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Foreword

This ETSI Technical report (ETR) has been produced by the Network Aspects (NA) Technical Committee of the European Telecommunications Standards Institute (ETSI).

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. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

Introduction

It is possible to specify third generation mobile communications functionality as an integral part of the fixed network. One of the advantages of this integration is that mobility features for the third generation mobile systems will benefit from the flexible service control including generic mobility management capabilities in Intelligent Network (IN) and the advanced call and bearer control facilities offered by Broadband Integrated Services Digital Network (B-ISDN) backbone networks.

Also the relation of Asynchronous Transfer Mode (ATM) as the transfer mode and the second generation mobile networks, especially Global System for Mobile Communications (GSM) needs to be considered. Application of ATM in second generation mobile systems provides some advantages, especially in data services and transport. Compared with traditional circuit-switched connections used in GSM transport network, ATM saves capacity as data is transmitted in packets only when needed. The circuit-switched connection is reserved also when there is no data to be transmitted. A further improvement in the efficient use of transmission capacity is achieved by the introduction of the ATM Adaptation Layer for Composite User information (AAL-CU).

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1 Scope

The scope of this ETR is to analyse different aspects of the integration of mobile networks and B–ISDN in order to derive requirements for B-ISDN. This ETR does not intend to give a in depth-analysis of the requirements but an high level overview on possible future requirements from mobile systems to B-ISDN. A detailed discussion of particular aspects will be published in future deliverables as soon as this seems to be appropriate.

Aspects addressed in this ETR are related to:

- integrated wireline and mobile access to B-ISDN;
- network support for B-ISDN service provision to users of mobile networks;
- wireless extensions to B-ISDN;
- interworking of B-ISDN with public mobile access networks.

2 References

This ETR incorporates by dated and undated reference, 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 these 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: "Special Mobile Group (SMG); Vocabulary for the Universal Mobile Telecommunications System (UMTS) (UMTS 01.02)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETR the following definitions apply:

NOTE: The following definitions are based on ETR 309 [1].

base station: A base station is the network side termination of the radio link between mobile termination and (access) network.

radio cell: Geographical area served by one base station.

handover: Is the process of changing connection elements. Handover is necessary to allow mobile stations to move among radio cells while maintaining the call. Handover does not alter the status of the call.

macro cells: In a layered structure of radio cells, the largest type of terrestrial radio cells are called macro cells. The geographical area of a macro cell may cover the geographical area of several micro or pico cells. The typical radio cell radius is < 5 km. Macro cells can be used to provide country wide coverage.

macro diversity: Possibility to maintain two parallel (radio) connection elements via the access network belonging to one call. The two connection elements carry identical information items and are merged in the fixed network into a single connection.

micro cells: Small radio cells with a diameter of up to 500 m typically 100 metres. Micro cells are typically used to provide high capacity in high traffic density area. Global coverage is not aimed at.

mega cells/satellite cells: Radio cells covering diameters of 100 km and up. Usually satellite cells.

mobile station: The mobile telephone.

mobile termination: Network termination point at the mobile station.

paging: Paging can have two meanings:

- Paging as part of the incoming call set-up: When a mobile station is being called the base station where it is thought to be located currently emit the stations identifier for it to get in contact with the nearest base station;

- Paging as telecommunication service: Is a telecommunication service where an indication, or numeric indication or alpha numerical string is send to a paging terminal (ERMES, EUROSIGNAL, Citiyruf, etc.).

paging area: The coverage area of the base stations involved in the paging.

personal mobility: The possibility for a person to register on different terminals with the same personal number. (e.g. provided as part of the UPT service).

pico cells: Radio cells with a diameter of tens of metres. Usually in-house.

radio interface: The physical link between base station and mobile station. Part of radio interface specifications are the lower layer protocols to control the radio interface parameters such as transmit power, time advance, frequency, time slot, etc.

seamless handover: A handover which is undetectable by the mobile station user.

tandem coding: In a cellular mobile-to-mobile call, the coded voice packets are:

- decoded in originating BSS;
- switched as 64 kbit channels in NSS;
- coded again in terminating BSS.

Such repeated coding creates delay and reduces voice quality.

terminal mobility: The ability of a terminal to change point of attachment to the network without changing its identity or alteration of the status of a call. In mobile networks the change of the attachment point can happen seamlessly.

3.2 Abbreviations

For the purposes of this ETR the following abbreviations apply:

AAL	ATM Adaption Layer
AAL-CU	AAL for composite user information
ATM	Asynchronous Transfer Mode
BCAF	Bearer Control Agent Function (relates to MBCF, RBCF)
BCF	Bearer Control Function
BER	Bit Error Rate
B-ISDN	Broadband ISDN
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CBR	Constant Bit Rate
CCAF	Call Control Agent Function
CCF	Call Control Function
CDMA	Code Division Multiple Access
CTM	Cordless Terminal Mobility
DCS1 800	Digital Cellular System at 1 800 MHz
DECT	Digital European Cordless Telecommunications
FPLMTS	Future Public Land Mobile Telecommunications Systems
GSM	Global System for Mobile Communications
IMT-2 000	International Mobile Telecommunications
IP	Internet Protocol
ISDN	Integrated Services Digital Network
IWF	Inter Working Function
MBCF	Mobile Bearer Control Function
MCCF	Mobile Call Control Function
MCF	Mobile Control Function
MRRC	Mobile Radio Resource Control

MRTR	Mobile Radio Transmission and Reception
MSC	Mobile Switching Centre
MSF	Mobile Storage Function
MT	Mobile Terminal
N-ISDN	Narrowband ISDNNSS Network Subsystem
NNI	Network Node Interface
PCS	Personal Communication System
PSTN	Public Switched Telephone Network
RACF	Radio Associated Control Function
RBCF	Radio Bearer Control Function
RFTR	Radio Frequency Transmission and Reception
RLL	Radio Link Layer
RRC	Radio Resource Control
SCAF	Service Control Agent Function
SCEF	Service Creation Environment Function
SCF(M)	Service Control Function (Mobile)
SDF(M)	Service Data Function (Mobile)
SIM	Subscriber Identity Module
SMAF	Service Management Access Function
SMF	Service Management Function
SRBCF	Special Radio Bearer Control Function
SRF	specialized Resource Function
SSF	Service Switching Function
TACAF	Terminal Access Control Agent Function
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
UMTS	Universal Mobile Telecommunication System
UNI	User Network Interface
VBR	Variable Bit Rate
VAD	Voice Activity Detection

4 Introduction to mobile networks

4.1 Introduction to UMTS and FPLMTS

Within Europe and world wide analogue mobile telecommunications is in a mature state. Newer, more efficient, higher capacity digital networks are now emerging. These two types of systems are commonly termed first and second generation systems respectively.

