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ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

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Foreword

ETSI Technical Reports (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 application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or I-ETS.

The evolution towards Broadband Integrated Services Digital Network (B-ISDN) is primarily a chain of events which are happening at a network level above the pure infrastructure and physical network. The physical network provides the prerequisites for implementing B-ISDN in both parts:

- the access network (local loop); and
- the interexchange network.

The evolution towards B-ISDN may be considered as a certain number of distinct steps. Such milestone aspects may refer to:

- the (logical) network for user information transfer (user plane);
- the (logical) network for control information transfer (control plane);
- the (logical) network for the transfer of network management information (management plane).

In all those areas mentioned above, conceptual progress may be recognised, which may lead to certain implementation steps of extended functionality and thereby additional protocol parts or amended releases with the objective to:

- support more or more advanced services; or
- improve the network economy or the economy of network operation.

Introduction

General considerations

The subject of evolution toward B-ISDN in the context of B-ISDN standardisation in ETSI, has to be regarded mainly as a support activity. Therefore, the purpose of this ETR is:

- to identify, in the context of certain possible and likely implementation steps, the specific standardisation needs;
- to provide information on such possible evolution steps, in the form of guidelines for all relevant ETSI TCs and STCs interested.

It should be noted, however, that evolution steps themselves are not considered to be a subject of standardisation. In addition, it must be clearly stated that the national network evolution paths or even the migration steps will depend on a number of specific factors (e.g. the starting situation, the national market conditions, the customer potential demand) and will, therefore, probably differ considerably.

The scope of this ETR is based on the following considerations.

All framework conditions (technological, non technical, service, etc.) which could create enabling and supporting effects for B-ISDN implementation are mentioned and briefly described in relation to their influences and their likely impact on the evolution towards B-ISDN. It should, therefore, be noted that the report is structured in such a way that all aspects and developments which have a relationship to B-ISDN are mentioned without being comprehensively elaborated, but emphasis is given to the evolution steps which will clearly lead to the B-ISDN functionality. Although B-ISDN may be considered as the ultimate solution, however, there does not exist any guarantee whether or not a certain state of deployment of final B-ISDN components in the network will ever be achieved. The techno-economic and strategic-political environment of B-ISDN evolution is much broader. The totality of all the framework conditions creates a number of influencing and stimulating factors and driving or preventing forces. The nature of the investigation has to be understood as an overall scenario assessment with the attempt to bring certain technological trends in a logical order and to point out specific implications for standardisation as defined in the above objectives. To fulfil this requirement "recommendations" (for technical standardisation-related or organisational action) are "spread" over the text at appropriate places in text boxes.

Such recommendations have to be seen in the context of:

- ETSI Sub-Technical Committee (STC) NA5 will produce an overall work plan for B-ISDN studies in ETSI, and this document will provide a valuable technical input to the generation of that work plan;

- the text of the report, at the relevant points, indicates that certain evolution steps of technical developments are considered likely to happen. As a result the report recommends that ETSI performs certain standardisation activities to facilitate these developments. Such "recommendations" have nevertheless to be considered in the context of the overall ETSI standardisation programme.

Network evolution scenarios and detailed probable steps of transition are elaborated to provide a "line for orientation" for the Public Network Operators (PNOs), users and the industry.

Main characteristics of B-ISDN

The term B-ISDN by its definition, refers and emphasises the broadband aspects of ISDN.

In considering the evolution towards B-ISDN, it is useful to recall the main characteristics as stated in CCITT Recommendations I.121 [1].

- The existing ISDN protocol reference model was extended to take into account the functionalities of B-ISDN;

- B-ISDN is based on the Asynchronous Transfer Mode (ATM) and, by definition, only supports the transport of digital signals;

- the access to B-ISDN is based on a limited set of well-defined user to network interfaces.

Other arrangements which do not fulfil the above criteria (e.g. physical integration utilising different wavelengths on the same optical path) are, by definition, not called B-ISDN.

1 Scope

This ETSI Technical Report (ETR) describes the evolution towards Broadband Integrated Services Digital Network (B-ISDN).

Network evolution is a very broad term. It is generally related to the allocation of more functionalities to existing network capabilities with the aim to develop the network and the service for the benefit of the users and the network operators.

Network development does not only refer to the evolution of ISDN but also to progresses in several networks which will be present at the moment of the introduction of B-ISDN and which will progressively evolve towards B-ISDN to provide homogeneous service to the customers.

The purpose of this ETR is to identify areas where further investigation in the context of evolution towards B-ISDN would be reasonable and items on which standardisation work appears to be necessary.

Evolution towards B-ISDN was defined in such a way that the description would encompass all relevant developments and trends in technical and non-technical sectors, in service and market aspects and in enabling and supporting technologies which were considered to be of relevance for the evolution towards B-ISDN. Specifically, those developments which at present still represent a dynamics of their own (as e.g. satellite development or frame mode bearer services) were briefly described, believing strongly in the overall objective and its feasibility, that all contesting trends finally may run into a general B-ISDN based network architecture.

Bearing this assumption in mind, the scope is defined in such a way that all relevant influences, at least as an intention, were taken into account, being aware of the fact that due to complexity, a certain development could become stronger or weaker. Furthermore, due to lack of knowledge of how and when developments will appear, a restriction of scope is necessary. This limitation specifically applies to the area of "interworking" as there is a logical relationship between network integration (as a major driving force of network evolution) and network (and service) interworking, the application of which may be considered to represent the contrary.

2 References

The following documents are referenced within this ETR.

[1] CCITT Recommendation I.121: "Broadband Aspects of ISDN".

[2] CCITT Recommendation I.150: "B-ISDN asynchronous transfer mode functional characteristics".

[3] CCITT Recommendation I.311: "B-ISDN general network aspects".

[4] CCITT Recommendation I.321: "B-ISDN protocol reference model and its application".

[5] CCITT Recommendation G.704: "Synchronous frame structures used at primary and secondary hierarchical levels".

[6] CCITT Recommendation G.751: "Digital multiplex equipments operating at the third order bit rate of 34 368 kbit/s and the fourth order bit rate of 139 264 kbit/s and using positive justification".

[7] CCITT Recommendation G.707: "Synchronous digital hierarchy bit rates".

[8] CCITT Recommendation G.708: "Network node interface for the synchronous digital hierarchy".

[9] CCITT Recommendation G.709: "Synchronous multiplexing structure".

[10] ISO 8802: "Information processing systems-Local area network".

[11] ISO 9314: "Information processing systems-Fibre Distributed Data Interface (FDDI)".

[12] IEEE 802.6: "Distributed Queue Dual Bus (MAN)".

[13] ETS 300 211: "Network Aspects (NA); Metropolitan Area Network (MAN); Principles and architecture".

[14] ETS 300 212: "Network Aspects; Metropolitan Area Network (MAN); Media access control layer and physical layer specification".

[15] ETS 300 217: "Network Aspects (NA); Connectionless Broadband Data Service (CBDS)".

[16] IEEE 802.3: "Local Area Networks-Carrier Sense Multiple Access with Collision Detecting (CSMA/CD) Access Method and physical Layer Specifications (same as ISO/IEC 8802.3-1990)".

[17] IEEE 802.5: "Local Area Networks: Token Ring Access Method and Physical Layer Specifications".

[18] prETS 300 275: "Network Aspects (NA); Metropolitan Area Network (MAN); Conformance specification for the Medium Access Control layer management".

[19] CCITT Recommendation I.233 (1991): "Frame mode bearer services".

[20] CCITT Recommendation Q.922 (1991): "ISDN data link layer specification for frame mode bearer services".

[21] Draft CCITT Recommendation M.3010: "Principles for a telecommunications management network".

[22] CCITT Recommendation I.112: "Vocabulary of terms for ISDNs".

[23] CCITT Recommendation I.113: "Vocabulary of terms for broadband aspects of ISDN".

[24] CCITT Recommendation I.324: "ISDN network architecture".

[25] CCITT Recommendation I.210: "Principles of telecommunication services supported by an ISDN and the means to describe them".

[26] CCITT Recommendation I.312: "Principles of intelligent network architecture".

[27] Draft CCITT Recommendation Q.1201: "Principles of intelligent network architecture".

[28] CCITT Recommendation I.320: "ISDN protocol reference model".

3 Abbreviations

For the purposes of this ETR, the following abbreviations apply.

AAL	ATM Adaptation Layer
AF	Access Facility
APON	Concept utilising a PON for ATM-structured signal transport
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband aspects of ISDN
BCN	Business Customer Network
CATV	Cable Television
CBDS	Connectionless Broadband Data Service (ETSI Standard)
CBR	Constant Bit Rate (service)
CENTREX	Centralised Exchange
CEQ	Customer Equipment
CL	Connectionless
CLSF	Connectionless Service Function
CMC	Coherent Multichannel
CPN	Customer Premises Network
DBS	Direct Broadcasting Satellite
DCN	Domestic Customer Network
DQBD	Distributed Queue Dual Bus
DXC	Digital Cross Connect
E/O (O/E)	electrical/optical (conversion)
ESA	European Space Agency
FDDI	Fibre Distributed Data Interface
FTTC	Fibre-To-The-Curb
FTTH	Fibre-To-The-Home
HDTV	High Definition Television
HDWDM	High Density Wavelength Division Multiplex
HiFi	High Fidelity
IMAI	MAN switching system ATM Interface
IN	Intelligent Network
INAI	Inter-Network operator ATM Interface
ISDN	Integrated Services Digital Network
ISO/MPEG	Motion Picture Experts Group in the International Standards Organisation
ISPBX	ISDN-Private Automatic Branch Exchange
IVD LAN	Integrated Video/Data Local Area Network
IWU	Interworking Unit
LAN	Local Area Network
LEX	Local Exchange
MAN	Metropolitan Area Network
MSS	MAN Switching System
N-ISDN	Narrowband-ISDN
NA5/VCM	Rapporteur Working Party within NA5 on Video Coding Matters
NSC	National Specialised Centres
OAM	Operation & Maintenance
OE	Optical/Electrical
OBP	On Board Processing
PABX	Private Automatic Branch Exchange
PC	Personal Computer
PDH	Plesiochronous Digital Hierarchy
PNO	Public Network Operator
PON	Passive Optical Network
POTS	Plain Old Telephone System
PTO	Public Telecommunications Organisation
S,T,V,	Reference points in the ISDN reference configuration
SDH	Synchronous Digital Hierarchy
SG	Study Group
SMG	Special Mobile Group (Technical Committee within ETSI)
STM	Synchronous Transport Module
TDM	Time Division Multiplex
TDMA	Time Division Multiple Access

TE	Terminal Equipment
TMN	Telecommunication Management Network
TPON	PON structure for the support of the Telephone service
TV	Television
UMTS	Universal Mobile Telecommunication System
UPT	Universal Personal Telecommunications
USI	User Specific Interface
VBR	Variable Bit Rate
VC	1) Virtual Channel (context: ATM) 2) Virtual Container (context: SDH)
VCC	Virtual Channel Connection
VP	Virtual Path
VPC	Virtual Path Connection
VPN	Virtual Private Network
WDM	Wavelength Division Multiplex

4 Technological and general telecommunication related developments

The development of network capabilities and service features to be supported by the network are strongly dependent upon:

- general innovation in the application areas of future telecommunication services;
- technological developments;
- development of market requirements.

