control and mobility management can be separated at Level 3.

13.2 Influence on UMTS concepts

13.2.1 Relation to pre-UMTS systems

UMTS should provide significant benefits to network operators compared to Level 1 and Level 2 systems, in order to meet anticipated market needs. If the UMTS standards shall be able to do this, they must not be pre-UMTS constrained. However, the evolution of existing networks towards UMTS should be possible, without incurring unnecessary expense and to a schedule which is market driven.

TC SMG and SMG5 should clearly distinguish between UMTS and pre-UMTS standards. It should be considered whether UMTS techniques need to be integrated with pre-UMTS techniques. Thus UMTS techniques would be positioned not only as integrating pre-UMTS service capabilities, but also as an high-end extension (adding wide-band capabilities) to pre-UMTS infrastructures.

13.2.2 Flexibility of UMTS standards

UMTS standards should be developed with the level of detail necessary to satisfy anticipated market requirements, but still allowing differentiation and competition differentiation and competition among manufacturers and among operators. Furthermore, UMTS standards should be flexible (technology agile) enough to allow evolutionary strategies and to reflect end-user needs at the market.

13.2.2.1 Information processing

The definition of UMTS based on a fully flexible distributed processing environment should be considered. The choice of information processing environment and its influence on migration feasibility is for further study

13.2.2.2 Functional models

The functional models of UMTS should be truly implementation-independent. The mapping of these functional models on the functional model of the evolved components of the different migration paths to UMTS will enable the identification of new requirements on standards in order to ensure the desired evolution. Such a process should however try to avoid to constrain the target UMTS functionality.

13.2.2.3 Radio bearer adaptation

To facilitate the evolution of the radio access system, a radio bearer adaptation functionality should be defined. This functionality encourages commonality and effectively decouples the access network from the core network.

13.2.3 Modularity

A modular approach should be considered in forthcoming work on UMTS. The generic access concept provides one means to achieve modularity in the UMTS standard.

13.2.4 Terminology of UMTS

UMTS standards should use appropriate terminology which does not imply any single migration path to UMTS. New terms emerging from the migration study should need to be included in the UMTS vocabulary ETR [1].

13.3 Influence to and from other groups

13.3.1 Input from European research programs

European research programs (e.g. ACTS) are encouraged to provide inputs to the standardisation of UMTS, taking also migration/evolution into account.

13.3.2 European Information Infrastructure (EII)

UMTS should be recognized as one mobile access to EII, providing radio access and mobility to services requiring bit rates up to 2 Mbits/s.

History

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