It has been appreciated that whilst second generation systems (such as GSM and Digital European Cordless Telecommunications (DECT)) will meet the needs of mobile telecommunications for some years to come; new higher capacity, lower cost, service and feature rich networks will be necessary to meet the needs of the coming decades. These third generation systems to be are variously known as the Universal Mobile Telecommunication System (UMTS) or the Future Public Land Mobile Telecommunications Systems (FPLMTS). FPLMTS is also known as International Mobile Telecommunications (IMT-2 000). UMTS will be specified within the TC SMG. Commonality and compatibility of UMTS with FPLMTS is intended to the largest extend possible. The share of mobile telecommunications in the telecommunications market is increasing (a market share of 50 % is widely quoted within the industry). It is therefore a logical step to reduce, or even remove, the distinctions between wired and wireless telecommunications, and indeed work towards functional integration of the distinct cellular, cordless and fixed networks.

This approach is being embraced by bodies both within Europe (ETSI TC SMG for UMTS) and world-wide (ITU-R TG 8/1 for FPLMTS/IMT-2 000) which are working on standards for third generation mobile systems targeting at an implementation early in the new decade.

4.1.1 Basic architecture of UMTS

For service, call and connection control, the IN concept is applied. As can be seen from the following figure taken from DTR/SMG-500301U an IN-like architecture has been adopted and IN techniques are anticipated for the support of mobility procedures (e.g. location management, handover control, paging).

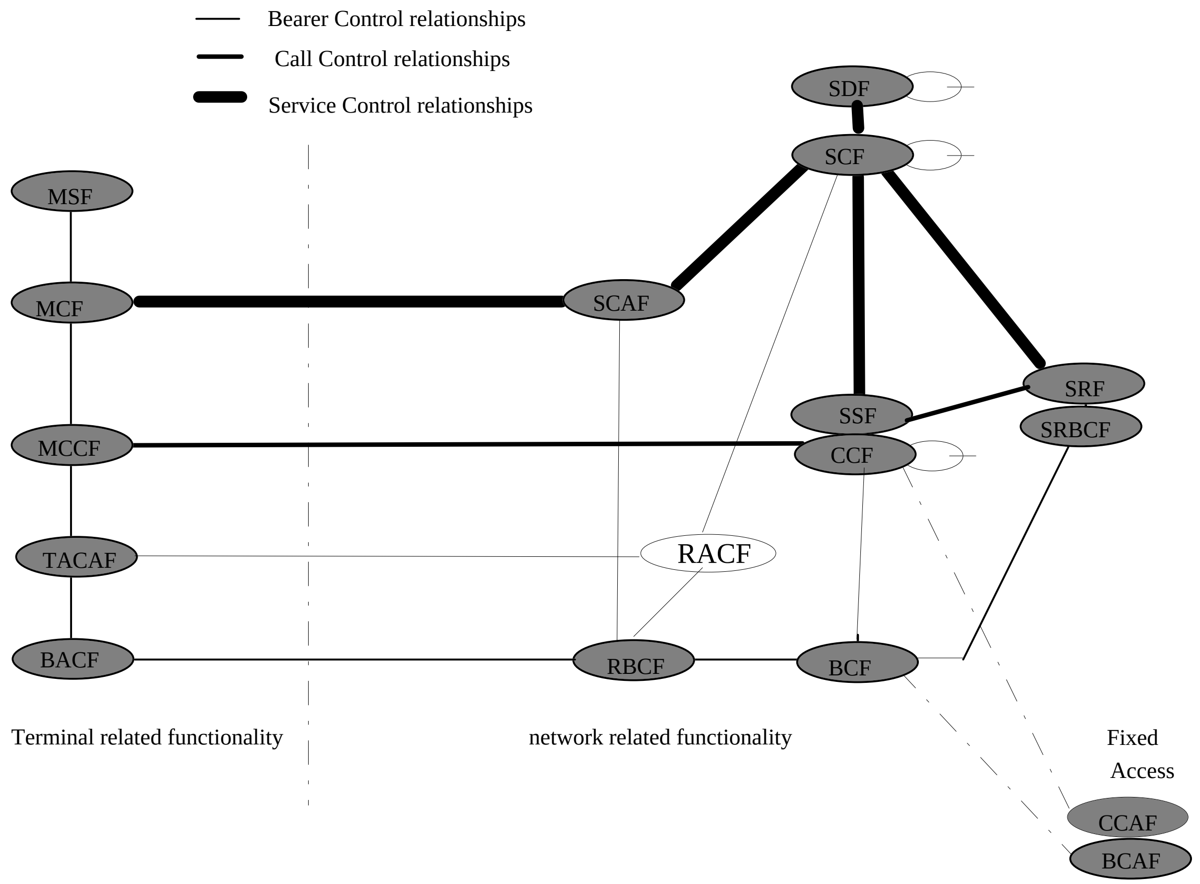

Figure 1: The UMTS functional model

Also visible in figure 1 is the assumption of separated call and connection control.

NOTE: Further explanation of the abbreviated functions can be found in DTR/SMG 050301U.

The flexibility given by separation of call and connection control in UMTS is essential for handover. The definition of handover from a network point of view illustrates why the separation of call and connection control is essential: "handover is the process by which one or several connection elements are replaced by one or several other connection elements". During a handover, however, a call does not change its state. Therefore, handover control should be able to perform the replacement of the connection(s) independently of the call and its state.