4.1 Technological developments

Due to the tremendous progress in technology in the last decade it can be stated today that all technology-based prerequisites for B-ISDN exist.

Specifically, key and enabling technologies, such as the following, have achieved a high state of maturity:

- **fibre technology:**

  the single mode fibre is used for optical transmission because the attenuation tends to achieve physical minimum value. Practical values for the 1 550 nm region are now between 0,15 and 0,20 dB/km. Dispersion compensated fibres may have a dispersion of 3,5 ps/nm.km in the wavelength range of 1 525 to 1 575 nm. High optical power levels can now be obtained, which allow for large distances;

- **optoelectronics:**

  broadband components (e.g. splitters, optical multiplexers) will be available with large bandwidth and low insertion attenuation values. Monocolour lasers with limited noise spectrum are available which allow high bandwidth as well as a small bandgap between laser wavelengths;

  optical switches are being developed according to following several principles:

  - optical space division switches which are composed of waveguide switches;
  - free space optical switching by geometric optics;
  - semiconductor optical amplifier switches;
  - electrical matrices with Electrical/Optical (E/O) and Optical/Electrical (O/E) conversion;

  switching times between 0,1 ps and 2 ps can be obtained with waveguide switching depending on the chosen semi-conductor material;

- **microelectronics:**

  the integration of the circuits leads to a higher number of components per square millimeter and thus allowing for higher cheap density and complexity and lower power consumption. Optical links at the inter-chip level give further opportunities;

- **software engineering:**

  system designers have sought to develop new architectures which in computing had led to the techniques of bit-slice and reduced instruction-set architectures;

- **radio frequency technology:**

  progress in microelectronics, notably modems and codecs, allows for improvement in the capacity and the transmission quality of radio and satellite systems. In fact, they will be adapted to carry SDH and ATM. The support of broadband services is driving also some tendencies in mobile network developments.

Developments in these areas are continuing at a rapid pace and will have a significant impact on telecom system capabilities in the future.

4.2 Developments of intelligence in the network

As a general tendency, features of equipment or networking facilities and procedures in their entirety which were recently still realised by hardware components are more and more going to be replaced by software capabilities of an increasing degree of complexity and sophistication.

These developments may particularly apply for network signalling, control and management. The computerisation of networks enables a number of quite new approaches to provide services and leads to dramatic changes in the type of services to be offered and the manner of offering them. This capabilities are leading to the concepts of service management in Telecommunication Management Network (TMN) and service creation environment in Intelligent Network (IN).

4.3 Video coding developments

Present video coding developments within the Motion Picture Experts Group in ISO (ISO/MPEG) and other international bodies, should enable high quality video at moderate rates (something between 1 and 10 Mbit/s).

Although results of the work are not yet known in their entirety it is expected that there will be influence on the evolution towards B-ISDN in two directions:

- low bit rate video signals of an order of magnitude of 5 Mbit/s will have conceptual impact on the way of providing specifically TV distribution services, in terms of number and simultaneity of TV channels;

- low bit rate video signals will favour other dissemination systems for video information (TV programmes) such as TV receive only satellite system, the terrestrial transmitter chain, coaxial cable-based distribution networks or even mobile systems, to become potential competitor in areas which were previously seen to be exclusive to B-ISDN.

5 Non-technical factors

Network evolution must be understood as a process which takes into account several non-technical factors, without being too strongly determined by them.

It is not possible to list all the non-technical factors which can influence the evolution towards B-ISDN. The major ones are regulatory environment; general political environment; open network provision; and economy.

Furthermore, it may easily be recognised that there are other factors of influence, such as:

- economical development in each European country and within Europe as a whole;

- the competitiveness of European telecommunications industries in terms of capabilities to provide reasonably priced equipment and terminal devices;

- the competitiveness of single European network operator and possible alliances among European Public Network Operators (PNOs) or with non-European network operator. These relationships in terms of strength and market power with respect to other network operator groups or single network operator, will influence the evolution of the network;

- the availability of standards at the right time.

Finally, it must be stated that the effects, influences and implications of those issues mentioned above do exist, however, it also needs be stated that the network operators will only have minor possibilities to influence, or to push, those factors in another direction.

6 Service evolution aspects related to B-ISDN

6.1 Service evolution

Service evolution is largely a result of requirements expressed by the user community such as:

- guarantee of specified quality of service;

- worldwide time and location-independent addressability of customers;

- home subscription conditions at any network access worldwide;

- user controlled configurability of network resources;

- dynamic composition of service features by the user;

- more flexibility in service provisioning.

6.2 Demand situation and service introduction

Independently of the customer sector, the following general considerations apply:

- initial demand will be rather dispersed, therefore, in medium/low density areas it will be hard to reach a critical mass;

- new demand may arise from today's non-dominating business sectors;

- new applications will not necessarily be a replacement of existing ones, but will respond to new communication needs;

- new communication needs will appear as a consequence of rationalisation effects by replacing traditional organisational modes of procedure and information flows and utilising more effective new (tele)communication means.

The technological developments in the field of terminals normally lead to their entry to the market before standardised services can be defined. Therefore, in the early phases, customers will be provided with bearer services, since specific applications supported by these services are related to restricted user groups.

The service evolution, in terms of a higher degree of sophistication of features and a deeper degree of definition, depends very much on economics (cost of terminals, cost of using a service, economic/social benefits from use of the service).

Service evolution will permanently refer to all types of services as e.g.:

- provision of permanent/semi-permanent services;
- on-demand bearer services;
- on-demand teleservices.

A consequence of this assessment for service evolution, is that network-based standards for the support of bearer services will, in general, be needed earlier than those for the support of teleservices.

6.3 Market areas for broadband services

Market-oriented considerations on service evolution needs to take into account several "dimensions" of this problem, i.e.:

- applications (intended by the users);
- types and categories of services;
- categories of users (domestic, small-medium-large business users);
- distribution of users / user categories in the serving area;
- market sectors (private, financial, hotel, etc.);
- network solutions to support the services (e.g. IN, B-ISDN, MANs, etc.).

All these dimensions are interactive and any comprehensive analysis of service evolution is consequently complex.

The following simple results relate to conclusions reached for the two basic market areas for broadband services.

Large and medium business customers are expected to be early users of broadband services. First business services are expected to be LAN-to-LAN interconnection, file transfer and data retrieval with and between large and very capable work stations; several applications can make combined use of these services.

It is expected that only TV/audio based services can be offered to domestic customers in addition to narrowband services.

However, it is important to reach the domestic market with broadband services, otherwise broadband networks will remain limited in scope and will have overlay structures.

Mobile and mobility related applications will be extensively demanded by all users.

Intelligent Network (IN) based services are expected to achieve major attraction of customers.

Frame relaying bearer service provides a simple connection-oriented layer 2 service, especially suitable for LAN interconnection. Networks and terminals supporting the frame relaying bearer service can be expected to be among the first users of high speed data services of B-ISDN.

6.4 Service innovation

Service innovation is considered to be the "high-end" aspect of service evolution whereby new services are invented or extended, which open up progressively new areas for telecommunications and promote new and sophisticated applications.

In contrast with 64 kbit/s based ISDN, the service innovation in B-ISDN will not only arise from a development of existing applications. It will arise from different sources, e.g.:

- upgrading of existing services to B-ISDN;
- new services upgrading existing communication needs;
- new services fulfilling new communication needs (e.g. multimedia),

and be influenced and initiated by technological progress.

Recommendation: Therefore, it is recommended that the ETSI entity responsible for (stage 1) service standards should give priority to -ISDN bearer services.

6.5 Terminal evolution

Some technology trends in the terminal evolution can be recognised:

- sophistication in applications, specifically in the office environment, support the trends towards multi-functionality of Terminal Equipment (TE) and their integration in a more complex customer equipment;
- integration of services leads to developments from:
    - simple TEs to more complex ones;
    - mono-service TEs to multi-service TEs.
- new TEs allow/require faster information transfer in the network (end-to-end);
- integration of equipment housing;
- terminal miniaturisation.

6.6 Traffic evolution

In general, it can be assumed since new services will have a certain traffic characteristics, that their introduction:

- may influence the customers' behaviour related to the utilisation of the new and existing services;
- will initiate changes in the statistics of the information flows in the network and traffic mix related to customers' service usage;
- will influence the load situation in the network which may lead to more sophisticated and refined control mechanisms with respect to resources/capabilities available.

The traffic demand and its evolution, in terms of nature and volume, will be dependent on:

- interactive or distributive information transfer;
- number and distribution of customers;
- traffic characterisation and distribution;
- service classes;
- modes of communication (permanent, semi permanent, on demand).

Services are classified as Constant Bit Rate (CBR) and Variable Bit Rate (VBR) services.

The bit rates of CBR services will vary from 64 kbit/s for ISDN, 2 Mbit/s (e.g. for file transfer, colour facsimile and HiFi sound), to 30-70 Mbit/s for TV picture transfer. With the introduction of new services, the call duration may vary from 100 ms to hours (e.g. picture transfer, video on demand).

The bit rate of VBR services will have the same variation in bit rate (in average) and call duration as CBR services but with LAN-interconnection and video-based applications as important additional applications. The duration of the peak bit rate may vary from less than 100 ms to 1 s.

The traffic characteristics of these two classes are different. Depending on how a service is offered (CBR or VBR) it has an influence on the traffic in B-ISDN.

Recommendation:

Since the knowledge of the characteristic of the traffic and the generated load strongly impacts on the approaches and procedures of resource management, it is recommended to have a concerted and co-ordinated traffic engineering study for B-ISDN within ETSI which includes studies on traffic control (an ATM technique issue), traffic characterisation (a service issue) and traffic ability (a performance issue).

7 Network evolution aspects towards B-ISDN

7.1 Overall network

7.1.1 Evolution of overall connection types

Connection types represent an association of functions to support telecommunication services and describe the basic lower layer functions of a network which are characterised by a set of attributes. Some of the attributes identified for the Narrowband (N-ISDN) like channel rate and access channel are not applicable for B-ISDN. New attributes are under discussion, taking into account the characteristics of ATM (virtual channel connection, virtual path connection, transfer capability limited by the access bit rate).

The specification of connection types for B-ISDN have not only to take into account the characteristics of ATM, as described above, but also the evolving architecture of the network developments (including IN, Universal Mobile Telecommunication System (UMTS), TMN, etc.) and the likely need for a more flexible method of service provision. All of this means that the connection types cannot be specified in isolation from a coherent architectural study of the evolution of the telecommunications network.

