ETSI TECHNICAL REPORT

ETR 112

September 1993

Source: ETSI TC-NA

Reference: DTR/NA-52106

ICS: 33.080

Key words: B-ISDN

Broadband Integrated Services Digital Network (B-ISDN); B-ISDN principles

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Foreword

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

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

The B-ISDN is a complex network, that supports a wide range of broadband audio-, video- and data-applications in the same network. The standardisation has reached a certain degree of maturity that makes it useful to give an overview to people, who have not yet been involved in B-ISDN activities. For understanding this document the general ISDN principles should be known. It is assumed that the user of this ETR knows the general ISDN principles.

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1 Scope

This ETSI Technical Report (ETR) contains the principles on which B-ISDN is based. The content of this ETR is mainly extracted from ITU-T Recommendations I.150 [3], I.211 [4] and CCITT Recommendation I.121 [2]. For further and more detailed information other material like ITU-T I.-Series Recommendations, European Telecommunication Standards (ETSs) and ETRs are available.

2 References

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

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

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

[3] ITU-T Recommendation I.150: "B-ISDN Asynchronous Transfer Mode functional characteristics".

[4] ITU-T Recommendation I.211: "B-ISDN service aspects".

[5] ITU-T Recommendation I.311: "B-ISDN General Network aspects".

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

[7] ITU-T Recommendation I.327: "B-ISDN Functional Architecture".

[8] ITU-T Recommendation I.350: "General aspects of quality of service and network performance in digital networks, including ISDN".

[9] ITU-T Recommendation I.361: "B- ISDN ATM layer specifications".

[10] ITU-T Recommendation I.362: "B-ISDN ATM Adaptation Layer (AAL) Functional Description".

[11] ITU-T Recommendation I.363: "B-ISDN ATM adaptation layer specification".

[12] ITU-T Recommendation I.364: "Support of broadband connectionless data service on B-ISDN".

[13] ITU-T Recommendation I.371: "Traffic Control and congestion control in B-ISDN".

[14] CCITT Recommendation I.412: "ISDN user- network interfaces - Interface structures and access capabilities".

[15] ITU-T Recommendation I.413: "B-ISDN user- network interface".

[16] ITU-T Recommendation I.432: "B-ISDN user-network interface - physical layer specification".

[17] ITU-T Recommendation I.610: "Organisation and maintenance principles of the B- ISDN Access".

[18] Draft ITU-T Recommendation M.36: "Principles for the maintenance of ISDNs".

[19] CCITT Recommendation G.702: "Digital hierarchy bit rates".

[20] CCITT Recommendation G.822: "Controlled slip rate objectives on an international digital connection".

[21] ETS 300 354: "Broadband Integrated Digital Network (B-ISDN), Protocol reference model)".

[22] ETR 089: "Broadband Integrated Digital Network (B-ISDN), Principles and requirements for signalling and management information transfer)".

3 Abbreviations

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

AAL	ATM Adaptation Layer
ATM	Asynchronous Transfer Mode
B-NT2	Broadband Network Termination 2
CBR	Constant Bit Rate
CLP	Cell Loss Priority
CRC	Cyclic Redundancy Check
CS	Convergence Sublayer
GFC	Generic Flow Control
HEC	Header Error Control
NNI	Network Node Interface
NP	Network Performance
OAM	Operation and Maintenance
PDH	Plesiochronous Digital Hierarchy
PDU	Protocol Data Unit
POH	Path Overhead
PTO	Public Telecommunication Operator
QOS	Quality of Service
RTS	Residual Time Stamp
SAR	Segmentation and Reassembly sublayer
SDH	Synchronous Digital Hierarchy
SOH	Section Overhead
SRTS	Synchronous Residual Time Stamp
STM	Synchronous Transfer Mode

TE	Terminal Equipment
TMN	Telecommunication Management Network
UNI	User Network Interface
VBR	Variable Bit Rate
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

4 Basic principles of B-ISDN

4.1 General

B-ISDN is a high speed transmission network supporting broadband services and is based on the concept of ISDN.

It supports switched, semi-permanent and permanent point-to-point and point-to-multipoint connections. It provides on-demand, reserved and permanent services.

Connections in B-ISDN support both circuit mode and packet mode services of a mono-media and/or multimedia type and of a connectionless or connection-oriented nature and in a bidirectional or unidirectional configuration.

A B-ISDN will contain intelligent capabilities for the purpose of providing advanced service characteristics, supporting powerful operation and maintenance tools, network control and management.

Since B-ISDN is based on overall ISDN concepts, the ISDN access reference configuration is also the basis for the B-ISDN access reference configuration. Different physical configurations of customer premises networks, as shown in ITU-T Recommendation I.413 [15], may be connected to the User Network Interface (UNI) of B-ISDN.

The B-ISDN architecture is detailed in functional terms and is, therefore, technology and implementation independent.

A layered structure approach, as used in established ISDN protocols, is also applied to B-ISDN, giving flexibility using different transmission systems for B-ISDN and serving different applications.

Asynchronous Transfer Mode (ATM) is the transfer mode for implementing B-ISDN.

4.2 The B-ISDN protocol reference model

4.2.1 The planes

The B-ISDN Protocol Reference Model (PRM) consists of three planes, the user plane, the control plane and the management plane.

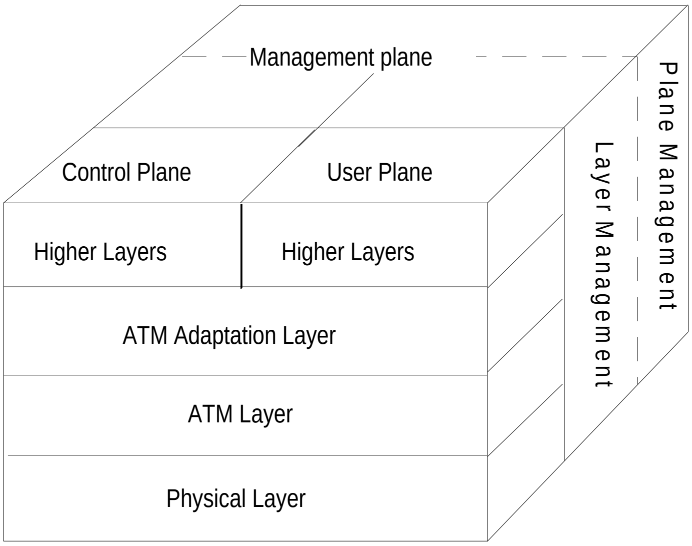


Figure 1: B-ISDN PRM

The description of the planes can be found in the ETS 300 354 [21].

4.2.2 B-ISDN layers

The ATM adaptation layer (AAL) and the Physical Layer (PL) are each divided into two sublayers as shown in figure 2.

Higher Layers	
Convergence Sublayer (CS)	ATM Adaptation Layer (AAL)
Segmentation and Reassembly (SAR)	
ATM layer	
Transmission Convergence Layer (TC)	Physical Layer (PL)
Physical Medium (PM)	

Figure 2: B-ISDN layers

For more detailed information on the functions of the B-ISDN layers see ETS 300 354 [21].