4.1.2 Advantages of integration of UMTS functionality in B-ISDN networks

Integrating UMTS with B-ISDN has several potential advantages. First, the same services as provided in B-ISDN can be made accessible for UMTS users - respecting bandwidth limitations due to radio transmission (e.g. 2M bit/s). Bearer services in UMTS include all B-ISDN bearer service categories. The user can thus transparently:

1) access identical services in cellular and wired communication networks;
2) connect to private and public networks;
3) move through all environments;

while being reachable and able to make calls.

Integration of B-ISDN and UMTS improves quality by using ATM as transport mechanism. This is because ATM can provide faster handover, mobility, flexibility, and lower Bit Error Rates (BERs) and delays. Lastly, integration reduces operational costs by shared use of infrastructure, protocols, functions, etc. by UMTS and B-ISDN.

In urban environments, a higher radio resource reuse is required, leading to micro (and even pico) cells, putting requirements on the base station interconnecting backbones. Especially for mobile operators that use leased lines for the interconnection of the network elements, it is of prime importance to manage the fixed part of the access network as a scarce resource.

The flexibility required from the mobile network infrastructure increases. It does not only have to cope with the increasing mobile traffic, but also with the mobile characteristics of it in terms of traffic distribution (e.g. public manifestations, rush hours, traffic jams on the highways,...).

Mobile communications have a growing importance in the overall telecommunication traffic, by which the network integration of mobile and fixed networks becomes an issue for the reduction of the cost of ownership for the operators. Currently, mobile infrastructures are largely independent from the fixed network communication backbones (overlaid networks).

4.2 The relation between 2nd generation networks and UMTS

UMTS can be viewed as a service offering system– not a network. Furthermore, UMTS can be viewed as a framework of cellular and fixed networks. This reminds us actually of the concepts of United States (U.S.) Personal Communication System (PCS) where there is similarly a cellular approach and fixed network approach. After year 2 000, the UMTS services will be provided from a variety of networks. To enable the evolution, UMTS functions can be realized by several, alternative protocol stacks. Exclusive solutions (only one option provided) should be used only when other solutions appear too complicated.

Although we cannot exactly predict at this moment which UMTS services/facilities cannot be met by the migration procedure we can already foresee that part of the UMTS services could be provided in the evolutionary second generation mobile networks. In fact, a number of innovative UMTS services and features are already being adopted by the GSM networks. The GSM Phase 2+ work items include topics such as GSM/DCS1 800 roaming, operation of dual band GSM/DCS1 800 by a single operator, DECT access to GSM, interworking with non-GSM applications on the SIM, radio local loop (RLL), fast call setup (UIC), group calls (UIC) etc.

The further evolution of GSM/DCS1 800 can comprise the introduction of a new (UMTS) air interface, increased bit rates and enhancement of the MAP to fulfil the UMTS system requirements, and more flexibility in transmission by use of ATM. Potentially, also new base station system technologies might be introduced. Cost-efficiency can be achieved by installing the new UMTS base stations at existing base station sites. Gradually, GSM evolves and in the end it will be able to provide also UMTS service.

Another evolution track can be seen via PCS. PCS has been allocated part of the FPLMTS spectrum in the U.S. so it will inherently constitute one evolution track to FPLMTS (and UMTS). PCS might also be regarded as an early implementation of FPLMTS. In PCS, there are two approaches: one based on the mobile networks and the other based on the fixed networks. Both approaches lead to the same service. PCS is also likely to have multiple air interfaces and it will be flexible in terms of modularity.

Figure 2 depicts the dual track evolution to UMTS.

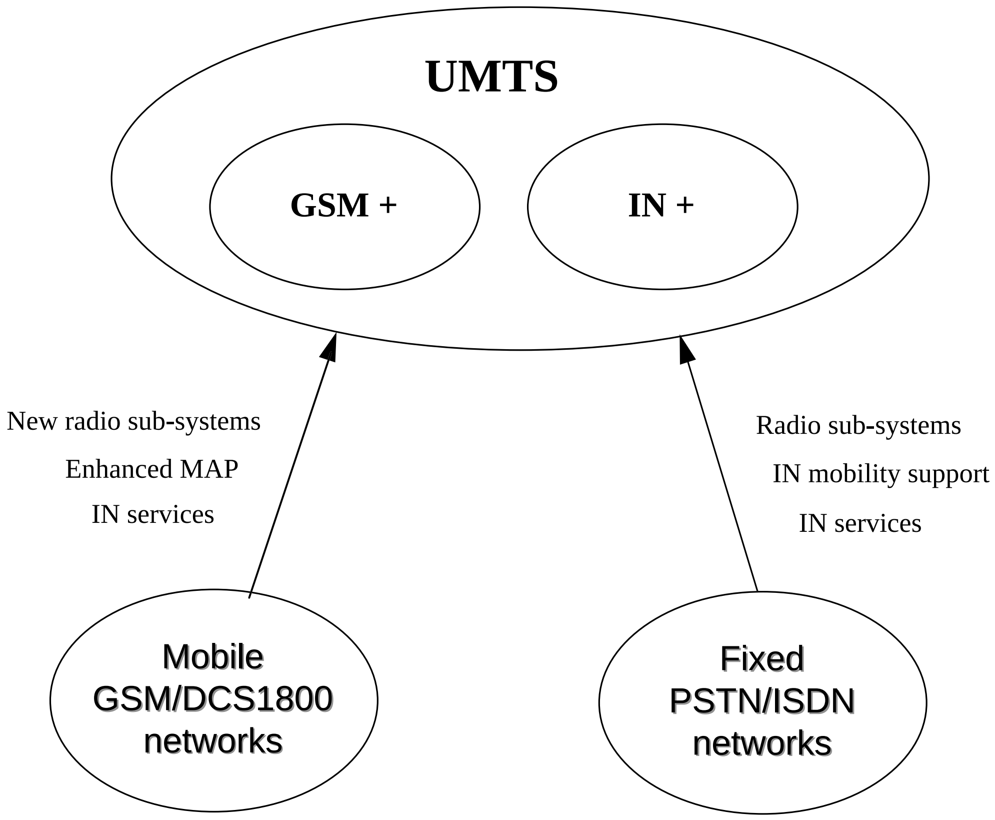

Figure 2: Dual track evolution towards UMTS

4.3 GSM

The GSM is a pan-European Public Land Mobile Network (PLMN). The network offers to its users a range of digital services and facilities, both voice and non-voice, that are compatible with those offered by fixed networks. The facilities it provides include automatic roaming, locating and updating of mobile subscribers. GSM has been designed as an access network for mobile subscribers to the fixed telecommunication networks. Although the objective of the design was that ISDN is the interworking network, so far in most cases Public Switched Telephone Network (PSTN) is the co-operating network.