7.1.2 Evolution of transmission and multiplexing techniques

Evolution of transmission and multiplexing techniques is not restricted to fixed network transfer capabilities only. The subject implies radio, satellite and mobile systems and related multiplexing schemes.

ATM is a transfer mode and is, in principle, independent of the transmission systems provided.

Plesiochronous Digital Hierarchy (PDH) systems defined in CCITT Recommendations G.704 [5] and G.751 [6] will still be in use when ATM will be introduced and so they are expected to support the transport of ATM cells.

SDH systems defined in CCITT Recommendations G.707 [7], G.708 [8] and G.709 [9] are suitable for the transport of ATM cells.

The SDH was developed to make multiplexing more easy and to allow for add/drop multiplexers. Further, the SDH technique facilitates the architecture of digital cross connects replacing mechanical distribution frames and giving the network management a basis for electronic and remote operation.

Therefore, all the functions of the transmission network will be offered also to the ATM cells transport. These are:

- flexible network configuration via network management system

  The B-ISDN service providers may lease transmission capacity from the transmission network according to their demand. Any change of the configuration may be performed within minutes only. The charges to be paid for transmission capacity may be based on the bandwidth used and on the time of usage;

- high availability

  The availability of established routes through the transmission network will be very high because the transmission network elements will be protected by standby units.

- management control

  The SDH transmission network will be embedded in a TMN based on TMN principles, which facilitate its operation & maintenance. Furthermore, the TMN may provide maintenance channels which can be transparently routed through the transmission network. Such channels may be used to enable the maintenance communication between a remote subscriber access digital section and the local exchange.

It may be appropriate to define cell-based transmission systems optimally designed for the transport of cells for certain access configuration.

The statistical multiplexing can be used in the ATM network for gain of resources, but not during the introductory phase where allocation will be based on peak bit rate.

Recommendation:

It is recommended to set up a study on network implications (advantages and drawbacks) and specification/standardisation needs of cell-based transmission systems for both the access portion and the internodal transport network.

7.1.3 Switching evolution

Switching systems will take advantage of the technological developments (see subclause 4.1) to provide to the users and network operators functionalities needed for new capabilities like point to multipoint, broadcasting, granularity (in term of bit-rate), better availability, etc. The transmission capacity could limit the possibilities of the switching system. The high capacity of exchanges, in addition to the transmission network capability, may have an innovative impact and stimulating effect on the global network architecture.

7.1.4 Signalling evolution

The B-ISDN signalling protocols must take into account the capabilities offered by an ATM network e.g. establishment of Virtual Channel, Virtual Path, negotiation of traffic characteristics (quality of service, bandwidth, asymmetric communication, etc.). Furthermore, other services such as multiparty calls, multimedia calls, multiconnection and point-to-multipoint connection establishment and release have to be supported. Two approaches are identified, the re-use of existing signalling protocols or definition of a new protocol. The choice is under study within CCITT Study Group (SG) XI. The capabilities of signalling protocols will evolve in correspondence with the market-related implementation needs of B-ISDN features. Therefore, an evolutionary process for the development of the protocol stack (different releases) has been defined in CCITT.

7.1.5 Network management evolution

CCITT SG IV will produce a set of Recommendations for the TMN which standardises the architectural approach (concept), related interfaces, protocol and procedures and messages. The specific ATM management specifications will be defined in ETSI/NA5 in future technical reports.

Evolution of network management is based on trends such as:

- full integration of all network elements, from the viewpoint of the conceptual approach;

- growing degree of sophistication in functionality;

- developments towards service management and access to the control of network resources.

7.1.6 Evolutionary trends in mobile communications

The current situation in mobile communications is characterised by the existence of large and dominant fixed networks accessed either by wired terminals or by cordless handsets. Mobile telephony is (and will generally be) handled by independent cellular networks with a large geographic coverage, with a general trend towards digital systems.

From the year 2 000, the UMTS is expected to provide mobile telecommunication services, offering more services in a greater variety of environments to a larger user base than any preceding system.

The implementation of UMTS will occur against the background of two significant trends in telecommunications (which will probably merge, either with the advent of UMTS, or shortly after) such as:

- the development of Universal Personal Telecommunications (UPT), a concept under study in CCITT and ETSI which is designed to overcome at least some of the current limitations experienced with fixed telephones by providing a certain degree of personal mobility. This mobility will be provided through the implementation of UPT as a service to be supported by any intelligent nodes and databases in the network particularly by means of the planned intelligent networks;

- the development of a progressively larger mobile system; as an overlay to the fixed network (e.g. ETSI/SMG or others);

- capability extension of mobile technology towards support of higher user bit rates up to 2 Mbit/s.

These are three extreme cases, which are not necessarily mutually exclusive.

Integration of mobile and B-ISDN

Compatibility of UMTS with the fixed network, both N-ISDN and B-ISDN may be a requirement, since both of them are supposed to support a common subset of services and are expected to be available at the time UMTS is introduced. The provision of inter working capabilities is the minimum requirement. Functional integration has further implications in terms of services, signalling and capabilities (protocols and functions). Service integration implies the possibility of offering N-ISDN and B-ISDN supported services, by means of the UMTS, with a minimal provision of inter working capabilities (a support of services provided in non-ISDNs may lead to more complex inter working situations).

There are many functions that could be integrated with common network elements strongly, depending on the final concepts, e.g. the B-ISDN local exchanges may have the functionality to connect base stations.

Signalling integration implies that B-ISDN can support UMTS signalling messages at its various interfaces (S, T, and across different public network node interfaces) with the expectation of increasing load in the network related to signalling messages, in terms of length and frequency. Part of the signalling could be common to UMTS and B-ISDN, e.g. similar use of UPT and, perhaps, commonality in call control messages.

Possible configurations for UMTS sub networks and fixed networks are given in figure 1.

In addition, the requirement being placed on the UMTS, UPT is also being designed to add personal numbering and mobility into the future B-ISDN. In order to make integration easier, the techniques must be closely aligned. Therefore, the development of UPT for the B-ISDN will have a significant impact on the development of the UMTS.

If integration is aimed for, standardisation activities will then include items related to the integration of mobile requirements into fixed networks.

Recommendation:

It is recommended to set up studies on the question of integration possibilities of UMTS and B-ISDN.

Related standardisation activities will have to progress the following issues:

- combinations of UMTS and B-ISDN database (could be part of TMN studies);

- one signalling system to include UMTS requirements;

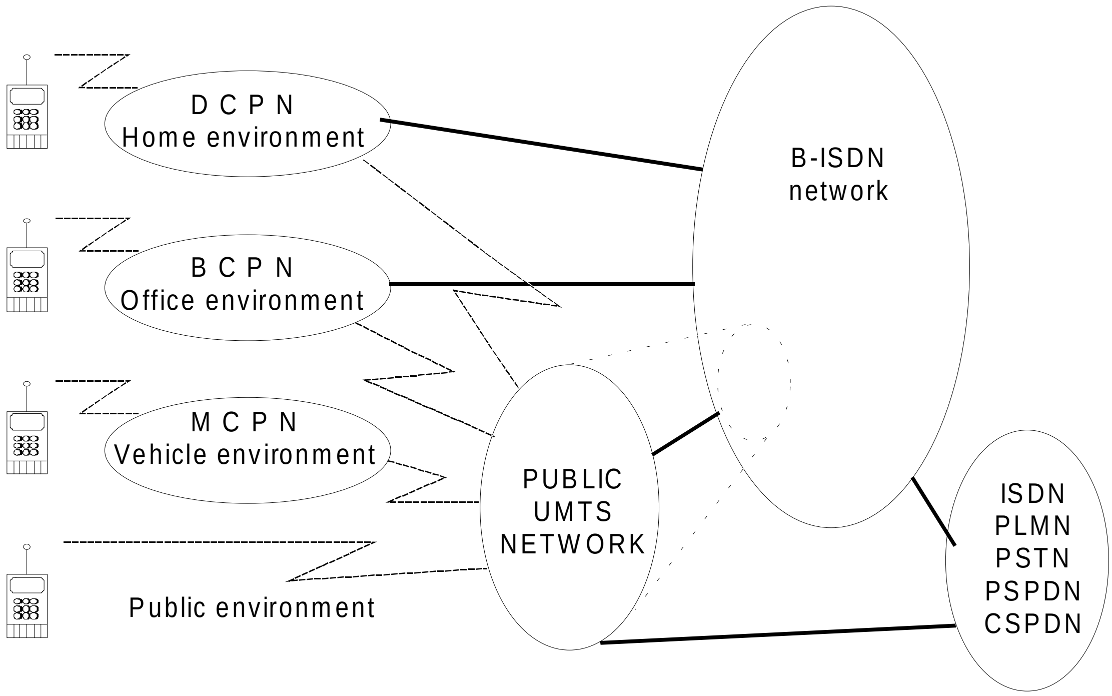
- integration of exchange to perform both fixed and mobile services switching;

- updating of interfaces in fixed networks to include mobility functions;

- definition of new network-network interfaces between entities with fixed and mobile functionalities (e.g. to provide hand-over between different environments);

- addressing principles for B-ISDN (taking into account the UMTS scenario);

- routeing principles for B-ISDN (taking into account the UMTS scenario).



B-ISDN	Broadband Integrated Services Digital Network
CPN	Customer Premises Network (B Business, D Domestic, M Mobile)
CSPDN	Circuit Switched Public Data Network
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network

Figure 1: Possible configurations for UMTS sub networks and fixed networks

7.1.7 Evolutionary trends in satellite communications

Satellite systems are flexible and adaptable communications means, which, in the early phases of the B-ISDN introduction, will cover the necessity for broad connectivity and provide the initial access to the B-ISDN of many users who are not served by the fibre optic network. In fact, satellite capacity can be easily reallocated to allow fast connectivity within any specific geographical region.

Once the terrestrial B-ISDN is well established, satellites will be used to complement the terrestrial network in areas where the installation of optical fibres is difficult and, therefore, uneconomic. Furthermore, they will be utilised as a back up for terrestrial systems. The facility of easy reallocation of network resources will still be used, for instance, in case of periodic or special events which requires short term connectivity. Finally, especially for some services (multipoint, broadcast), the use of satellites instead of a terrestrial link are very interesting, from both the technical and economical viewpoint.

In fact, the satellites, as a shared medium resource, have specific advantages for multipoint and broadcast communications in wide areas, as other shared media have in limited areas, because all customers in the covered area receive the same physical signal and the bandwidth occupancy is independent of the number of customers connected in the covered area; that is, the larger the number of customers receiving the same signal the lower the amount of network resources engaged per customer.