4.3 Evolutionary aspects

Since B-ISDN is based on the concepts developed for ISDN it may evolve from ISDN by progressively incorporating, directly into the network, additional B-ISDN functions enabling new and advanced services.

The evolution to B-ISDN should ensure the continued support of existing interfaces and services. Any extension of network capabilities or change in network performance parameters should not degrade the Quality of Service (QOS) of existing services.

New network capabilities will be incorporated into B-ISDN in evolutionary steps to meet new user requirements and to accommodate advances in network developments and progress in technology. Further inclusion of additional intelligent network features has to be considered in an overall context and may be allocated to different network/terminal elements.

It is recognised that B-ISDN may be implemented in a variety of ways according to specific national situations.

5 Functional characteristics of ATM-based B-ISDN

Due to the cell transport concept and specific cell transfer principles, some of the specific, advantageous facilities of ATM-based B-ISDN are:

- high flexibility of network access offering to the user the possibility to establish different connections for different services to different locations at one UNI;
- dynamic bandwidth allocation on-demand for each of these connections with a fine degree of granularity restricted only to maximum service bit rate the interface provides;
- flexible bearer capability allocation and easy provision of semi-permanent connections due to the virtual path concept;
- optimisation of network resources utilisation;
- independence of the means of transport at the PL.

5.1 Principles of ATM

ATM is the term for a specific packet oriented transfer mode, which uses asynchronous time division multiplexing techniques. The multiplexed information flow is organised into blocks of a fixed size called cells. A cell consists of an information field and a header (see figure 3).

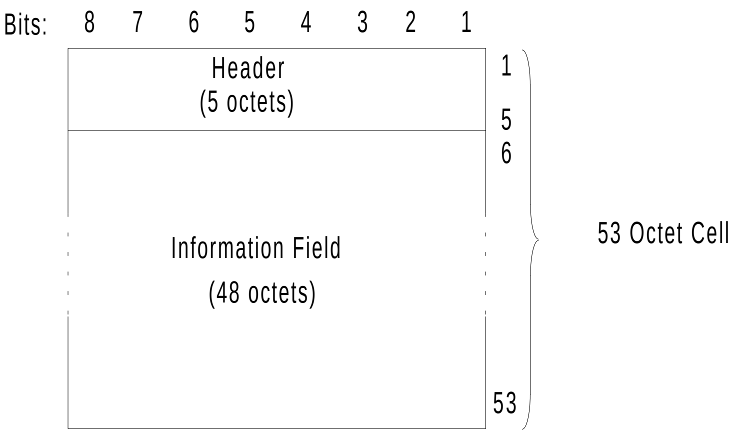


Figure 3: ATM-cell

The primary role of the header is to identify cells belonging to a specific connection within the asynchronous time division multiplex. The information field contains user information, (e.g. coded video or audio signals) which is transported transparently by the ATM layer. No processing, e.g. error control, is performed on the information field at the ATM layer. ATM is a connection oriented technique, connection identifiers are assigned to each link of a connection when required and released when no longer needed. The transfer capacity of a connection is assigned by negotiation and is based on the source requirements and the available capacity.

ATM offers a flexible transfer capability common to all services, including connectionless services. Additional functionalities on top of the ATM layer (e.g. in the AAL) are provided to accommodate various services. The boundary between the ATM layer and the AAL corresponds to the boundary between functions supported by the contents of the cell header and functions supported by AAL specific information. The AAL specific information is contained in the information field of the ATM cell.

The header and information field each consist of a fixed integer number of octets. The header size, (5 octets), and the information field size, (48 octets), remain constant at all reference points, including the UNI and the Network Node Interface (NNI), where the ATM technique is applied.

5.2 ATM layer

As ATM is the transfer mode for implementing B-ISDN, in this subclause, the main aspects of the ATM layer are described.

5.2.1 Concept of virtual channel and virtual path

ATM uses virtual connections for information transport. The transport functions of the ATM layer are subdivided into two levels:

- Virtual Channel (VC) level;
- Virtual Path (VP) level.

VC and VP are generic terms used to describe unidirectional communication capabilities for the transport of ATM cells.

The basic unit is the VC. A VP consists of a bundle of VC links which all have the same endpoints.

VP links which all have the same endpoints are multiplexed together into a transmission path that performs the transmission at the PL. Figure 4 shows the relationship between VCs, VPs and the transmission path.

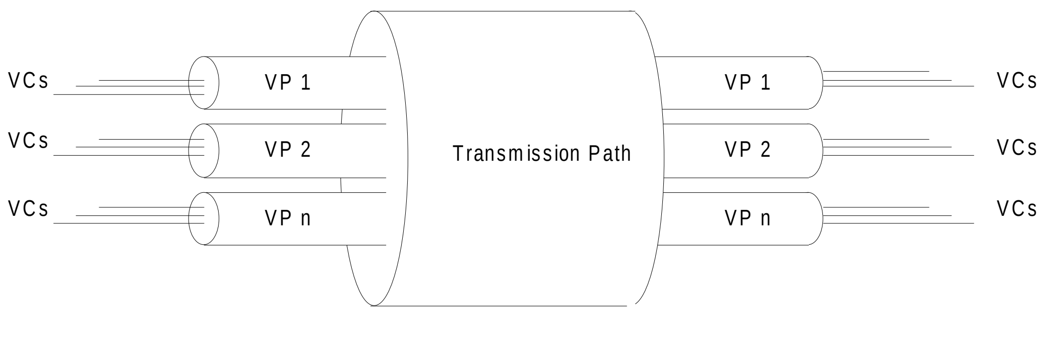


Figure 4: Relationship between the VC, the VP and the transmission path

5.2.1.1 ATM layer connections

A virtual connection at ATM layer (ATM layer connection) consists of the concatenation of ATM layer links in order to provide an end-to-end transfer capability to access points. As to the hierarchical levels of the ATM layer there are VC connections and VP connections as shown in figure 5.