4.3.1 GSM data services

GSM provides the following bearer services:

- data circuit duplex asynchronous: 300, 1 200, 1 200/75, 2 400, 4 800 and 9 600 bit/s (T/NT);
- data circuit duplex synchronous: 1 200, 2 400, 4 800 and 9 600 bit/s (T/NT);
- pad access circuit asynchronous: 300, 1 200, 1 200/75, 2 400, 4 800 and 9 600 bit/s (T/NT);
- data packet duplex synchronous: 2 400, 4 800 and 9 600 bit/s (T/NT);
- alternate speech/unrestricted digital. The service facilitates swapping between speech and data during call (T/NT);
- speech followed by data. After a certain amount of time with speech connection the user can switch to data connection during the call. No swapping back to speech is possible (T/NT);
- 12 kbit/s unrestricted digital. The service can only be used inside the GSM network.

The connection can be transparent (T) or non-transparent (NT). The former type transfers the data without trying to correct possible transmission errors which are quite common to radio connections. The latter packetizes the data into Radio Link Protocol (RLP) frames and in case of an error, the packets are retransmitted. This, of course, decreases the net speed.

The teleservices such as Fax group 3 uses one of these bearer services for the transmission through the GSM network. With the exception of 12 kbit/s service, all the services are based on the asynchronous and synchronous transparent or non-transparent services up to 9 600 bit/s.

In addition, the following teleservice can be considered important from the viewpoint of data services. Short Message Service Mobile Terminated/Point to Point (SMS-MT/PP). The messages can be transmitted from the short message service centre to a single mobile station. Size of a point-to-point message is 140 octets (or 160 7 bit ASCII characters).

Short Message Service Mobile Originated/Point to Point (SMS-MO/PP). A mobile station can send a message to another mobile station. Size of the message is 140 octets (or 160 7 bit ASCII characters).

Short Message Cell Broadcast (SMS-CB). A message is broadcast to all mobile subscribers inside a geographical area. The broadcast information can be 80 octets long.

4.4 DECT

The Digital European Cordless Telecommunications (DECT) is a standard provided for cordless communications for both voice and data traffic. The system consists of the Portable Part (PP) and Fixed Part (FP). No fixed infrastructure has been defined. The connection to the networks is made through InterWorking Unit (IWU), functions of which are defined in the DECT profiles. DECT typically offers micro and pico cells. DECT is candidate to provide CTM (cordless terminal mobility) service to public mobile users.

4.4.1 DECT data service classes

The data profiles are a group of separate DECT standards each defining a different type of service. The services are related to each other by forming a family tree of standards. There are six different DECT data service types, each of which has two alternative mobility support classes: for local area and roaming applications.

The six principal service classes are: A, B, C ,D ,E and F.

Type A service is a low speed frame relay service which has net sustainable uni- or bi-directional throughput up to 24 kbit/s. The service is optimized for bursty data, for low power consumption and low complexity of applications such as hand-portable terminals. It could be used, for instance, in local area networks (LANs) and from the application point of view for e-mail, file transfers, printing or remote terminal access. This specification contains interworking annexes to both Token Ring and Ethernet LANs.

Type B service is a high performance frame relay with uni-directional throughput up to 552 kbit/s or bi-directional up to 288 kbit/s and optimization for speed and latency with bursty data. The service can be used in LANs or metropolitan area networks (MANs). The type B equipment shall interoperate with the type A equipment. The applications are very much like with the class A while the B type can serve applications with high speed requirements such as multimedia. This specification contains interworking annexes to both Token Ring and Ethernet LANs.

Type C service provides non-transparent connection for data streams that require Link Access Protocol (LAP) services with optimization of high reliability and low additional complexity. For asynchronous data streams the service provides packet assembly/disassembly function. The service is built on the services A and B. Application examples are very similar to type A service. This specification contains currently interworking annexes to RS-232/V.24 and a generic bearer access services including interworking to PSTN modems.

Type D service is a transparent and isochronous connection of synchronous data streams. The connections are optimized for applications which require continuous data streams such as video.

Type E service offers a short message transfer or paging service which can be unacknowledged or acknowledged. The service is optimized for ultra low power consumption. Applications could be paging and telemetry.

Type F service is a profile designed for teleservices such as fax. It uses the services provided by types A, B and C. The F service is optimized for terminal simplicity, spectrum efficiency and network flexibility.

Currently, the DECT data services interworking is limited to LANs and PSTN modems. However, it is likely that in the future the interworking to ATM, X.25 and Internet Protocols will be defined. Also DECT/ISDN interworking profile exists providing interworking to narrowband ISDN including 64 kbit/s bearer services over the radio interface.

4.5 Radio interface evolution

The current and future evolution of the second generation radio interfaces have direct consequences for the fixed side of the mobile access networks.

Mobile operators invested heavily in the recent years. As a consequence, the reuse of existing investments is considered as of prime importance **(migration)**. This argument is most valid for the system parts closest to the radio interface: the base station sites, the base stations themselves, and the base station interconnection networks. Also, backward compatibility towards the existing users plays an important role in evolution. A requirement towards ATM based solutions is that they should allow gradual evolution or migration.

The **radio resource** is the limiting factor, while radio licenses form important assets, leading to **optimization** requirements. A basic principle hereby is that a communication channel should at every instance only receive the radio resources it requires, e.g. by flexible bandwidth allocation and adaptive coding. Future mobile backbones will have to support this, e.g. through the adoption of ATM.

In order to provide a complete radio coverage, in terms of capacity, services and radio cell types, different radio interfaces will have to co-exist. For instance in Europe, besides the macro-cellular GSM, DCS-1 800 and GPRS are emerging, while satellite access and DECT based CTM are being deployed. In addition, it can be expected that this gamma will be extended by new radio interfaces for 2 Mbit/s throughputs in the FPLMTS/UMTS frequency bands, or other intermediate GSM based solutions (HSCSD).