Therefore, for their characteristics, satellites are complementary to terrestrial networks. In a broadband network, the efficient and economical provision of distribution services to wide areas by the use of satellites offers the B-ISDN a unique opportunity to provide services which require an extensive use of geographical multipoint/broadcast capabilities, even in the early phase. Therefore satellites can speed up the process of deep penetration of B-ISDN, preventing or limiting the proliferation of different specialised networks.

For instance, the satellite can be used to set up a broadcast/multipoint connection between one transit exchange and a group of local exchanges between one transit exchange and a group of transit exchanges, and in the access connection elements (the satellite can provide a distribution link as well as an interactive link).

The evolving technology, i.e. the use of an On-Board Processor (OBP), will allow the use of satellites not only as transmission media, but also as a means to establish/support switched networks. However, in the implementation of B-ISDN traffic carrying capability, it will be prudent to start with a simple architecture and gradually migrate to a more advanced one, as dictated by traffic and cost considerations. In this philosophy of gradual network evolution, it is logical to first consider enhancements to the ground segment, while relying on existing and planned (transparent) satellites, and then address enhancements on-board.

Satellite evolution towards B-ISDN will take place in three different environments:

- in the transit network;

- in the access network;

- in the provision of specific services such as mobile services (directly, or as a support to a mobile network) and broadcasting,

by mutual adaptation of satellite characteristics and B-ISDN facilities.

Integration of satellite systems and B-ISDN

As a general trend a strong common effort in international standardisation bodies may be noted, (e.g. as in CCITT and CCIR), to align developments which in the past did not take mutual account of each other, namely to adopt standards in the satellite and radio field on the one hand, and ISDN on the other hand, in such a way that interfaces, protocols and other facilities may mutually support each other and especially the services provided. However, in order to get the objective of easily integrating terrestrial and satellite links in the B-ISDN operation, an adaptation of functions, parameters and protocols needs to be addressed.

Recommendation:

Taking the advantages and the ease of penetrating a coverage area by means of satellites into account it is recommended to study as soon as possible the following items of concern to standardisation:

- the definition or adaptation of an interface to allow satellite networks to be integrated in and report to the TMN;

- the definition of Operation & Maintenance (OAM) for multipoint connections;

- the definition of routeing capabilities in network management for the routeing of the traffic in the most convenient path or link (including satellite links), depending on the service attributes and network status;

- the definition and specification of signalling for supporting multipoint and broadcast services, notably on shared media;

- the definition or adaptation of communication protocols in the user part, in the control part and the management part, to take due account of delay in long distance communications (such as the ones including satellite links). Investigation on protocol functions such as window negotiation, timers negotiation and selective re transmission for layers above the ATM Adaptation Layer (AAL) should be undertaken within this standardisation activity;

- the definition of an ETSI preferred solution for the transport of SDH elements at rates below Synchronous Transport Module - 1 (STM-1); use of the sub-STM frames (STM-RR), as recommended for radio relay/satellite systems in Annex A of CCITT Recommendation. G.708 [8], transparent transport of virtual containers, or others.

7.2 Customers network

NOTE: In this subclause, the term "Customer Network" is used equivalently to Customer Equipment (CEQ) as defined in CCITT Recommendation I.324 [24].

The following evolutionary steps can be foreseen for the Business Customer Network (B-CN) and the Domestic Customer Network (DCN). In general, two trends may be identified:

- increasing sophistication of services support in customer networks in advance to any adequate related offer of network services in the public network;

- developments towards utilisation of typical private network/customer premises equipment features embedded in the public network, such as the Centralised Exchange (CENTREX) and/or Virtual Private Network (VPN) developments.

7.2.1 Evolution of business customer network

7.2.1.1 Present situation

Currently, business networks usually provide one specific service to a user or group of users. Two main types of business networks exist: Private Automatic Branch Exchanges (PABXs) based networks, which are primarily designed to support voice services (since the end of the 1970's, digital PABXs have been on the market offering almost the same services as ISDN does, at the customer premises); and LANs, which provides the interconnection of computer equipment or data communications devices in a local area (over distances typically less than 10 km). A considerable industry and user support of LAN technology has led to a set of international standards in ISO 8802 [10] and 9314 families [11].

7.2.1.2 Near term evolution

The development of high speed LANs, LAN to LAN interconnection on one side and complete ISDN PABXs and PABX to PABX interconnection on the other side, will be more urgent than the integration of voice and data on the same sub network.

Digital PABXs will support voice and other circuit switched communication. Evolution will be centred around ISDN conformance in order to converge to the standard ISDN based ISDN-Private Automatic Branch Exchanges (ISPBXs) over the next few years.

The increasing data traffic will be taken care of by extension of already existing IEEE 802.x based LANs and by the next generation high speed LANs (e.g. FDDI-1). There will be a large demand for LAN inter working (by means of bridges and routers).

A general trend towards integration of LANs and PABXs may be identified, however there are currently no products on the market based on the IEEE Standard 802.9 (Integrated Video/Data Local Area Network (IVD LAN)) which specifies an integrated access for the IEEE 802 family and ISDN. On the other hand, a possible inter working between LANs and digital PABXs will be limited, due to the relatively low bandwidth within a PABX (n x 64 kbit/s).

7.2.1.3 Long term evolution

When the B-ISDN network comes into existence, it will have to include adapters, gateways and inter working units, to be able to adapt existing network architectures and protocols and to connect existing interfaces and terminal equipment. This integration should not be so tight as to provide only sub optimal solutions for both isochronous and non-isochronous traffic. The ideal would be to have a flexible interconnection structure that allows optimisation to a particular customer's needs by selecting parts as appropriate. As the alternative tight integration would probably produce the existence of different specialised network products, providing optimal solutions for particular types of traffic, but not combined with the B-ISDN.

The above considerations lead to the general structure of the Business Customer Network (BCN) shown in figure 2, which contains the following main building blocks:

- a centralised hybrid ATM/ISDN PABX, for the support of audio and video related applications;

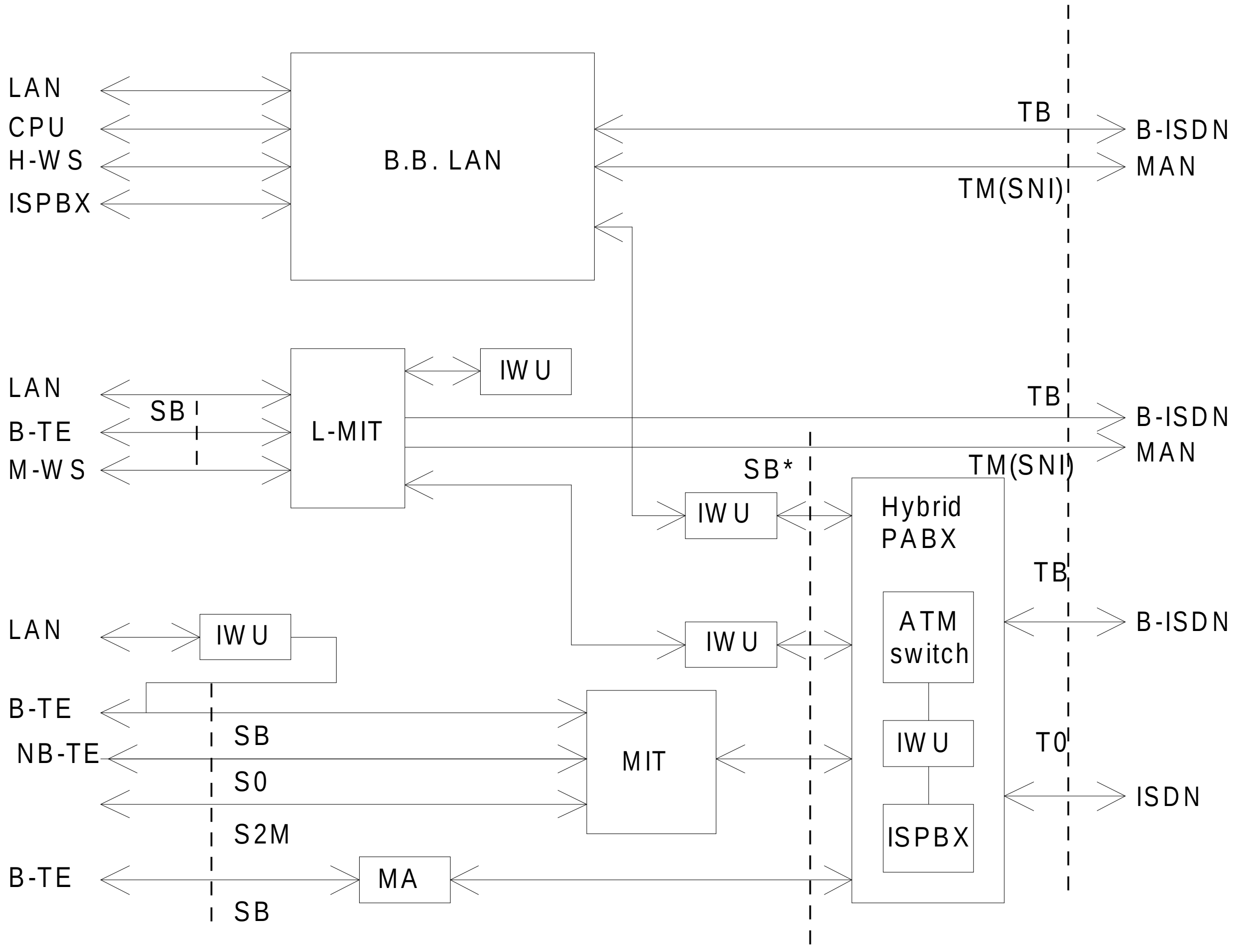
- a Broadband LAN (BB-LAN), operating at very high speed (up to the Gbit/s range) and supporting the interconnection of existing LANs and high performance devices. It should also be able to support ATM traffic;

- a Multi Interface Termination (MIT), supporting the connections to the central PABX. It needs to be able to handle different synchronous and asynchronous interfaces (e.g. ISDN primary and basic interfaces, ATM) in a flexible manner;

- a LAN-oriented MIT (L-MIT) which provides a lower cost access of LANs to the BB-LAN;

- Inter Working Units (IWU) for the interconnection of the above building blocks. The name IWU here is used in its general sense; its function may range from medium attachment to simple conversion to service level inter working.

The above list includes all possible building blocks. Some of them may be used alternatively, but not simultaneously.



B-TE:	Broadband Terminal Equipment (B-ISDN/ATM)	MA:	Medium Adapter
CPU:	Central Processing Unit	MIT:	Multiple Interface Termination
H-WS:	High performance Workstation	BB LAN:	Broadband LAN
ISPBX:	Integrated Services Private Branch Exchange	M-WSS:	Medium performance Workstation
IWU:	Inter working Unit	NB-TE:	Narrowband Terminal Equipment
LAN:	Local Area Network	SB*:	Optical version of SB
L-MIT:	LAN Multiple Interface Termination		

Figure 2: General structure of business CN

A trend towards connectivity in the customer network by means of wireless equipment has also to be considered. Wireless PABXs and wireless LAN solutions will be introduced into the market. Broadband wireless equipment may also be introduced in the customer network, following the development in the field of UMTS.