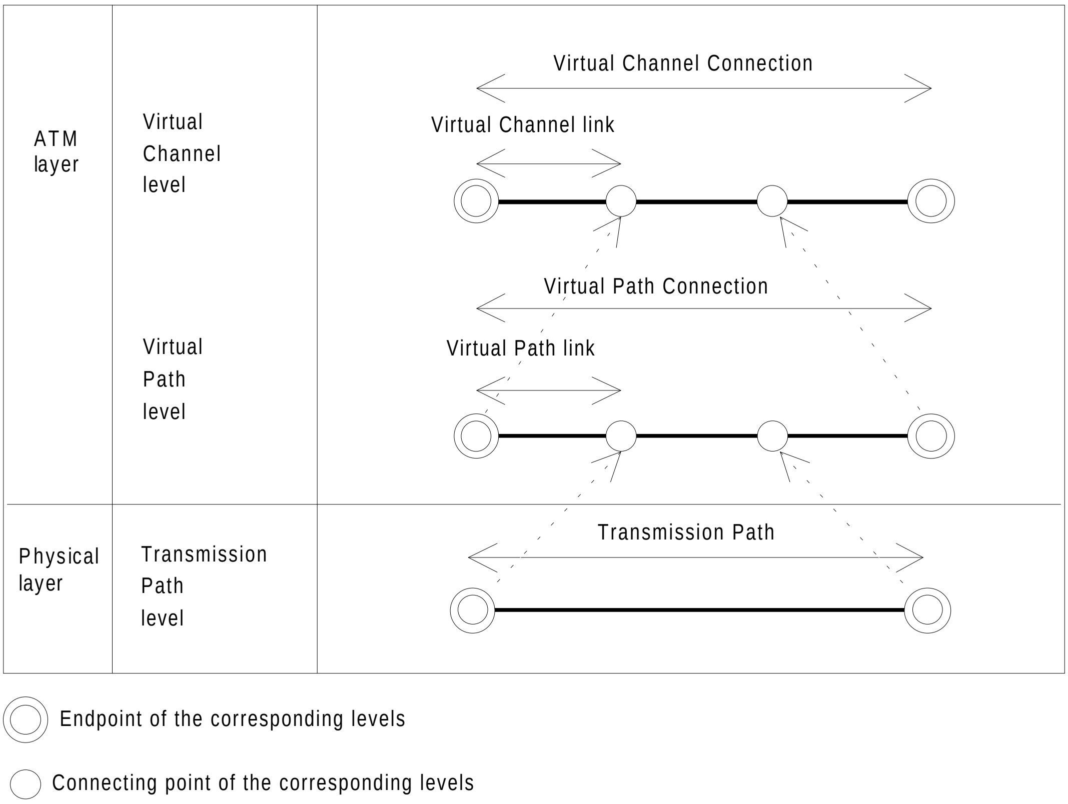


Figure 5: ATM layer connections

Cells of different VC links and VP links are multiplexed in an asynchronous manner into the same physical transmission path.

NOTE: The transmission path is further subdivided into the digital and the regenerator section.

5.2.1.2 Connection identifiers

Each link of a connection which is multiplexed into the transmission path is distinguished by connection identifiers. They are assigned to each link of a connection when required and released when not longer needed.

At a given interface, in a given direction, the different VP links multiplexed at the ATM layer into the same physical layer connection are distinguished by the Virtual Path Identifier (VPI). The different VC links in a Virtual Path Connection (VPC) are distinguished by the Virtual Channel Identifier (VCI) (see figure 4).

Two different VCs belonging to two different VPs at a given interface may have the same VCI value. Therefore, a VC is only fully identified at an interface by both VPI and VCI values.

A specific value of VCI has no end-to-end significance, if the Virtual Channel Connection (VCC) is switched. VPIs may be changed wherever VP links are terminated (e.g. cross-connects, concentrators and switches). VCIs may only be changed where VC links are terminated. As a consequence, VCI values are preserved within a VPC.

At the UNI, 24 bits (at the NNI, 28 bits) are available in the VPI/VCI field for connection identification (number of active connections at the UNI/NNI).

At the UNI the actual number of routeing bits in the VPI and VCI fields used for routeing is negotiated between the user and the network, e.g. on a subscription basis.

At the NNI the actual number of routeing bits in the VPI and VCI fields used for routeing across the interface is established at installation.

NOTE: One or more VCIs within a VPC are not available to the user of the VPC (see ITU-T Recommendation I.361 [9]).

The number of VC field routeing bits used in a user-to-user VP is negotiated by the users of the VP.

5.2.1.3 Multiplexing and switching of VCs and VPs

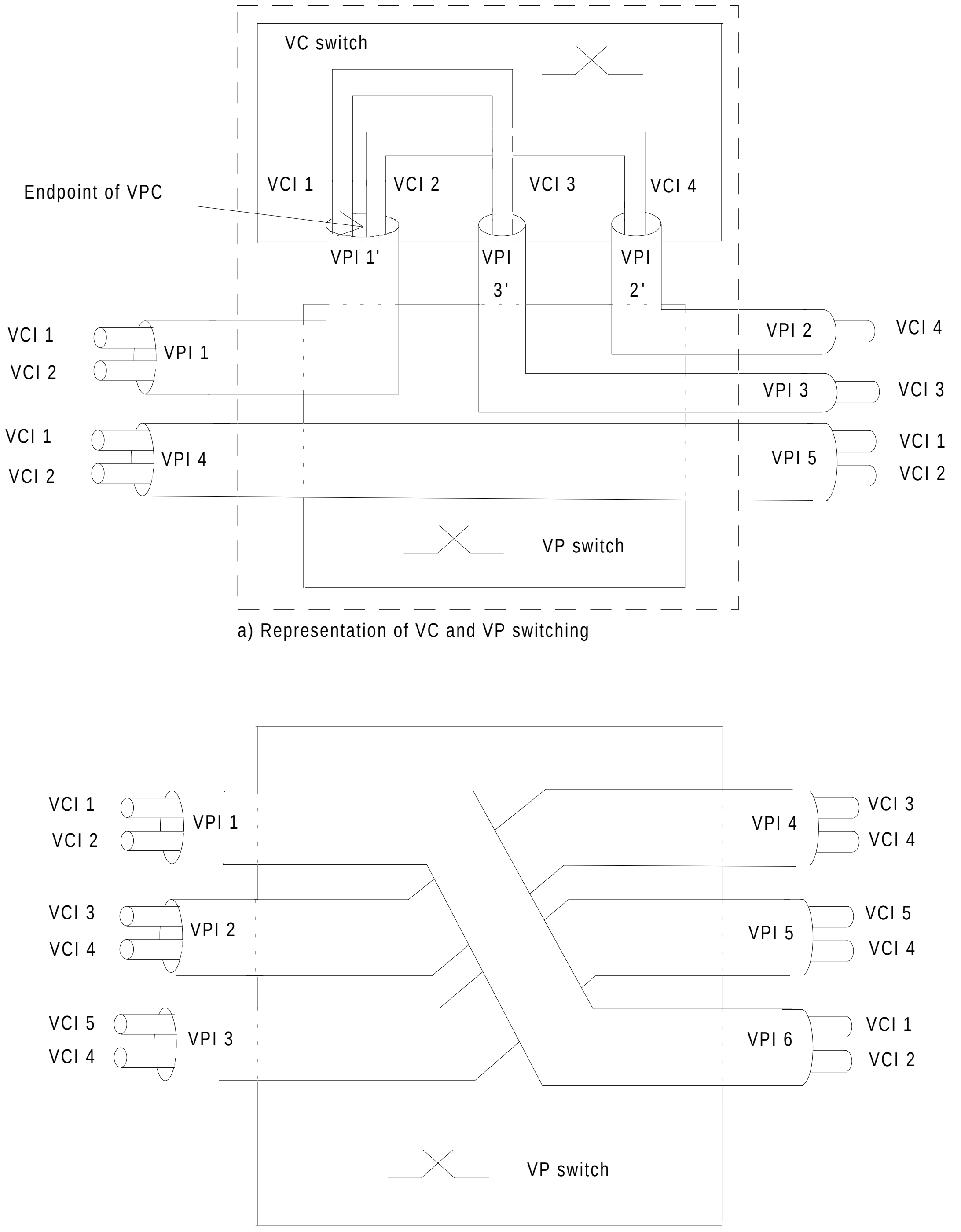
The basic ATM routeing entity for switched services is the VC. It is handled in VC multiplexers/demultiplexers and switches.