5 Use of ATM to upgrade GSM

The GSM network has internal methods and signalling to set up calls and handle the transmission. Therefore, the GSM network does not place stringent requirements on the B-ISDN functions, and a similar set of services as ATM offers will be sufficient.

One requirement is that the use of B-ISDN shall not increase the call set-up time. In ATM, a virtual channel can be set up permanently between the base station (BSS, see figure 3) and the controlling network element, and still the transmission capacity is not used until needed. At GSM call set-up, the ATM transmission capacity is immediately available. It might be necessary to allow for the use of unused DBR capacities of this permanent channel by other connections for an efficient use of ATM at bitrates below 64 kbit/s.

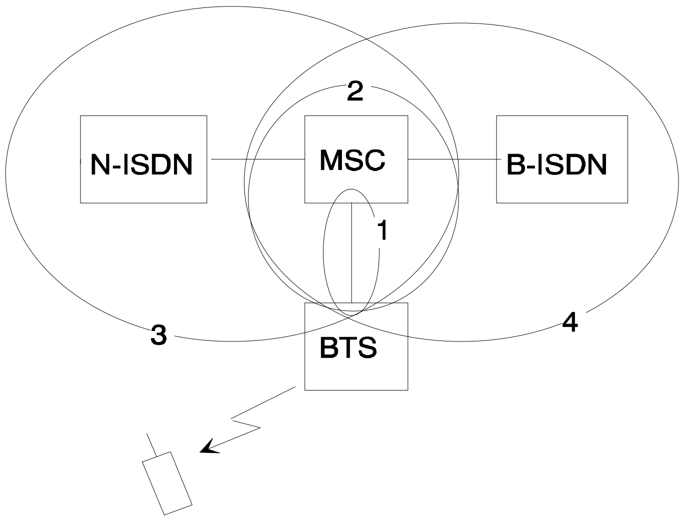

Figure 3: Several areas for the application of ATM in GSM can be distinguished (Numbers refer to the list below)

Application of ATM in GSM provides some advantages, especially in data services and transport. Compared with traditional circuit-switched connections used in GSM transport network, ATM saves capacity as data is transmitted in packets only when needed. The circuit-switched connection on the contrary is reserved also when there is no data to be transmitted. The effective use of the transfer capacities will be supported by the introduction of the AAL-CU (see subclause 7.3.2 for more information).

Several ways for the introduction of ATM into GSM are under consideration:

ATM transmission in GSM Base Transceiver Station (BTS). ATM transmission can be used for GSM by transmitting speech channels on ATM cells.

ATM switching. If single ATM cells contain only information for a single speech or data connection, the switching elements of GSM network can be ATM switches. ATM is a cost effective solution for large scale switching.

ATM transmission beyond the mobile network. If there are fixed networks with ATM connections, it is possible to route the ATM cells directly to the destination. Voice coding will be transcoded at a transcoding interface, as close to the destination as possible. This way the transmission saving (from coding and Voice Activity Detection (VAD)) extend as far as possible.

ATM routeing. If the origin and destination of a call are connected to the same ATM network, it is beneficial to route the ATM cells directly to the destination. This saves transmission capacity and also avoids tandem coding.

To use ATM transmission, the lowest layers of GSM protocol stacks in the fixed network (G.703, MTP-2) are replaced by ATM layers.

GS_1: The introduction of ATM in GSM may not require any changes at the radio side of the existing GSM network.

GSM is not an appropriate standard to allow for ATM via the radio interface, since the changes in GSM would be that significant, that the result would be a new standard and not a evolution of the former one.

6 DECT and ATM interworking

Because ATM will presumably be one of the main data transfer networks in the future, some level of interoperation between ATM and DECT could be considered. Two interworking options are illustrated in figures 4 and 5.

6.1 Intermediate system interworking

The intermediate interworking scenario consist of DECT Fixed Part (FP) attached to the ATM network and an ATM compatible terminal attached to Portable Part (PP). In this case DECT would be a cordless extension to the ATM network by plainly transferring the ATM cells across the radio interface. One solution could be to use the A/B or C data service profile for the ATM cell transfers. The selection of a profile depends on the bit error requirement. The ATM 53 byte cells can be transferred in two timeslots thus the maximum rate that could be accomplished would be over 400 kbit/s uni-directional on the radio interface.

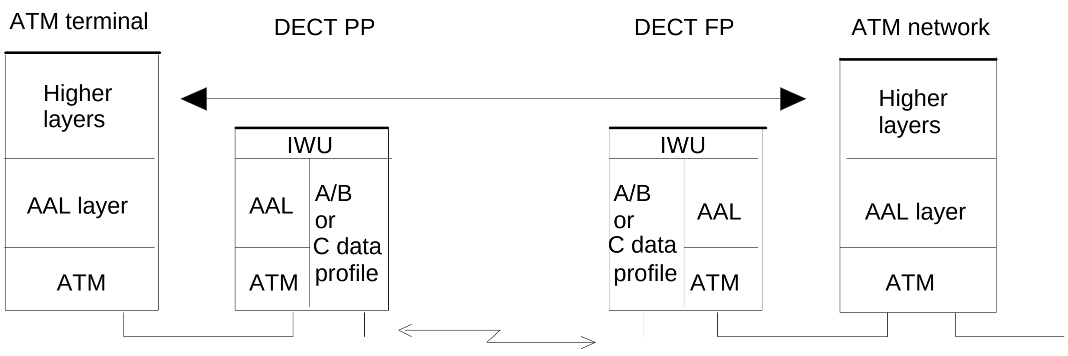

Figure 4: DECT/ATM intermediate interworking

6.2 End system interworking

The end system interworking scenario consists of a normal DECT data system with an ATM network attachment in the FP. In this case the PP does not even have to be aware of the interworking network thus no additional features are required from the terminal. The rates are in this case those provided by the DECT data profile. This configuration utilizes the air interface better than the intermediate system since no additional information such as ATM cell headers are conveyed.

One option is also to utilize the ATM N-ISDN and ISDN DECT interworking descriptions and in this way easily create a DECT/ATM interworking profile. Thus rates of the services would be 64 kbit/s or more.