7.2.2 Evolutions of domestic customer network

The development of a standard-based domestic customer network (D-CN) is related to and will follow the evolution of service provision. The D-CN should be targeted at low cost with modularity to enable step-wise introduction and future upgrades.

7.2.2.1 Present situation

Currently, equipment is grouped in independent clusters, each cluster is dedicated to a service category (e.g. telecommunications, video, audio). Private homes are connected to radio wave broadcast, (and/or Cable TV (CATV) and/or Direct Broadcast Satellite (DBS)) and to the telephone network. Services in the home focus on entertainment (e.g. TV, radio) whilst services in a small office environment focus on low cost dialogue services (e.g. telephony, facsimile, PC data exchange).

7.2.2.2 Near term evolution

Many home systems will appear on the market before the DCN is in operation. Some low speed networks are already available. In order to make these systems compatible, proposals for standardisation where different applications have been taken into account, have been provided by different bodies (e.g. ESPRIT, Eureka, etc.).

To support the required applications, multimedia protocols have been proposed, taking into account several physical media (i.e. twisted pair, coaxial cable, power-line, infrared transmission, radio transmission).

7.2.2.3 Long term evolution

It is generally accepted that the capability to access video services, primarily television, is likely to be a major factor in the decision to invest in some form of home system. In addition to previous home systems, the DCN will allow the user to access the new services which the B-ISDN provides such as video conversational services, retrieval audio and video services, multimedia services, High Definition TV (HDTV).

When the DCN is introduced, there may be many environments in which a home system has been installed. An integration of those systems will then be required.

Recommendation:

Studies of the impact of different types of CEQ (including wireless solutions) on the standardisation of user-network interfaces and protocols should be executed.

7.3 Access network

The prerequisite for the introduction of B-ISDN and its associated services, is the availability of an adequate infrastructure in the local network, which may require a fibre based access system. As optical fibres represent a major investment in the access, they are likely to be introduced stepwise as a result of a demand for particular broadband services, long investment policies or technological advances. In some cases, satellites will cover the necessity for broad connectivity and provide the initial access to the B-ISDN of many users who are not served by the fibre optic network. Once the terrestrial B-ISDN is well established, satellites will be used to complement the terrestrial network in areas where the installation of optical fibres is difficult and, therefore, expensive.

Optical fibres are already being exploited in the feeder section of the access for the transport of existing services. The strategy for the introduction of the fibre in the access network (e.g. the decision on whether to limit initially fibre deployment to the curb or to go straight to the home) may be strongly governed by economic and OAM criteria, as well as the network topology. Economics currently favours Fibre-to-The-Curb (FTTC), whilst OAM considerations suggest a straight deployment of Fibres To The Home (FTTH) without any intermediate active components.

In an introductory phase, multiple optical carrier systems may prove to be suitable for the transport of a number of services in addition to B-ISDN and analogue distribution services (e.g. ISDN, POTS, leased lines) in a common fibre infrastructure. As a consequence there is an urgent need to standardise the relevant optical interfaces and the related optical spectrum requirements, in order to ensure a smooth evolution from existing networks and services towards B-ISDN.

The regulatory situation in different countries will lead to different economic choices (e.g. depending on whether the same PTO is allowed to transport both telephony and CATV signals).

In the business sector, the demand for interconnections of various private data networks, specially LANs (the annual growth rate of sale of LANs in Europe is about 25%) is likely to grow substantially in the following years. To meet with this demand, which obviously cannot wait for the introduction of B-ISDN, dedicated frame relay networks and Metropolitan Area Networks (MANs) are currently considered. MANs will be successively integrated into B-ISDN, whose deployment is expected a few years after MANs. Due to the significance of MAN as an evolution step towards B-ISDN, particular attention has to be paid to this issue.

The evolution of the access network can be considered as a process which should take into account:

- the evolution of the access techniques;

- the possible structures and architectures for the terrestrial access network;

- the use of satellite and radio links techniques in the access network.

7.3.1 Access technique evolution

The introduction of the broadband access can be related to different access techniques. Three possible approaches for the provision of interactive and distribution services are investigated. Depending on customer density, service demand and PNO strategies these approaches can either be realised in sequence, or in parallel. Different strategies may apply for different serving areas of the same network operator.

7.3.1.1 Separate access for broadband and narrowband services

In this approach, broadband services are offered to customers over a separate access link to the ATM local exchange (see figure 3a). Narrowband services are provided separately over the existing network.

This approach provides a low cost start with potential early revenue, allowing an early introduction of end-to-end connectivity without impacting on the narrowband access network. On the other hand, this approach leads neither to a simplification of network OAM, nor to a real integration between new and existing services, and in general it leads to an overlay network structure. In addition, customers provided with this separate access may be reluctant to move to full ATM access.

In the starting phase, when the broadband customer density is still low, the separate access method is likely to be implemented.

7.3.1.2 Multiple access techniques

This approach relies on a single broadband access link to the customer, carrying a multiplex of narrowband and broadband services. Before being presented to the customer, the composite traffic is demultiplexed, so that existing narrowband CEQ can still be used (see figure 3b2).

For this approach, Wavelength Division Multiplex (WDM) and ATM have been identified as the major candidate multiplexing techniques.

Since with WDM the narrowband and broadband service signals are carried on separate wavelengths on the access link fibre, such a technique should be considered very close to the separate access (see figure 3a).

With the ATM multiplex, the narrowband services are converted into an ATM format and then time multiplexed with other ATM cells carrying the broadband services (see figure 3b1). Before presentation to the customer, the narrowband services are stripped off the ATM cell stream and converted into the appropriate STM format. The ATM multiplex approach is nearer the target than the WDM, since in the former approach, the replacement of the multiplexing equipment at the Local Exchange (LEX) with an integrated connection to the B-ISDN switch is a logical and straightforward step. The ATM multiplexing approach may require for the standardisation of a new V interface.

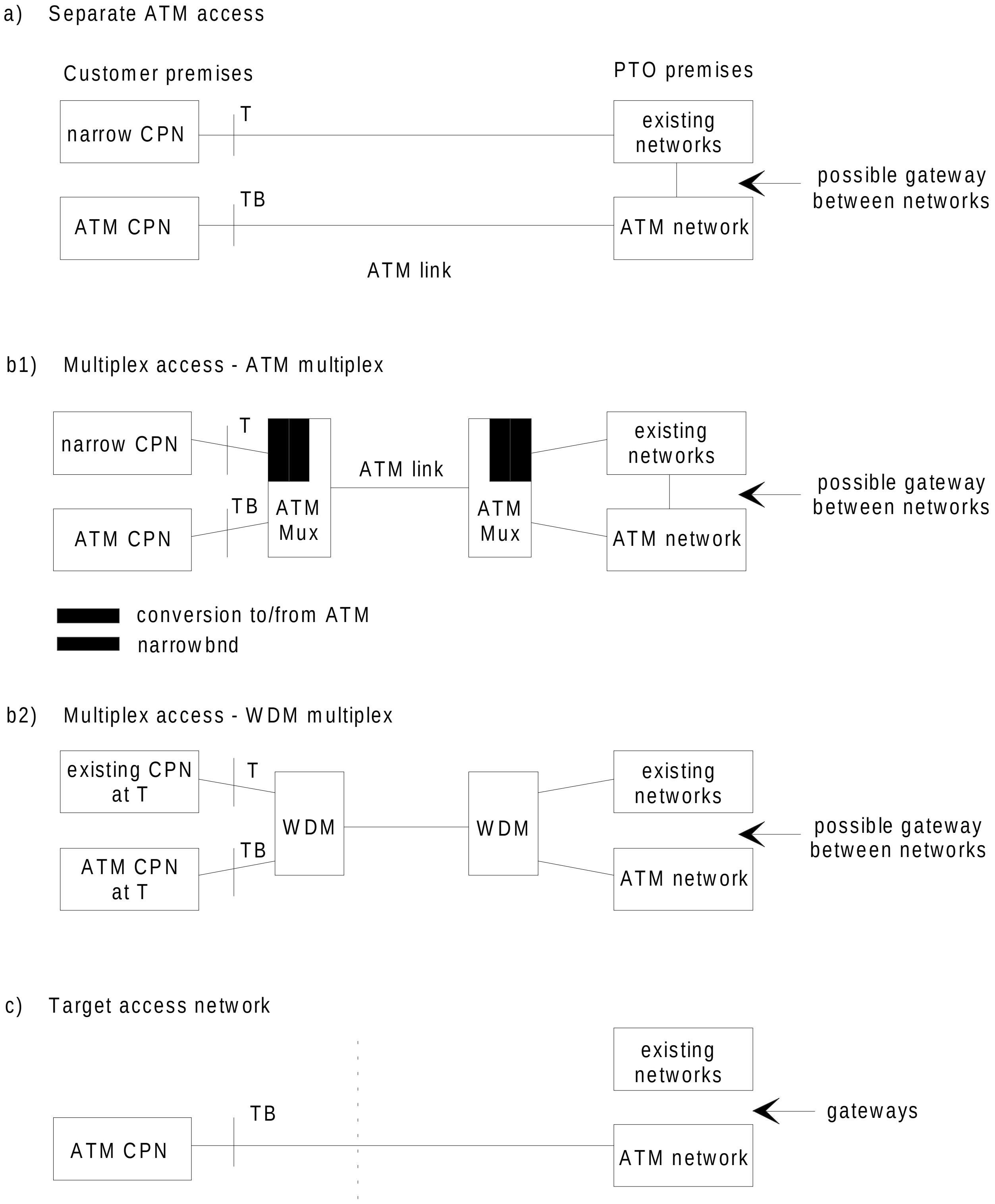
The multiple access techniques allow a moderate cost start with potential early generation of revenue, providing an early introduction of end-to-end ATM connectivity and a simplification of local network operations and management.

7.3.1.3 Target access

This approach is based on the assumption that when ATM networks are being introduced, some customer equipment using ATM techniques will be available. It aims to offer the customer optimal use of ATM equipment, by providing full ATM access to an ATM exchange (see figure 3c). Both existing narrowband services and new broadband services will be carried on this ATM access in an integrated way and handled by the ATM switch based on the B-ISDN protocol stack. The access to the existing networks is provided by gateways.

In this target solution, maximum potential for revenue and flexibility for customers are expected together with the greatest simplification in local network operations and management.

The main drawback of this approach is in the high cost start, caused by the need for gateways to non-ATM networks and for interfaces between non-ATM and ATM equipment.