In VC multiplexers one or more VCs are multiplexed into a VPC which may be routed as such through VP multiplexers/demultiplexers and VP switches/cross-connects (for the definition of switch and cross-connect see ITU-T Recommendation I.311 [5] § 4.1).

For the routeing functions the VPI and VCI values in the header are used.

The routeing functions for VCs are done at a VC switch/cross-connect. This routeing involves translation of the VCI values of the incoming VC links into the VCI values of the outgoing VC links, see figure 6 a).

The routeing functions of VPs are performed at a VP switch/cross-connect. This routeing functions involve translation of the VPI values of the incoming VP links into the VPI values of the outgoing VP links, see figure 6 b).



a) Representation of VC and VP switching

b) Representation of VP switching

Figure 6: Representation of the VP and VC switching hierarchy

In case a VPC extends from end to end (user-to-user VPC), the network passes the VCI fields of all cells belonging to that VPC transparently with the exception of some standardised VCI values (see ITU-T Recommendation I.361 [9]). The routeing field assignment is under the control of the user (e.g. user-to-user signalling procedures, user-to-user management procedures, etc.).

5.2.2 General characteristics of virtual connections

5.2.2.1 Provided characteristics

A user of a VCC/VPC is provided with a QOS specified by parameters defined in ITU-T Recommendation I.350 [8] such as cell loss ratio and cell delay variation.

VCCs/VPCs can be provided on a switched or (semi-)permanent basis.

Cell sequence integrity is preserved within a VCC.

Cell sequence integrity is preserved within a VPC.

5.2.2.2 Traffic parameter negotiation and usage monitoring

When a user requests from the network the establishment of a VCC/VPC, traffic parameters shall be negotiated between a user and a network for each VCC/VPC at VCC/VPC establishment and may be subsequently re-negotiated. Input cells from the user to the network shall be monitored to ensure that the negotiated traffic parameters are not violated.

5.2.2.3 Assignment of VCI and VPI values

At a B-ISDN interface (e.g. UNI or NNI) there are two directions of transmission. The assignment of the VCI and VPI values are as follows:

- when a routeing field value (i.e. VPI plus VCI) is assigned for a VC link at an interface (e.g. UNI or NNI), the same value is assigned for both directions of transmission;

- when a routeing field value (i.e. VPI) is assigned for a VP link at an interface (e.g. UNI or NNI), the same value is assigned for both directions of transmission.

The routeing field value used in one direction is only to be used in the opposite direction to identify the VC link or VP link respectively involved in the same communication.

NOTE: It should be noted that:

- the bandwidth in both directions may be the same (symmetric communication); or

- the bandwidth in both directions may be different (asymmetric communication); or

- the bandwidth of the opposite direction may be equal to zero (unidirectional communication without any reverse information); or

- the bandwidth of the opposite direction should be large enough to carry ATM layer management information (unidirectional communication with reverse management information).

5.2.2.4 QOS provided for virtual connections

5.2.2.4.1 QOS related to VCCs

A user of a VCC is provided with one of a number of QOS classes supported by the network. Specific QOS classes and the quality provided by each QOS class require further study. Requested QOS classes are indicated to networks at call/connection establishment. The QOS class associated with a given connection within a call will not change for the duration of the connection. Re-negotiation of the QOS class may require the establishment of a new connection.

5.2.2.4.2 QOS related to VPCs

A user of a VPC is provided with one of a number of QOS classes supported by the network. Specific QOS classes and the quality provided by each class require further study. Requested QOS classes are indicated to networks at call/connection establishment. The QOS classes associated with a VPC will not change for the duration of the VPC.

NOTE: A VPC will carry VC links of various QOS classes. The QOS of the VPC need to meet the most demanding QOS of the VC links carried.

5.2.2.4.3 QOS related to cell loss priority

Some services may require for a virtual connection a certain QOS for one part of the cell flow and a lower QOS for the remainder. The distinction of this two QOS levels is made by using the Cell Loss Priority (CLP) bit in the cell header. Cells with a low priority setting may selectively be discarded by the network in using the CLP bit. The exact use of the CLP bit and network mechanisms to monitor connections and to provide different levels of network performance are described in ITU-T Recommendation I.371 [13].

Some VBR services will benefit if the user or service provider (e.g. layered coding video provider) can select which cells have the higher loss sensitivity.

5.2.3 Establishment and release of VCCs and VPCs

There are different methods for establishing and releasing VCCs/VPCs:

5.2.3.1 Establishment and release of a VCC

5.2.3.1.1 Establishment and release at the UNI

VCCs may be established/released using one or more of the following four methods:

a) without using signalling procedures, e.g. by subscription ((semi-)permanent connections);

b) meta-signalling procedures (ITU-T Recommendation I.311 [5]), e.g. by using a meta-signalling VC to establish/release a VC used for signalling;

c) user-to-network signalling procedures, e.g. using a signalling VCC to establish/release a VCC used for end-to-end communications;

d) user-to-user signalling procedures, e.g. using a signalling VCC to establish/release a VCC within a pre-established VPC between two UNIs.

The value assigned to a VCI at a UNI using the methods listed above could be assigned by one of the following:

a) the network;

b) the user;

c) negotiation between the user and the network;

d) standardisation.

The specific value assigned to a VCI at a UNI is, in general, independent of the service provided over that VC. For terminal interchangeability and initialisation it is desirable to use the same value for certain functions on all UNIs. For example, the same VCI value for the meta-signalling VC will be used on all UNI's in order to simplify initialisation of the terminal equipment.

5.2.3.1.2 Establishment/release at the NNI

ATM network elements (e.g. ATM switches, cross-connects and concentrators) process the ATM cell header and may provide VCI and/or VPI translation. Therefore, whenever a VCC is established/released across the ATM network, VC links may need to be established/released at one or more NNIs. VC links are established/released between ATM network elements using inter-network and intra-network signalling procedures. Other methods are also possible.

5.2.3.2 Establishment and release of a VPC

A VPC may be established/released between VPC endpoints by one of the following methods:

a) establishment/release without using signalling procedures:

  - in this case the VPC is established/released on a subscription basis;

b) establishment/release on-demand:

  - customer controlled VPC establishment/release where VP configuration may be performed by the user invoking signalling or network management procedures;

  - network controlled VPC establishment/release may be performed by network signalling procedures.

5.2.4 Pre-assigned VCIs/VPIs

VCI values are reserved for the following special purposes:

- unassigned cell identification and physical layer cell identification;

  NOTE: For unassigned cell identification and cells reserved for use by the physical layer, a pre-assigned value of VPI/VCI combination is reserved. This combination cannot be used for other purposes.