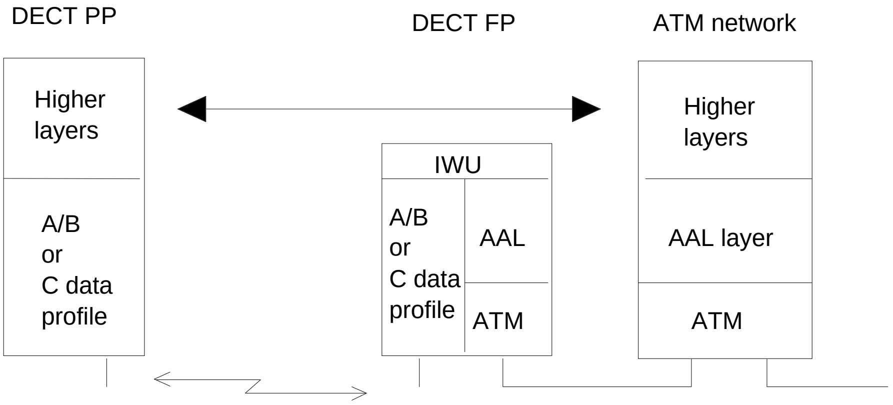

Figure 5: DECT/ATM end system interworking

7 The concept of integrating UMTS and B-ISDN

The basic idea behind integrating mobile and fixed communications is the communality of the required functionalities. Of course, mobile networks need to provide for handover and paging. However, functions like call handling, mobility management for personal and service mobility, transport of user data, registration, location update, and switching need to be available in both fixed and mobile networks. By integrating mobile and fixed communications into one network, duplication of common functionality can be avoided.

Discussing the degree of integration of UMTS in B-ISDN, is quite complex. Choice on the degree of integration shall still be made. In our view, a good approach is to make a distinction between various aspects of a system that can be either integrated or not. The following aspects can be distinguished:

services: integration of services means that there is an overlap between UMTS services and B-ISDN services (e.g. telephone service is the same for UMTS and B-ISDN users);

functions: integration of functions means using B-ISDN call and connection control as well as access independent mobility management functions to implement UMTS services;

protocols: integration of protocols is the re-use of B-ISDN protocols for UMTS. This should be viewed at all layers of the OSI stack. For instance, UMTS might reuse the B-ISDN network protocols but use different application layer protocols for UMTS purposes only;

infrastructure: integration of infrastructure is achieved when UMTS and B-ISDN have common physical entities and physical interfaces.

Following evolution issues are important:

Mobile data services will grow strongly in the near future: text based services such as Internet access, on line services. These services will require - besides the dominant voice service - efficient network capabilities to support packet access, Variable Bit Rate (VBR) services and higher throughputs as currently available. In general, this requires generic bearer capabilities supporting all services, which formed an important element in the definition of ATM.

In order to enable B-ISDN like services in the wireless context, end-to-end ATM transport is required. Due to basic radio resource limitations in cellular networks, ATM cells can only be transported through interworking techniques such as segmentation and additional error protection, resulting in relatively low throughputs and high delays. Indeed, ATM is designed for broadband, error scarce, and fast transport media, namely optical fibres, while radio access offer narrow (expensive) bandwidths, high and unpredictable error rates, and often high delays. Therefore, so called wireless ATM (applying ATM on the air) can from a practical sense only be supported in higher frequency bands (in the 20 to 60 GHz range), and in pico cellular (often indoor) applications.

In the following sections, some detailed studies on the possible extent of integration are presented for the various aspects of integration.

7.1 Services

With integrated services, a user will not notice the difference between services offered by either mobile or fixed terminals. This implies that services should not only be compatible; they should also have the same user-interface procedures.

Though UMTS and B-ISDN can have common services, UMTS will not be able to provide the full set of B-ISDN services. The limited bandwidth on the radio interface will restrict UMTS services to a rate of 2 Mb/s. Moreover, the bandwidth constraints will require more bandwidth efficient source coding of bearer components (e.g. speech coding). Transcoding of bearer components will be required for calls between fixed and mobile terminals. Even if the coding of the bearer components is different in fixed and mobile environments, the services and the service architecture can still be the same, in the sense that users will not experience differences in bearer component coding itself.

7.1.1 Transcoding

Transcoding is the change of coding of information items to meet the specific requirements of the air interface. The air interface is characterized by low capacity (scarce shared radio resource) and a high vulnerability of information items due to external noise and interference. In this context relevant measures to deal with these conditions is source coding in order to reduce bit rate on the air interface (as for instance in GSM between A law 64 kbit/s and GSM 13 kbit/s for voice) or to increase robustness against degradation due to e.g., fading or interference. In addition, specific channels will be defined at the air interface of UMTS (both for CDMA and TDMA). Transcoding also translates the B-ISDN data format to the format as supported on the air interface and vice versa.

Requirements derived:

> TR_1: the requirements on transcoding are that it has to be performed as efficiently as possible (in terms of network resources), and in respect to the transport mechanism on the air interface. The latter requirement means for instance a minimization of the data processing delays by putting emphasis on integration, more than on interworking.
>
> TR_2: when the transcoding function is allocated at other places than base stations (i.e. further down in the network) then the payload of the ATM cells transmitted between the transcoder and the base stations shall have a format compatible with the format used at the air interface.

7.1.2 Mobility support

In UMTS, a call can be routed along a connection set up as virtual channel or virtual path. Due to the roaming of the mobile terminal or due to changing radio conditions, it can be decided to modify parts of a connection (connection elements), e.g. to attach the terminal to a new base station. This action (handover) is performed while a call is active and has to be performed seamlessly to the user. In addition, it is foreseen that in certain environments and configurations, it is required to perform a re-routing of active connections, i.e. a change of the route of a connection without changing the air interface link (route optimization).

Handover and re-routing is performed between two bridging nodes, by switching the route from an old to a new connection element. Bridging is a UMTS function which is allocated in the switching nodes supporting mobility (e.g., a local exchange).

The modification of a connection element during handover or re-routing puts the following requirements on B-ISDN:

> MS_1: handover control should be able to set-up and release connection elements.
>
> MS_2: the change of the connection shall be performed seamlessly, thus without cell loss, without disruption of the cell sequence, and without introducing service quality affecting delays.