ATM: Asynchronous Transfer Mode
CPN: Customer Premises Network (customer equipment)
WDM: Wavelength Division Multiplex
T/TB: Reference point

Figure 3: Possible technical approaches for the access network

The approaches described above relate to the evolution of the access techniques to support the existing narrowband and the new broadband services, considering the common provision of interactive and distribution services. Nevertheless, a separate provision of interactive and distribution services can also be considered, taking especially into account that the provision of distribution services is likely to remain unswitched in the near future. The relevance of the distribution services could increase in the business area, when some groups of customers (e.g. hotel and TV studios) will require also distributive and/or broadband services provided by Network Specialised Centres (NSC) and in the residential area, when inexpensive digital TV sets and direct and simple interfaces to these TV sets will be available. In order to allow, in the early phase, an independent evolution of interactive and distribution services with the related supporting technologies, a separate access to these two categories of services could be offered to the customer. The related signals could be combined at the access to the public network and then separated in the local exchange, allowing the use of the same fibre as transmission medium. In this way, a physical integration of interactive and distribution services is realised, making use of simple passive components. For this purpose various multiplexing schemes can be considered (WDM & Time Division Multiplex (TDM), High Density Wavelength Division Multiplex (HDWDM), Coherent Multichannel (CMC)).

With respect to the functional integration of interactive and distribution services, which gives a fully switched provision through a single user-network interface, the above solution allows neither simplification of OAM operations, nor terminal integration.

Recommendation:

It is recommended to study the impact of different alternative solutions for access network on standardisation activities of related system and network interfaces, e.g. V reference point when using ATM multiplexing techniques.

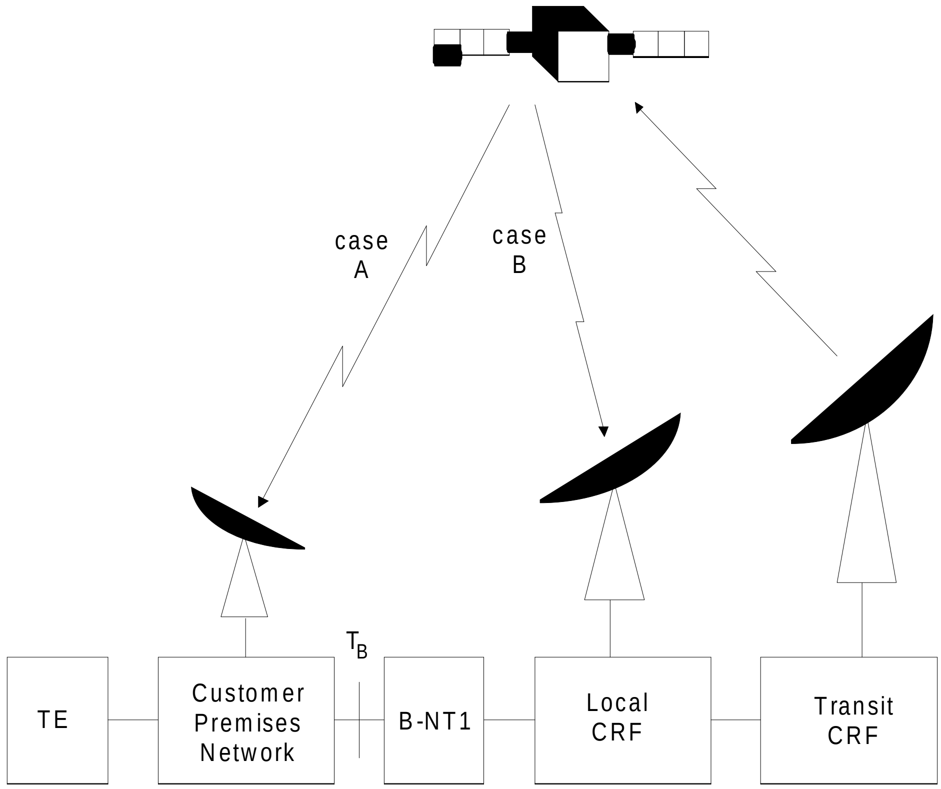
The provision of distribution services can also be provided by satellite, which is naturally suited to broadcast/multipoint applications.

In the network configuration shown in figure 4 for the support of distribution services by satellite, the TV studio is connected to the transit exchange and uses its connection and transmission facilities. Programmes are either originated in the TV studio, or they arrive through the (international) transit links and can be processed in the TV studio (e.g. for language translation, coding) before being broadcast.

Two solutions can be envisaged for the provision of TV broadcasting to the customer.

In the first solution (see figure 4, case A), which is applied in the direct-to-home TV broadcast service, all customers have a direct access to the programs: the CEQ is connected to the satellite by means of monodirectional receiving link.

In the second solution (see figure 4, case B), the earth station is connected at the level of local exchange: broadcast services reach the B-ISDN customers through the optical connection to the local exchange, which allows the B-NT1 to provide the customer access to both interactive and distribution services.



B-NT1: Broadband Network Termination
CRF: Connection Related Function
TE: Terminal Equipment

Figure 4: Provision of TV distribution service via satellite

7.3.2 Possible structures and architectures for the fixed access network

The star-based topology will be the likely target solution for most of the accesses when the density of B-ISDN subscribers is high and the mean traffic load produced by them is also high.

For the access of residential subscribers, who individually may not produce a high traffic load, but whose number is very large, an economic solution may be achieved by application of concentrators in the access network.

Nevertheless, for the terrestrial access network, different architecture solutions can be considered:

- ATM over a Passive Optical Network (APON);
- ring-based SDH networks;
- MAN;
- frame relay access.

Recommendation:

It is recommended to study:

- the relationship among APON, ring based SDH network, MAN and frame relay network;
- the possible combination of the above structures and architectures in an integrated access network.

7.3.2.1 ATM over a passive optical network

ATM over a Passive Optical Network (APON) has been suggested as a method for the early introduction of ATM to small business and residential customers. In this network, which is a tree-based topology, a 155 Mbit/s cell stream is broadcast from the exchange end to the customer terminals, which selects the cell destined for them. In the reverse direction a negotiation protocol is invoked that gives each terminal a chance to transmit its cells, which are timed so that a single cell stream is formed. This cell stream is then transmitted to the ATM node. The APON structure is the same as a PON structure for the support of the Telephone service (TPON) but the TDM protocol is replaced by the ATM. The following standardisation considerations need to be taken into account in relation with evolution of Passive Optical Network (PON):

- PONs in the local loop must be able to convey narrowband services as well as broadband services;
- wavelength allocation is a very important issue. Therefore, this should be standardised as soon as possible;
- in the (tree) network, passive optical power splitters will be used. Because of management, the splitting ratio shall not exceed 1:64. Splitters need to be wavelength flattened;
- management of the transmission equipment will be done following the TMN concept. A Q-interface will be present on the transmission equipment in the local exchange, to deal with the transmission medium dependent maintenance (laser control, laser monitoring, receiver control, receiver monitoring, etc.; local and remote). The digital path maintenance functions will be supported by the switch (loop control, CRC-handling, frame alignment, etc.) through the V-interface;
- for interactive services, interfaces V and T/S will be according to the existing standards (e.g. 2 Mbit/s for POTS, V3 and V4 for PRA and BA ISDN). For distribution services, interfaces are for further study.

  NOTE: For the time being, common non-ISDN standards, e.g. for broadcasting and CATV need to be adopted.

Recommendation:

The following standardisation issues should be studied in relation with APON:

- wavelength allocation;
- management of transmission equipment taking into account the TMN concept;
- interfaces at T, S, V reference points for distributive services.

7.3.2.2 Ring-based SDH networks

The ring-based SDH networks can serve the current communications needs of subscribers, such as basic and primary rate access (N-ISDN) and interfaces at 2, 34 and 140 Mbit/s (e.g. for video-conference). The architecture includes add/drop multiplexers which are able to insert/extract flows at 2 and 34 Mbit/s. For this network, no particular access protocol is specified. Once a subscriber being served by a ring system wants to get access to B-ISDN, it will easily be possible by equipping a STM-1 interface to the add/drop multiplexer. The ring has an OAM system for its configuration and maintenance.

The add/drop multiplexer may be located at the subscriber premises, or at some office close to the subscriber.

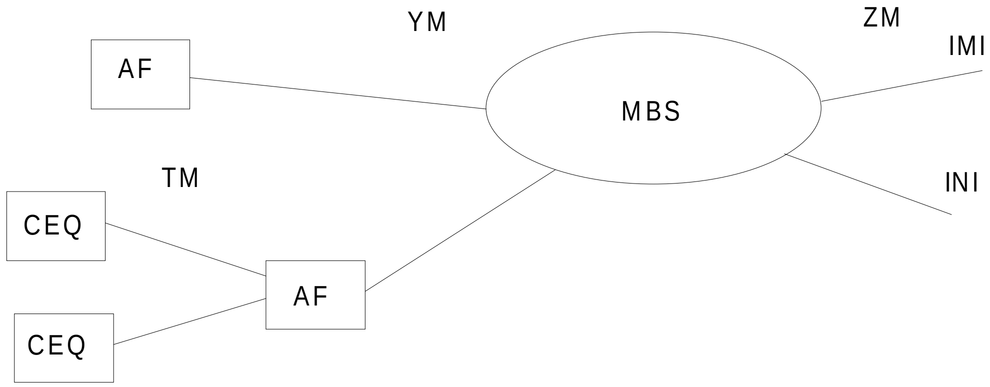
7.3.2.3 Metropolitan area networks

MAN which have been defined as public networks, represent a suitable solution for the broadband access network. A range of first-generation MAN products is already being offered by some of the largest telecommunications. The potential customers of MANs are mainly the large business customers of the present network. They generally own private LANs and/or high performance work stations, and mainly request high speed transfer of data/image applications. The integration of voice and data traffic is not of prime interest in a first step.

Indeed, the main reason that led to the development of MANs make Connectionless (CL) communication their natural mode of operation, even though other services are envisaged (i.e. isochronous and connection-oriented non-isochronous services) as defined in ETS 300 211 [13]. The IEEE 802.6 [12] Distributed Queue Dual Bus (DQDB) protocol, adopted in ETSI. ETS 300 212 [14] defines all the functionalities needed to support the CL service over MAN.

In order to ensure that connectionless service provided by MAN will also be supported by B-ISDN, a technology independent Connectionless Broadband Data Service (CBDS) has been specified in ETSI (see ETS 300 217 [15]). This service is suitable for being supported by high-speed networks, i.e. MAN and ATM-based network, and allows the same service to be offered to the customer, irrespective of the access link and related technology.

The general architecture for MAN is shown in figure 5. The key functional components are the MAN Switching System (MSS), which provides routeing and switching functionalities, and the Access Facilities (AF) that connect user equipment to the MSS. The MSS performs the typical functions of the local exchange (the Local Connection Related Functions (LCRF), while the AF represents the access link.