- meta-signalling VC identification;

- general broadcast signalling VC identification;

- point-to-point signalling VC identification;

- F4 Operation and Maintenance (OAM) flows;

- other uses are for further study.

There are pre-assigned combinations of VPI and VCI values which are shown in detail in tables 1, 2 and 3 in ITU-T Recommendation I.361 [9].

5.2.5 Pre-assigned cell header values

Cells reserved for the use of the PL have pre-assigned values reserved for the whole header; these values are not to be used by the ATM layer.

5.2.6 Management plane interactions

ATM layer management is part of the management plane and only performs management functions specific to ATM layer such as meta-signalling, ATM layer OAM and ATM resource management. These functions support the management plane to perform management functions related to a system as a whole and to provide co-ordination between all planes.

The ATM layer management information is conveyed via the following two methods:

One method uses payload type indicating user information and ATM layer management information is placed in the cell payload. A bi-directional connection is established for the sole purpose of providing this layer management information.

The other method uses payload type indicating layer management information and ATM layer management information is placed in the cell payload. It is transported using the same VPI/VCI value as the user/control plane VCC.

5.2.7 Functions of the ATM layer

The functions of the ATM layer are supported by the header of the ATM cell.

8	7	6	5	4	3	2	1	BIT / OCTET
GFC/VPI				VPI				1
VPI				VCI				2
VCI								3
VCI				PT			CLP	4
HEC								5

CLP	Cell Loss Priority	PT	Payload Type
GFC	Generic Flow Control (at the UNI)	VPI	Virtual Path Identifier
HEC	Header Error Control	VCI	Virtual Channel Identifier

NOTE: The last four bits (bit 5 to 8) of the first octet are GFC values at the UNI and VPI values at the NNI.

Figure 7: Cell header of a ATM cell

5.2.7.1 Cell multiplexing

In the case of more than one ATM connection, the ATM layer is responsible for the multiplexing as described in subclause 5.2.1.

5.2.7.2 Payload type functions

The payload type field is used to provide an indication of whether the cell payload (i.e. information field) contains user information or management information.

In user information cells the payload consists of user information. The payload type field codings for ATM user information are used to provide two additional indications, i.e.:

- congestion indication;
- ATM layer user to ATM layer user indication.

The payload type field codings for management information are used to distinguish between three types of cells, i.e.:

- OAM F5 end-to-end associated cells (see Clause 7);
- OAM F5 segment associated cells (see Clause 7);

- resource management cell (see ITU-T Recommendation I.371 [13]).

If the payload type field indicates management information, the payload does not form part of the user's information transfer. In this case further information concerning the type of layer management will be found in the information field of the cell.

5.2.7.3 Cell loss priority control

One bit in the cell header is used for explicit CLP indication. This bit may be set by the user or service provider to indicate lower priority cells. Cells with the CLP bit set are subject to be discarded depending on network conditions. Cells with the CLP bit not set have higher priority.

The network will monitor the connection in accordance with mechanisms described in ITU-T Recommendation I.371 [13] in order to protect the QOS of other users.

The rate of higher priority cells will be determined at call establishment and may be subsequently re-negotiated. Cells arriving at the network in excess of this rate will be subject to usage parameter control. Cells arriving at the network in excess of other agreed parameters for the call will also be subject to usage parameter control.

NOTE: The CLP mechanism would not normally be used for Constant Bit Rate (CBR) services, i.e. cells belonging to a CBR service would not normally have the CLP indicator set.

5.2.7.4 Generic flow control

The GFC mechanism is only applied at the UNI. It assists in the control of the flow of traffic from ATM connections of various QOS classes (related to the ATM layer). More specifically, the GFC mechanism is used to control traffic flow in order to alleviate short term overload conditions that may occur.

There are two sets of procedures for use within the GFC field, "uncontrolled transmission" procedures and "controlled transmission" procedures (defined in ITU-T Recommendation I.361 [9], § 3.1):

- the "uncontrolled transmission" procedures can be used across the interface at the S_B and T_B reference points;

- the "controlled transmission" procedures can be used at the interface at the S_B reference point and across the interfaces inside the customer network which are identical to the interface at the S_B reference point (see ITU-T Recommendation I.413 [15], § 2.3.1.2).

In case where a terminal equipment is directly connected to the interface at the T_B reference point, the Terminal Equipment (TE) can execute the "controlled transmission" procedures. However, the public network can implement the "uncontrolled transmission" set of procedures.

In case of the "uncontrolled transmission" no GFC action is taken.

The "controlled transmission" set of procedures for both multi-access and point-to-point B-TE configurations are for further study. They are expected to conform to the following:

a) the flow control at the UNI is supported by the ATM cell header. The GFC field is used to provide this function;

b) the GFC mechanism may assist the customer network in providing various QOS within the customer network;

c) the GFC mechanism should not perform flow control of traffic from the network.

5.2.7.4.1 GFC at S_B Reference point

The GFC field is present at the interface at the S_B reference point and at the interfaces inside the customer network which are identical to the interface at the S_B reference point.

The GFC mechanism should provide flow control of information generated locally by terminals within a customer's premises. This traffic may occur in directions to and from the terminal across the interfaces mentioned above. The specific mechanism at these interfaces is for further study. Operation of the GFC mechanism within the Broadband-Network Termination 2 (B-NT2) to control the traffic in the B-NT2 to terminal direction is for further study.

5.2.7.4.2 GFC at T_B reference point

The GFC field is present at the interface at the T_B reference point. In cases where a TE is directly connected to the interface at the T_B reference point, the TE can execute the "controlled transmission" procedures. However, the public network can implement the "uncontrolled transmission" set of procedures:

a) the GFC mechanism resides in the ATM layer and is independent of the PL;

b) the GFC mechanism applies at UNIs and should support the configurations of ITU-T Recommendation I.413 [15] § 2.2;

c) the GFC mechanism should allow a terminal to achieve an assured capacity or bandwidth allocated by the network to both CBR and Variable Bit Rate (VBR) calls. In the case of VBR services the GFC mechanism needs to be able to partition fairly and efficiently the capacity above that guaranteed for all active connections;

d) the GFC mechanism should not compromise terminal interchangeability.

5.2.7.5 Header error control

The HEC is not a function of the ATM layer. The HEC field is processed by the PL to perform cell delineation and error control of the cell header.

5.2.8 Relation of the ATM layer with other layers

It is shown in the B-ISDN protocol reference model that the ATM layer uses the services of the PL to transmit the ATM cells (see figure 2). As B-ISDN can use different transmission systems, an adaptation to the different physical media is necessary. This function is provided by the transmission convergence sublayer of the PL. For detailed information refer to CCITT Recommendation I.321 [6].

B-ISDN supports a wide variety of services with different specific needs (e.g. service timing or error detection/correction). To meet this specific needs which the ATM layer does not provide, the adaptation to the higher layers is done by the AAL. A functional description of the AAL is given in ITU-T Recommendation I.362 [10].