In case of macro-diversity (especially required for CDMA technique) in the uplink direction, more than one base station receives the data broadcasted by the terminal, and transmits it to a so called combining point in the access network. A combine function then receives in theory identical inputs and produces (e.g. by selection) a single output. In the downlink, more than one base station broadcasts the same information to a MT, within which combining is performed. In the access network, a multicast function distributes the same data to all base stations of the macro-diversity group (i.e. the group of all base stations participating in this particular macro-diversity handover). In case this macro-diversity is implemented in a B-ISDN network, some additional requirements are put on the ATM transfer mechanism:

> MS_3: the ATM multicast and routeing should be able to support the macro-diversity multicast and combine functions.
>
> MS_4: synchronization of the different paths in the fixed part of the access network. In the uplink, this synchronization (e.g. by in band signalling) assures that the combine function compares and combines the same data. In the downlink, the synchronization assures that all base stations of a macro-diversity group are able to transmit the same information at the same time on the air.

7.2 Functions

Functions that are candidates for integration are, for example, database functions and call and bearer control functions. UMTS and B-ISDN could use a common database to store user profiles and to provide personal (user) mobility. The goal of integrating call and connection control functions is to be able to use the same exchanges (Local, Transit or Private Branch Exchanges) for UMTS and B-ISDN.

Many of the UMTS mobility procedures are implemented according to IN principles with a high degree of commonality in personal/service mobility functions for wireless and wireline access. Thus, reusing call and bearer control means using the same call state models. This implies that the integrated call state models should provide the necessary handles for the mobile specific procedures. The logical split of IN based mobility concepts in generic, access independent personal and service mobility (for wireless and wireline terminals) and radio specific terminal mobility functions will have also to be taken into account.

Handover and terminal paging procedures will also lead to UMTS requirements to call and connection control. New transport functions need to be defined and existing ones need to be altered to support handover. Such functions include bridging, splitting, and multicasting.

7.3 Protocols

The integration of protocols is related to the physical interfaces over which these protocols are used. If a physical interface is integrated, this implies that the same protocol architecture shall be used (e.g. the same physical layer protocol should be used). However, if the protocol architecture is sufficiently flexible, additional protocols can be included for the mobile specific functionality.

If the integration of protocols is to be successful, a new flexible protocol architecture for the User to Network Interface (UNI) will have to be defined. This protocol architecture should take into account the requirements for radio related protocols but should enable the use of the standard B-ISDN protocols for fixed and personal mobility communications. Similar considerations might influence the Network to Network Interface (NNI) and VBR.

The point in the network up to which ATM is used, will have further impact.

7.3.1 Protocol stack for speech and Constant Bit Rate (CBR) data service

One of the main targets of UMTS is the integration with B-ISDN. This integration aims at the transparent provision of services to mobile and fixed network users (although limited by the bandwidth over the air interface), and at the shared use of network equipment (protocols, infrastructure and functions).

Two issues can be identified where the integration of UMTS has an impact on ATM: transcoding and mobility support (see also sections on Services above). These two issues are discussed in relation with the presented protocol stack for the speech and CBR data service. The protocol stack for the optimized use of network capabilities for compressed voice and low bitrate is described in subclause 7.3.2.

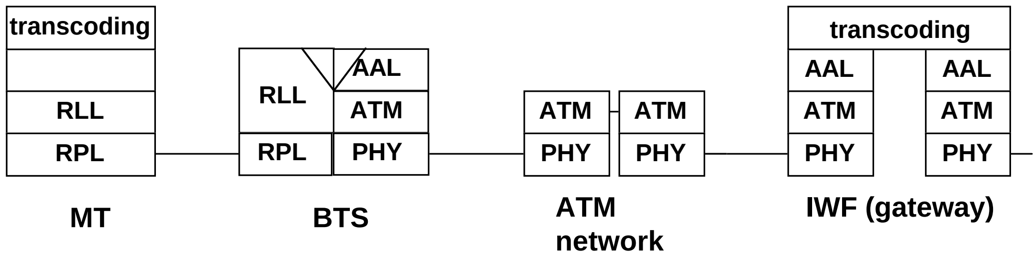

Figure 6: Protocol stack for speech and CBR data

In figure 6, the protocol stack that can be used for the transport of the speech (and CBR data) service is shown. This protocol stack postulates three points of interaction: one in the Mobile Terminal (MT), another one in the Base Transceiver Station (BTS), and one somewhere in the fixed ATM network (at a interworking function point).

In the MT the speech is transcoded, i.e. the coding of the information is modified to meet the requirements from the radio interface. This source encoded data is then channel encoded, interleaved and modulated in the radio link layer and the radio physical layer.

In the BTS, the demodulation, deinterleaving and channel decoding is performed. Some additional information about the quality of the received data is added (inband signalling). The transport and control interworking is performed at the RLL-AAL as shown in figure 6. The RLL layer covers very similar functionality compared to both AAL and ATM layer (see table 1). This is to limit the impact on the fixed network of the mobile link control.

Table 1: General relation between the RLL and AAL/ATM layers

Mobile side	Fixed side
RLL	AAL
- segmentation and reassembly	- segmentation and reassembly;
- timing relation	- timing relation between source and destination (required or not required);
- bit rate	- bit rate (constant or variable);
- connection mode	- connection mode (connection-oriented or connectionless).
	ATM
- flow control	- routeing
- error detection and correction	- flow/congestion control
	- cell loss
NOTE: Some functions are not applicable for the considered services, e.g., the connection mode for speech will always be connection oriented	

The resulting data (service and quality information) is sent over the fixed network using ATM as transport mechanism (an AAL is used to adapt the service of the ATM layer). The format (framing) of the data between the BTS and the IWF has to be chosen such that the processing is minimal. Therefore, this data format is highly related with the format used on the radio interface. However, in order to make the access network as much as possible radio interface independent, a generic format is desirable. The source decoding (transcoding) is performed in a more centralized node, for the purpose of sharing these resources. At this IWF point, all other radio related functions (e.g. inband signalling) are terminated. The mobility aspects, such as handover and re-routing, are proposed to be solved in a service control point of the access network. These mobility functions will only impact the ATM layer. The requirements on the ATM layer due to mobility support are already presented in this ETR (MS_1 to MS_4).