MSS MAN	Switching System
AF	Access Facility
CEQ	Customer Equipment
IMI	Inter MSS interface
INI	Inter network operator interface
TM, ZM, YM	Reference points

Figure 5: General architecture for MAN

The AF may consist of a direct link between the user equipment and the MSS (AF1). In this case the access interface, called User-MAN Interface (UMI) is based on the DQDB protocol. Users can also access the MSS via a sub network consisting of several DQDB nodes. Each node may provide several User Specific Interfaces (USI) using widespread LAN protocols such as IEEE 802.3 [16] and IEEE 802.5 [17] or through a DQDB-based interface as for UMI. In the former case, the node acts as a bridge terminating the LAN protocol and allowing the conversion into the DQDB protocol.

Evolutionary steps for the integration of MANs into B-ISDN

MAN, which covers a restricted geographical area, will be the early answer to the needs of business customers requesting LAN-to-LAN, LAN-to-HOST interconnections on a metropolitan area. In the following, the interconnection of MANs and the inter working between MAN and ATM-based network will be needed in order to cover larger areas. Therefore, the evolution can be characterised by the following phases:

- **Phase 1:**

  interconnection between MANs by means of dedicated links. In this phase the specification of the interfaces, intended for the direct interconnection of two MSSs, is based on DQDB protocol (see ETS 300 275 [18]) and neither routeing protocols, nor congestion procedures, are specified;

- **Phase 2:**

  interconnection of MSSs based on an ATM interface. In this phase the MSSs are connected by means of ATM connections established on a semi-permanent basis through an ATM Digital Cross Connect (DXC). The specification of the interfaces between MSS and ATM DXC is based on the ATM;

  NOTE: The related interfaces (MSS-ATM interface and inter-network operator ATM interface) are under definition in ETSI NA5.

- **Phase 3:**

  after the general introduction of the B-ISDN, MANs may serve as gathering networks for the access to B-ISDN. In this phase it is expected that a fully switched ATM-based network will be able to provide several services, including CL broadband data service, on a wide geographical area. For this purpose, specific CL service functions (CLSF) have to be included in the ATM-based network. Inter working functions have to be provided as well, in order to connect an ATM user to a MAN user.

Recommendation:

The following standardisation issues should be studied:

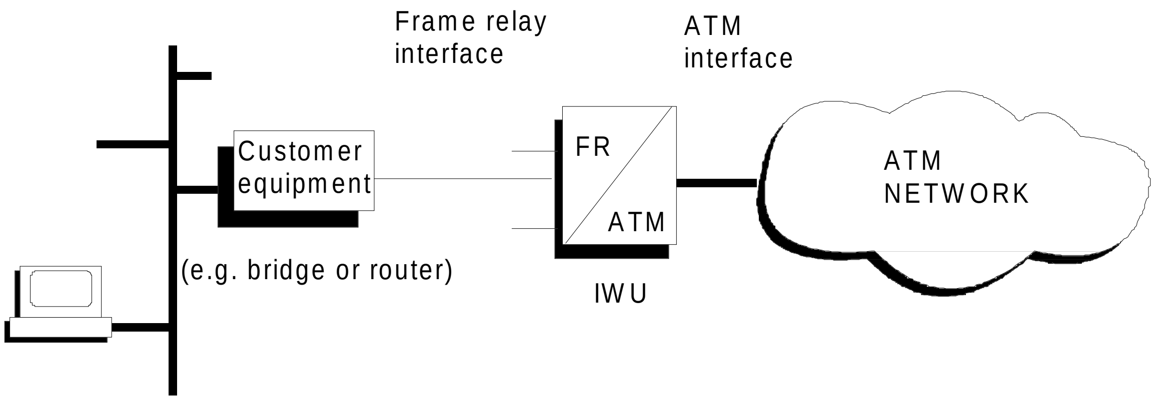
- addressing matters (especially group addressing in MAN and ATM environments);
- interconnection of MANs based on an ATM interface via ATM connections established on a semi-permanent basis;
- inter working between MAN and ATM connectionless users. This implies in the ATM-based network the definition and specification of network element, protocols and interfaces able to support CBDS over ATM.

7.3.2.4 Frame relay access network

The frame relaying service is a simple connection-oriented layer 2 service, especially suitable for LAN interconnection. The service has originally been defined by CCITT as a packet mode bearer service for N-ISDN (see CCITT Recommendation I.233 [19]). The trend is to use this service in the field of dedicated LAN interconnection networks, offering virtual private network service. The frame relay interface standard (based on CCITT Recommendation Q.922 [20] core protocol) defines the interface between customer equipment (e.g. LAN bridge or router) and a public/wide area network. Frame relay services then replace the leased lines between customer equipment by a virtual private network.

The potential customers for frame relay access are mainly the medium size business customers. They generally own private LANs in several locations, but do not require (and are not willing to pay for) as high performance interconnection as MANs can offer. The frame relay access has currently been specified up to 2 Mbit/s, but higher speeds of 34 to 45 Mbit/s are also under study. The significant advantage of the speeds up to 2 Mbit/s is that they can be implemented over current copper-based access networks.

Frame relay based LAN interconnection services are already running in several countries. Frame relay users form a large potential user group for the first ATM based services (see figure 6).



ATM: Asynchronous Transfer Mode
FR: Frame Relay
IWU: Inter working Unit

Figure 6: Utilisation of frame relay protocols in the access network

Recommendation:

The following should be studied:

- inter working matters between frame relay and ATM network;
- the applicability of existing AALs, or the definition of a new AAL type, able to support the transfer of frames into ATM cells.

7.3.3 Access network with satellites

Examples of utilisation of satellite in the access network are described by the following two scenarios:

a) Scenario with transparent satellite

In this scenario the satellite provides a transparent repeater functionality and acts as a B-ISDN link. This scenario may apply to the early phase of B-ISDN introduction. Satellites with transparent repeaters operating in the Ku band (14/12 GHz) and full European coverage are foreseen. The goal is the early provision of access to advanced services, to users, or user groups (i.e. MANs) which, in this phase of the B-ISDN, will be most likely dispersed.

The following terminal types are foreseen:

- user stations (equipped with small diameter antennae), located at user premises;

- hub stations (equipped with medium diameter antennae), which can play the role of gateways connected to a public network, or can act as the hub of a private Very Small Aperture Terminal (VSAT) network.

Clusters of user terminals are linked to a central hub in a star configuration, forming a broadband sub-network. Several types of connections are provided: user-to-hub in Time Division Multiple Access (TDMA) mode; hub-to-hub and hub-to-user in TDM mode. Only the adaptation of the ground segment is required to facilitate the inter working of the emerging B-ISDN with the existing satellite system, since in this example, the satellite is purely a transmission medium.

b) Scenario with regenerative satellite

In this scenario, the use of regenerative satellite allows on-board switching capability and a spot beam coverage. The satellite acts as a B-ISDN node. The satellite system can provide the access of remote users to B-ISDN and/or the interconnection of B-ISDN islands or MANs.

As in the scenario, a "user" and "hub" terminals are foreseen. The system (spacecraft plus ground stations) constitutes an ATM exchange. Switching is implemented on-board; line terminations are provided by the ground segment to interface terrestrial lines.

The network terminals access the ATM on-board switch in TDM mode, and the user terminals access it inTDMA mode, all down link transmissions are in TDM mode.

7.3.4 Access with wireless systems

A number of solutions, based on wireless transmission techniques for accessing fixed networks are designed for ISDN. The provision of the same facilities for use within B-ISDN can be foreseen, provided that the sustainable bit rate and the management and signalling capabilities do not limit the B-ISDN services.

Recommendation:

With respect to wireless access techniques, it should be clarified whether or not there exists a need to study their technological possibilities and evolutionary opportunities in the context of cell transfer.

7.4 Transit network

The transit network of a B-ISDN environment encompasses both the transport functions specific to B-ISDN as provided by the general transport network and higher layer functions of B-ISDN.

7.4.1 Transport network

At present, transport network developments worldwide are related to 3 trends:

- major efforts are made for implementing new technologies, based on signal structures related to the SDH (see CCITT Recommendations G.707 [7], G.708 [8], G.709 [9]) and a transport network architecture, as addressed in drafts of CCITT Recommendations. G.sna 1 and G.sna 2;

- the transport network structures will be increasingly supported by means of electronic remotely controlled switches, called "cross-connects";

- sophisticated network management tools (progressively being based on conditions/features as defined in CCITT Recommendation M.3010 [21]) will be implemented in the network, in order to increase network availability and to ease resilience measures.

The transport network architecture generally aims at matching the existing PDH with that of the synchronous one by defining adaptation functions for the transport of PDH structured signals in an SDH frame or a sub-entity (Virtual Container) of it. It is assumed that SDH will represent the technical and architectural base for future transport networks all over the world.

As B-ISDN, by definition, is exclusively based on the ATM (see CCITT Recommendation I.121 [1], § 1.4) and as the transport of information in the B-ISDN is based on the establishment of Virtual Paths Connections (VPCs) and Virtual Channel Connections (VCCs) the principle of exclusive support of B-ISDN by ATM requires the establishment of B-ISDN connections (VPCs and VCCs) via the future SDH-based transport network.

This recognition will then require that the bandwidth independent virtual ATM connections will logically fit into the framework conditions of the SDH-based transport architecture, bearing in mind that an SDH structured network will provide a number of subunits of transport (see CCITT Recommendation I.311 [3] Annex A).

The multiplicity of options demand for the definition of certain harmonised evolution paths, in order to limit the number of possibilities.

7.4.2 Architecture

The transit network architecture may be split logically into three different networks:

- a network for user information transfer;

- a network for signalling message transfer;

- a network for management message transfer.

All parts will probably underlie severe changes in the future.

The future transit network (for user information transport) will change considerably, in comparison to existing networks based on "traditional" switching hierarchies. As the future transfer mode in the network will be ATM, the transit network will consist of interleaved (logical) networks based on:

- the virtual path concept;

- the virtual channel concept.

In addition, the concept of Intelligent Network (IN) will increasingly be utilised and penetrate existing and future networks aiming at certain service-related establishment functionality (such as service switching, control and management points).

This concentration of feature-specific functionality requires an extreme level of signalling activity in terms of volume and speed. Furthermore, new concepts, such as separation of call control and connection control are under discussion and may lead, together with the above trends, to quite new efficient signalling (transport) networks with the ultimate goal to achieve a much higher flexibility regarding service creation, offering and provisioning and probably operating at higher speeds.

The network for telecommunication management command in general will not be specific to B-ISDN, there may, however, be some specific issues related to the ATM as the basic transport mechanism, which are presently under investigation within ETSI.