5.3 AAL

The main purpose of the AAL is to enhance the services provided by the ATM layer to support the functions required by the next higher layer. The AAL performs functions required by the user, control and management planes and supports the mapping between the ATM layer and the next higher layer. Therefore, the functions performed in the AAL depend upon the higher layer requirements. Examples for such functions are segmentation and reassembly of user information, handling of transmission errors, handling of quantization effects due to the cell information field size, flow control and timing control.

As the services supported by the B-ISDN have different needs, the AAL is service specific and supports multiple protocols.

5.3.1 Basic principles of the AAL

The adaptation between the higher layers and the ATM layer is performed by mapping the higher layer Protocol Data Units (PDUs) into the information field of the ATM cell and vice-versa. The AAL entities exchange information with the peer AAL entities to support the AAL functions.

5.3.1.1 Sublayering of the AAL

As shown in figure 2 the AAL is subdivided in two logical sublayers, namely the Convergence Sublayer (CS) and the Segmentation and Reassembly sublayer (SAR). Depending on the different AAL protocols this sublayers may be further subdivided.

The prime functions of the SAR are:

- segmentation of higher layer information into a size suitable for the information field of an ATM cell;

- reassembly of the contents of the ATM cell information fields into higher layer information.

The prime function of the CS is to provide the AAL service to the higher layer. This sublayer is service dependent.

In some applications the SAR and/or the CS may be empty.

5.3.1.2 Service classification for the AAL

In order to minimise the number of AAL protocols, a service classification is defined based on the following parameters:

- timing relation between source and destination (required or not required);

- bit rate (constant or variable);

- connection mode (connection-oriented or connectionless).

NOTE: Since not all combinations of the above parameters are foreseen, four classes are distinguished, as shown in figure 8.

<table>
<tr><th></th><th>Class A</th><th>Class B</th><th>Class C</th><th>Class D</th></tr>
<tr><td>Timing relation between source and destination</td><td colspan="2">Required</td><td colspan="2">Not required</td></tr>
<tr><td>Bit rate</td><td>Constant</td><td colspan="3">Variable</td></tr>
<tr><td>Connection mode</td><td colspan="3">Connection-oriented</td><td>Connectionless</td></tr>
</table>

Figure 8: Service classification for AAL

Examples of services in the classes A, B, C and D are as follows:

class A: circuit emulation; constant bit rate video;

class B: variable bit rate video and audio;

class C: connection oriented data transfer;

class D: connectionless data transfer.

6 Signalling principles of B-ISDN

The principles for signalling in B-ISDN are described in ETR 089 [22].

7 OAM principles

This Clause gives an overview of the OAM concept at the B-ISDN customer access. It refers only to the aspects of the PL and the ATM layer.

The network configuration for maintenance activities in ISDNs is described in draft ITU-T Recommendation M.36 [18]. This configuration is also applicable for B-ISDN.

7.1 Actions of OAM

The following actions are relevant for specifying the OAM functions of B-ISDN:

- performance monitoring: normal functioning of the managed entity is monitored by continuous or periodic checking of functions. As a result, maintenance event information will be produced;

- defect and failure detection: malfunction or predicted malfunctions are detected by continuous or periodic checking. As a result, maintenance event information or various alarms will be produced;

- system protection: effect of failure of a managed entity is minimised by isolating the involved entities or changeover to other entities. As a result, the failed entity is excluded from operation;

- failure of performance information: failure information is given to other management entities. As a result, alarm indications are given to other management planes. Response to a status report request will also be given;

- fault localisation: determination by internal or external test systems of a failed entity if failure information is insufficient.

NOTE: Some of this actions are not subject to the description in this ETR.

7.2 Layering of OAM functions

7.2.1 OAM levels and flows

OAM functions for the customer access network are described by a layered approach with five hierarchical levels. The functions of each OAM layer are performed by a corresponding bi-directional information flow. These OAM flows are called F1, F2, F3, F4 and F5 flows. Depending on different configurations not all flows need to be present and the functions of a missing level will be performed by the next higher layer.

The following levels have been defined:

- virtual channel level (F5 flow);

- virtual path level (F4 flow);

- transmission path level (F3 flow);

- digital section level (F2 flow);

- regenerator section level (F1 flow).

Each of them extends between its appertaining two endpoints (see figure 9) and is concatenated of one or more sections of the underlying level. Since the regenerator section level is the lowest, it is the smallest entity for OAM functions and, therefore, does not consist of several segments. The definitions of the five levels are given in ITU-T Recommendation I.311 [5] § 2.3 and § 2.4.