The connection between the BTS and the IWF is a low bitrate connection for the speech service, e.g. in GSM the bitrate between BTS and transcoder is 13 kbit/s (GSM full rate) or 6.5 kbit/s (GSM half rate) instead of 64 kbit/s in the core network. The AAL-CU layer (subclause 7.3.2) was developed to handle these low bitrate (< 64 kbit/s) connections. Furthermore, this connection is also influenced by the mobility of the users. This has an impact on the parameters (e.g. delays) of the connection. The algorithms used in the current AALs should be checked if they fulfil all the requirements coming from mobile communications. Next to the requirements on ATM, the following requirements on the AAL layer can be identified:

TR_3: the synchronization mechanisms should also be valid for low bitrate connections.

MS_5: the change of the connection should not only be performed seamless on the ATM layer, but also on the AAL layer.

For data services, transcoding is not required. Also for mobile-to-mobile speech calls transcoding can be omitted, if both mobile users "understand" the same speech coding format. For both cases, some functions (e.g. mobility management, protocol adaptation etc.) still may have to be performed at the interworking point.

7.3.2 Special AAL for bandwidth-efficient use of transmission capacity

In order to allow a bandwidth-efficient use of N-ISDN network capabilities for the transmission of low-bitrate services as e.g. compressed speech at 13 kbit/s (GSM full rate) or even 6.5 kbit/s (GSM half rate) a new AAL is proposed. It is called AAL for Composite User information (AAL-CU). Standardization of the AAL-CU is ongoing in ETSI, ITU-T (SG 13), and ATM-forum (VTOA). Since the work on AAL-CU is progressing rather fast this subclause will just deal with the basic idea of AAL-CU. More detailed information can be found in the relevant standards.

The AAL-CU is defined to allow for transporting efficiently data of low bit-rate applications, which is, especially in the mobile case, mainly compressed voice data. The aim is to transport the compressed voice with low delay and high bandwidth efficiency. AAL-CU will be used in the mobile access network. The idea behind AAL-CU is, that several mobile calls share the same virtual ATM connection, i.e. small packets of different calls are multiplexed into one ATM cell (see figure 7). The minimum packet size that will be supported is 1 octet, the maximum packet size is under discussion for the time being and may exceed 48 octets.

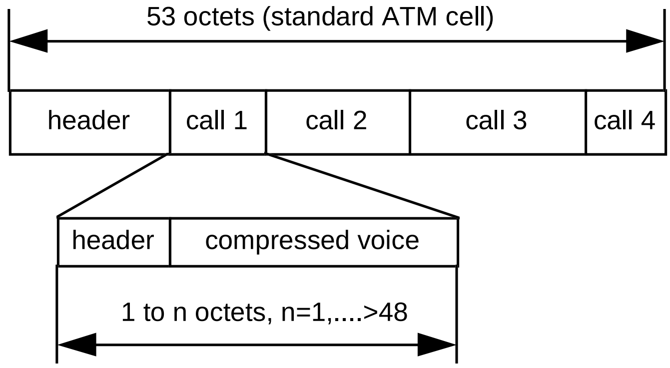

Figure 7: AAL-CU principle

7.4 Infrastructure

The aim of integrating the infrastructure of UMTS and B-ISDN is cost reduction with the same quality and performance or even better than existing networks. This cost reduction is achieved through ease in network management and provision of personal mobility throughout all types of environments. Integration would reduce the costly duplication of infrastructure as UMTS base stations and B-ISDN terminals can be connected to the same backbone network.

8 UMTS requirements on B-ISDN

In this clause all requirements are collected. For easy reference they are numbered with abbreviations:

TR: Transcoding;
MS: Mobility Support;
GS: GSM.

TR_1: the requirements on transcoding are that it has to be performed as efficiently as possible (in terms of network resources), and in respect to the transport mechanism on the air interface. The latter requirement means for instance a minimization of the data processing delays by putting emphasis on integration, more than on interworking.

TR_2: when the transcoding function is allocated at other places than base stations (i.e. further down in the network) then the payload of the ATM cells transmitted between the transcoder and the base stations shall have a format compatible with the format used at the air interface.

TR_3: the synchronization mechanisms should also be valid for low bitrate connections.

MS_1: handover control should be able to set-up and release connection elements.

MS_2: the change of the connection shall be performed seamlessly, thus without cell loss, without disruption of the cell sequence, and without introducing service quality affecting delays.

MS_3: the ATM multicast and routeing should be able to support the macro-diversity multicast and combine functions.

MS_4: synchronization of the different paths in the fixed part of the access network. In the uplink, this synchronization (e.g. by in band signalling) assures that the combine function compares and combines the same data. In the downlink, the synchronization assures that all base stations of a macro-diversity group are able to transmit the same information at the same time on the air.

MS_5: the change of the connection should not only be performed seamless on the ATM layer, but also on the AAL layer.

GS_1: the introduction of ATM in GSM may not require any changes at the radio side of the existing GSM network.

9 Conclusion

Some arguments are related to the world-wide acceptance of ATM as switching and transmission standard for B-ISDN.

- As B-ISDN is not deployed yet widely, many operators (especially in Europe) formulate the requirement that **B-ISDN has to support both mobile and fixed access**, through network integration. Network integration should in addition ease the service integration, the latter based on IN principles.

- The adoption of ATM as switching and transport mechanism in the mobile backbones offers future safety in terms services and network extensions. Besides, there is no (widely adopted) alternative for broadband other than ATM, allowing the **reuse of ATM based equipment** for mobile applications. In order to allow for an optimized transport for data of low bit-rate applications (mainly compressed voice) a new AAL, the AAL-CU has been introduced for the access network.

- New operators, e.g. the **cable operators** that will be allowed to offer telecommunication services from 1998 on in Europe, can enter the market with an ATM based backbone, e.g. through a fibre and ATM based extension of their cable networks. Besides wireline applications, the shared use of this backbone for mobile applications could offer interesting perspectives.

Annex A: Bibliography

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

History

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