7.4.3 Use of satellites

The provision of international transit connection has been the major role of satellite for a long time. This will remain an important area of application in the future B-ISDN. In the definition of a satellite architecture providing interconnection between B-ISDN exchanges, it should be considered that the satellite sub network is a transmission system with limited resources (power, bandwidth, orbital position) which have to be dimensioned efficiently, i.e. the transmission bandwidth and bit rate on each link should preferably be matched to the level of real traffic being carried. The five basic steps in the evolution of satellite sub network architectures summarised in this subclause are, therefore characterised by this objective. The first three steps foresee the use of fully transparent satellites and the introduction of extra functions in the ground segment. The last two steps foresee the use of a regenerative satellite with spot beam coverage. The less demanding requirements in the terrestrial segment allows the use of an architecture with a large number of earth station, and the reuse of frequencies in the different spots enlarges the available bandwidth resources.

Transparent satellite

1) At a starting situation of satellite utilisation for the support of B-ISDN implementation, the satellite sub network would support B-ISDN services through the establishment of SDH paths between B-ISDN exchanges. Paths are established on a semi-permanent basis and are established or released according to traffic demand in the network. Interfaces with terrestrial networks are based on STM-1 signals at 155,52 Mbit/s.

   There is a provision to support path full STM-1 frames over the satellite path (e.g. using larger transponders and more efficient earth stations) and sub-STM frames for radio (STM-R), as recommended for radio relay/satellite systems in Annex A of CCITT Recommendation G.708 [8] or single Virtual Containers (VCs) (e.g. using narrowband transponders of smaller bandwidth characteristics and a medium size earth station).

   The key features of this sub network is the position of SDH cross-connects capability for the satellite sub network. The cross-connect allows for multiplexing, demultiplexing and "add-drop" functions in order to extract from the incoming STM-1 streams, lower-order VCs, discarding "unused" VCs carrying no information and mapping them in the appropriate envelope (STM-1, STM-R, etc.).

2) In a second phase, the SDH cross-connect capability of the previous sub network is augmented by ATM Virtual Path (VP) cross-connect functions. The VP mapping used to perform the routeing of ATM cells is established on a semi-permanent basis; since it does not change on a dynamic basis, access to signalling information is not required.

3) In a third phase, signalling handling capability is added to the satellite sub network essentially making the switching facility an ATM Virtual Path (VP)/Virtual Channel (VC) switch.

Regenerative satellite

4) An architecture based on regenerative satellites allows the introduction of OBP capability in the form of a VP cross-connect on board the satellite. The VP mapping used to perform the routeing of ATM cells towards the different spots beams is ground-controlled and established on a semi-permanent basis. Therefore, access to signalling information is not required.

5) In a second development phase for regenerations satellite, a more complex satellite-based sub network is foreseen based on full B-ISDN signalling and ATM switching on board. This approach has already been considered in studies by the European Space Agency (ESA).

7.4.4 Evolution of transit network

The evolution of the transit network can be mainly characterised by the following steps, such as:

- introduction of ATM cross-connects. The ATM based cross-connect network provide a virtual leased meshed network;
- introduction of ATM switches with call by call facilities;
- full capabilities of B-ISDN access;
- provision of IN capabilities, making use of controlling B-ISDN resources.

  NOTE: These steps may not be distinguished as clearly time-related phases. There may be some overlap in the approach of step-related network penetration.

Due to the general technological development in microelectronics and software, the hierarchical structure of switched networks will change considerably and will, in general, tend to a lower number of hierarchical switching stages.

As mentioned previously, the transit network and its evolution is dependent on the development of control mechanisms, where present discussions not only tend to much more sophisticated signalling protocols, but also quite new control network concepts, which will impact on the transit network in its entirety.

In the near future, the implementation of MAN technology in the network can be foreseen. Although a MAN in the future may turn out to become a gathering network which could be integrated in an overall B-ISDN approach and, therefore, may be considered more as an access type network, it cannot be excluded that in an interim period (until full B-ISDN/ATM capability is available) some installations for interconnecting MAN may take place. Although these developments may lead to a quite independent architecture, in the sense of an overlay network based on (semi-permanent) leased lines, it can, however, with a high degree of probability, be assumed that an ATM cross-connect supported network may already be available to offer MAN interconnection means.

As a prediction, it can be identified as a technological trend that electronic switching fabrics will be replaced by optical ones, an exchange in the network of which may be the less difficult, the more the definition of the control system succeeds to become independent of the switching matrix.

Strongly depending on the time scale of product availability and implementation decision, the evolution of the transit network may be slightly different in its evolution path, without deviating from the way towards the target solution of ATM-based ISDN.

Recommendation:

In order to progress the further network development in the transit network area, it is recommended to execute studies on the following areas:

- impact of potential evolution steps (as described above) on the network architecture, connection types, reference configuration and network element (e.g. to support services such as CBDS);
- relationship between signalling network and management network requirements and general transit network architecture;
- influence of satellite developments on the transit network;
- investigation on the requirement of additional intra-network interfaces related to MAN and satellite developments.

Annex A: Explanation of terms

The following terms are used in this ETR.

Access Network: the entirety of network elements to enable access of terminals to the user-related network node (in general the local exchange) and to support the establishment/release of calls.

Asynchronous Transfer Mode (ATM) (CCITT Recommendation I.113 [23]): a transfer mode in which the information is organised into cells; it is asynchronous in the sense that the recurrence of cells containing information from an individual user is not necessarily periodic.

ATM over Passive Optical Network (APON): an access network concept utilising cell transfer on a physical PON structure.

Broadband ISDN: the broadband aspects of ISDN (set up upon an identical conceptual philosophy as ISDN), technically based on the ATM.

Cellular network: a mobile network based on a concept which allows intelligent control of a large number of small-radius radio dissemination coverage areas, called cells.

CENTREX: a concept to provide sophisticated PABX features by means of the public network (exchange).

Connectionless service: a service where the information blocks are submitted to the network in form of datagrams (self-routeing entities).

Connection type (CCITT Recommendation I.112 [22]): a description of a set of ISDN connections that consists of stated values of one or more ISDN connection attributes.

Control plane: the entirety of functions for the control of the functions of the network nodes (user and network control) (see CCITT Recommendation I.321 [4]).

This plane has a layered structure and performs the call control and connection control functions; it deals with the signalling necessary to set up, supervise and release calls and connections.

Cross connect: a piece of equipment which handles and reorganises incoming and outgoing bit streams of different magnitudes.

Customer equipment (CCITT Recommendation I.324 [24]): the concatenation of equipment on the user side of the T reference point (i.e. TAs, TE2s, TE1s, NT2 and associated transmission media). In the case of multiple access, the customer equipment includes all the equipment on the user side of all those accesses comprising the multiple access.

Customer Network: a network connected at the user side to public ISDN and operated based on the subscription to public (ISDN) services offered at the T reference point (i.e. the so-called customer access point 1 according to CCITT Recommendation I.210 [25]).

Evolution step: a single step of functionality increase between two network development stages.

Fibre Distributed Data Interface (FDDI): a certain ISO standard-based concept for the implementation of LANs and, increasingly, MANs.

Frame Relaying (transfer mode): a new connection-oriented transfer mode, based on the transport of variable length frames.

Infrastructure: the entirety of elements representing the physical medium.

Intelligent network (extract from CCITT Recommendation I.312 [26]/draft CCITT Recommendation Q.1201 [27]: the IN is used to describe an architectural concept which is intended to be applicable to all telecommunications networks. IN aims to ease the introduction of new services (i.e. Universal Personnel Telecommunication (UPT), Virtual Private Network (VPN), freephone, etc.) based on more flexibility and new capabilities.

Local Area Network (LAN): a concept of a mainly data network, with a conceptually very limited extension, applying shared medium utilisation.

Logical network: entirety of functions or a part of it which (in a planary description approach) are allocated above the physical network.

Management plane: the entirety of functions to optimally operate and administer the network.

The management plane provides two types of functions, namely layer management and plane management functions.

Metropolitan Area Network (MAN): a concept of a mainly public network, based on IEEE (ISO) and ETSI standards for the prime support of connectionless services of a limited coverage area and number of accesses.

Multiconnection establishment/release: partly (for a certain period of time) parallel connections belonging to the same communication related to information transfer of different information types.

Multiparty calls: a call which involves more than 2 parties.

Multimedia calls: a service concept involving simultaneously different types of information in one single communication.

Network evolution: the process a network is passing during its life-time encompassing all transition steps from a given capability level to a more sophisticated one.

NOTE: The capability extension may be related to any level of functionality when considering the network as a planary structured entity.

Packet transfer mode (CCITT Recommendation I.113 [23]): a transfer mode in which the transmission and switching functions are achieved by packet oriented techniques, so as to dynamically share network transmission and switching resources between a multiplicity of connections.

Passive optical network: primarily a fibre-based tree-shaped infrastructure, containing optical splitters at branching points which distribute/collect optical power in the ratio of splitter inlets and outlets.

Physical network: the entirety of functionality in a network responsible for the information (bit) transport.

Protocol reference model (CCITT Recommendations. I.320 [28], I.321 [4]): an abstract model for the description and allocation of network functionality.

Shared medium: a transport medium which is, by means of common access, jointly used for different communication paths, either simultaneously or not simultaneously.

Synchronous digital hierarchy (CCITT Recommendations G.707 [7], G.708 [8] and G.709 [9]): primarily a new multiplexing scheme, allowing related transmission systems, for very extended path layer, link and section control, containing surveillance capabilities and sophisticated OAM features.

Synchronous Transfer Mode (STM) (CCITT Recommendation I.113 [23]): a transfer mode which offers periodically to each connection a fixed-length word.

Telecommunication management network: a network management concept of an overall approach for the resource control, optimisation and surveillance, based on CCITT M series of Recommendations.

Transfer Mode (CCITT Recommendation I.113 [23]): aspects covering transmission, multiplexing and switching in a telecommunications network.

Transit network: the entirety of network elements to support transport information and routeing of calls.

Universal mobile telecommunication system: system based on standards under development of a Europe-wide (global) unique nature, the basic idea of which is to integrate all mobile service and allow for Europe-wide roaming.

Universal personal telecommunications: a network independent service concept, using personal identification features allowing for worldwide free customer movement enabling permanent address ability and communicability (with home conditions).

User plane (CCITT Recommendations. I.320 [28], I.321 [4]): entirety of functionality to guarantee end-to-end information transfer The user plane, with its layered structure, provides for user information flow transfer, along with associated controls (e.g. flow control, and recovery from errors, etc.).

Virtual channel (VC) (CCITT Recommendation I.113 [23]): a concept used to describe unidirectional transport of ATM cells, associated by a common unique identifier value.

Virtual channel connection (CCITT Recommendation I.113 [23]): a concatenation of virtual channel links that extends between two points, where the adaptation layer is accessed.

Virtual Path (VP) (CCITT Recommendation I.113 [23]): a concept used to describe unidirectional transport of ATM cells, belonging to virtual channels that are associated by a common identifier value.

Virtual path connection (CCITT Recommendation I.113 [23]): a concatenation of virtual path links that extend between the point where the virtual channel identifier values are assigned and the point where those values are translated or removed.

Virtual private network: the concept to provide private network capabilities by means of public network resources.

History

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