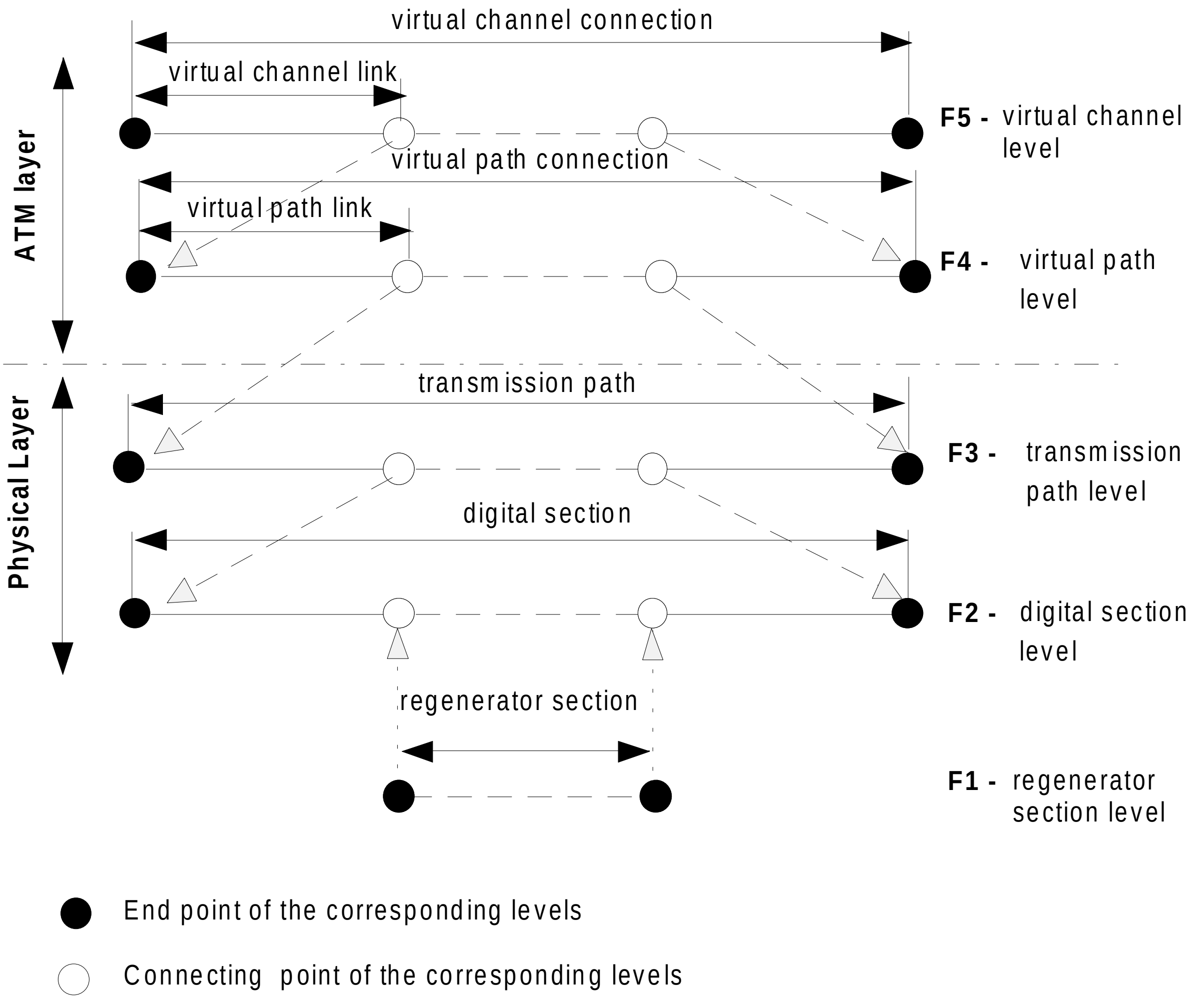


Figure 9: OAM hierarchical levels and their relationship with the ATM layer and PL

7.2.2 Relationship of OAM functions with the B-ISDN

OAM functions for the PL are carried by F1 to F3 flows and for the ATM layer by F4 and F5 flows. The functions are performed by the layer management of the B-ISDN PRM.

The layered concept requires the independence of the layers. Therefore, the OAM functions related to an OAM layer have to be provided independently of the functions of all other layers. The results of processing OAM information flows by the layer management may be provided to the plane management or to the adjacent higher layer. Because of the hierarchical layering, no support to a lower layer is given by a higher layer.

7.3 OAM mechanisms and functions

7.3.1 Physical layer

7.3.1.1 Mechanisms

The mechanisms to provide OAM flows at the PL depend on the type of the transmission system. At present three types of transmission systems are foreseen for B-ISDN:

- in case of a SDH-based transmission system F1 and F2 flows are carried in the Section Overhead (SOH) and the F3 flow is carried in the Path Overhead (POH) of the SDH-frame;

- n case of a cell based transmission system F1 and F3 flows are carried in special OAM cells (PL-OAM cells) which are recognised at the PL by a specific pattern in the cell header. They are not passed to the ATM layer. The format of these cells is given in ITU-T Recommendation I.432 [16] § 4.2.1. The F2 flow is not provided since there is no multiplexing on digital section level, but the associated functions are performed by the F3 flow.

- a PDH-based transmission system may only be used on the network side of the B-NT1. Monitoring of the section performance for this systems is specified by specific means as violation code counting Cyclic Redundancy Check (CRC) etc.

7.3.1.2 Functions

Two types of OAM functions at the PL are distinguished:

- OAM functions supported solely by F1 to F3 flows for detection and indication of unavailability state, requiring "real time" failure information transport towards the affected end points for system protection;

- OAM functions with regard to the system management which may be supported by F1 to F3 flows or other means, e.g. TMN via the Q-interfaces, for performance monitoring and reporting or localisation of failed equipment.

OAM functions for the SDH-based and the cell based PL are described in ITU-T Recommendation I.610 [17] § 5.

7.3.2 ATM layer

7.3.2.1 Mechanisms

OAM flows F4 and F5 at the ATM layer are carried by special OAM cells which are recognised at the ATM layer by a specific pattern in the cell header (see ITU-T Recommendation I.610 [17] § 4.2). The bi-directional OAM cells at the ATM layer need to follow in both directions the same physical route so that the connecting points supporting that connection can correlate the fault and performance information from both directions.

For each of both flows there can exist two types simultaneously in a VPC (F4 flow) or in a VCC (F5 flow) respectively:

- end-to-end flow which extends between the endpoints of a VPC or a VCC respectively and is used for OAM end-to-end communications;

- segment flow which extends between the endpoints of one or more concatenated VP links or VC links respectively and which are all under the control of one administration or organisation. Such a concatenation is called a segment. The segment flow is used for OAM communications under control of one network operator.

The format of the F4 and F5 OAM cells is given in ITU-T Recommendation I.610 [17] § 7.

7.3.2.2 Functions

At present, only fault management and performance monitoring are defined as OAM functions at the ATM layer. Additional functions for testing, fault localisation and performance measurement are for further study.

An overview of the OAM functions and the related OAM flows is given in table 1.

Table 1: OAM functions of the ATM layer

Level	Function	Flow	Defect/failure detection	System protection and failure information
Virtual path	Monitoring of path availability Performance monitoring	F4	Path not available Degraded performance	For further study
Virtual Channel	Monitoring of channel availability Performance monitoring	F5	Channel not available Degraded performance	For further study

The defined OAM functions are described in ITU-T Recommendation I.610 [17] § 6.

8 Service aspects of B-ISDN

8.1 General network aspects of broadband services

8.1.1 General

This Clause provides information concerning some of the important aspects which need to be taken into account when supporting and developing services for the B-ISDN.

8.1.2 Multimedia aspects

Broadband services may involve more than one information type. These services are termed multimedia services. For example, video telephony will include audio, video and possibly some form of data. Other information types may be text and graphics for example. A structured approach to the development of multimedia services is recommended to ensure:

- flexibility for the user;
- simplicity for the network operator;
- control of interworking situations;
- commonalty of terminal and network components.

The B-ISDN provides independent call and connection control facilities, which should be exploited to help achieve the above objectives (for the definition of call and connection control see ETR 089 [22]. The B-ISDN will make it possible, within a single call associated with a specific service, to establish a number of connections which may each be associated with a specific information type. The B-ISDN will enable the addition and/or deletion of optional information types during a call.

It is recommended, therefore, that the development of multimedia services proceeds on the basis of the following principles:

- that a limited set of standardised information types are developed;
- that the association of services and standardised information types is controlled, but in a flexible manner.

8.2 Quality of service aspects

8.2.1 General

Principles of QOS and Network Performance (NP) and their relationship with each other are described in ITU-T Recommendation I.350 [8]. A method of identifying QOS and NP parameters is given in Annex A of ITU-T Recommendation I.350 [8]. Further enhancement of the methodology and the definition of individual parameters for B-ISDN are for further study.

8.2.2 QOS indication and negotiation

QOS is negotiated during the call set up phase and possibly during a call. It is for further study whether specific QOS parameter values will be explicitly indicated (e.g. by a specific cell loss ratio values) or implicitly associated with specific service requests (e.g. a standardised service will by definition include the specification of all relevant QOS parameters).

For several reasons, including network operation, interworking and service development, a limited number of specific QOS will be standardised.

Additionally, for some services there is a need for an explicit CLP indication on a cell by cell basis as a means of managing cell loss during periods of network congestion. This allows a user to use two levels of cell loss ratios for ATM connection. However, if this indicator is used it will be necessary during the call set up phase to indicate the intended incidence of use of this indicator. This is necessary to facilitate appropriate network resource allocation and usage/network parameter control. Further details on the use of CLP bits are in ITU-T Recommendation I.371 [13].

8.3 Service bit rate aspects

8.3.1 General

The issue of service bit rates and associated user assurances is very much related to suitable allocation of network resources. The objectives should include:

- support of service bit rate requirements;
- simplicity of service bit rate expressions;
- efficient utilisation of network resources;
- exploitation of the inherent variable bit rate capability of ATM;
- increased use of network resources during lightly loaded periods.

8.3.2 Constant bit rate services

Constant service bit rates are negotiated at call set up time for on-demand services and the necessary network resources are fully allocated at this state for the duration of the call. Changes to bit rates during a call may be negotiated via signalling and details are for further study. Service bit rates for permanent and semi-permanent services can be determined by signalling, by agreement with the Public Telecommunication Operators (PTOs) or by some other method. This approach is consistent with that adopted for Synchronous Transfer Mode (STM) networks.

For several reasons, including network operation, interworking and service development, a number of specific bit rates will be standardised. For example, the circuit mode n x 64 rates of the 64 kbit/s-based ISDN, and the rates of the 1,544 Mbit/s and 2,048 Mbit/s hierarchies (see CCITT Recommendation G.702 [19]) will be supported.

8.3.3 Variable Bit Rate (VBR) services

Variable bit rates may be expressed by a number of parameters, related to the traffic characteristics described in ITU-T Recommendation I.371 [13].

These parameters for on-demand services should be negotiated at call set up time, and if agreed, supported for the duration of the call. Service bit rates for permanent and semi-permanent services can be determined by signalling, by agreement with the PTOs or by some other method. Changes to these parameters may be negotiated within the call period. A set of discrete bit rates will be chosen.

8.3.4 Maximum service bit rate supported by the 155,52 Mbit/s (622,08 Mbit/s) interface

The transfer capability at the user network interface is 155,52 Mbit/s (622,08 Mbit/s) with a payload capacity of 149,76 Mbit/s (599,04 Mbit/s). With the ATM cell format of a 5 octet header and 48 octet information field, the maximum rate provided by the ATM layer to the AAL at the interface for all cell information fields is 135,631 Mbit/s (542,524 Mbit/s)

The maximum service bit rate provided by the AAL to the higher layers which can be supported by this interface may be equal to or less than 135,631 Mbit/s (542,524 Mbit/s). The actual maximum service bit rate is for further study. The following factors, if applicable, will affect the available maximum service bit rate:

- the service delay and buffering requirements;

- the transfer capacity for signalling and OAM cells;

- the AAL overheads.

8.3.5 Bit rate assurances

Constant bit rates negotiated at call set up time and negotiated by the PTOs should be assured to the user for the duration of the call. Similarly, the parameters relating to VBR services should be assured for the call duration. No assurances can be given concerning additional traffic above that negotiated.

8.4 Service timing/synchronisation aspect

8.4.1 General

Service requirements for timing functions vary widely and may be supported in a number of ways based both on end-to-end service information and on facilities available from the network.

Some existing services of 64 kbit/s-based ISDN will require 8 kHz structured information transfer on an end-to-end basis. Such structured information transfer can be provided by B-ISDN for CBR services (see ITU-T Recommendation I.363 [11]).

8.4.2 Source clock frequency recovery

Some services will require end-to-end transfer of source clock frequency. For these services the following are examples of methods available.

Example 1: Synchronous Residual Time Stamp (SRTS) method.

The transmitter provides a measure of the difference between the local service clock and the network provided reference clock. This information is encoded as a residual time stamp for transport to the receiver. The receiver uses the received residual time stamp and the network provided reference clock to reconstruct the local service clock.

Example 2: Adaptive clock method.

The receiver writes the received information field into a buffer and then reads it with a local clock. The filling level of the buffer is used to control the frequency of the local clock.

Example 3: Use of a synchronisation pattern.

The transmitter writes an explicit synchronisation pattern in its information field which is then used by the receiver to synchronise the local clock.

For more detailed descriptions of SRTS and adaptive clock methods, see ITU-T Recommendation I.363 [11].

8.4.3 Network provided timing information

Mechanisms should be provided to enable the full requirements regarding network provided timing and synchronisation to enable services with 8 kHz integrity to be supported. For some services, SRTS method of source clock frequency recovery will rely on network provided clock to meet timing requirements.

Two examples of network provided timing are:

- driving a local clock with timing information available from the T-interface;
- the provision of network sourced time stamped cells.

8.5 Simultaneous service capabilities

The B-ISDN interfaces will be able to simultaneously support many combinations of services requiring different bit rates (both CBR and VBR) including broadband and existing ISDN services. The simultaneous service capabilities will be bounded by the payload capacity of the appropriate interface (e.g. 155,52 or 622,08 Mbit/s user-network interface).

8.6 Connectionless data service aspects

A connectionless data service supports data transfer between users based on connectionless data transfer techniques. It need not directly imply connectionless methods implemented within B-ISDN.

In the B-ISDN, virtual channels are established at the ATM layer only by means of the connection oriented technique. Therefore, connectionless data service can be supported using the B-ISDN in two ways as follows (see also ITU-T Recommendation I.327 [7]):

- indirectly via B-ISDN connection oriented service.

    a) in this case a transparent connection of the ATM layer, either permanent, reserved or on-demand, is used between B-ISDN interfaces. Connectionless protocols operating on and above the adaptation layer are transparent to the B-ISDN. The connectionless service and adaptation layer functions are implemented outside the B-ISDN. The B-ISDN thus imposes no constraints on the connectionless protocols to be adopted;

- directly via a B-ISDN connectionless service.

    b) in this case the connectionless service function could be provided within the B-ISDN. The connectionless service function handles connectionless protocols and routes cells to a destination user according to routeing information included in user cells. Thus a connectionless service above the adaptation layer is provided in this case.

Service a), may lead to an inefficient use of virtual connections of user-network interface and network-node interface, if permanent or reserved connections are configured among users. With the availability of signalling capabilities, an end-to-end connection may be established on-demand at the commencement of connectionless data service. This on-demand operation of service a) may cause call set up delay, and may introduce a load on call control functions within the network.

For service b), there are also two options, depending on the availability of B-ISDN signalling capabilities. Option one is to use pre-configured or semi-permanent virtual connections between users and connectionless service functions to route and switch connectionless data across the network. Option two is to establish virtual connections at the commencement of the connectionless service session.

Support of Service a) will always be possible. The support of a direct B-ISDN connectionless service (Service b) and the detailed service aspects are described in ITU-T Recommendation I.364 [12].

8.7 Interworking aspects

The ISDN will have broadband (ITU-T Recommendation I.413 [15]) and narrowband (CCITT Recommendation I.412 [14]) interfaces connected logically to the same network. Services normally available from narrow-band interfaces will also be available from broadband interfaces. Such services will fully interwork without limitations.

8.8 Service related signalling aspects

The following are signalling requirements from the service perspective.

a) interactive services;

- generic signalling mechanisms should be capable of simultaneously supporting many combinations of services;

- specific signalling mechanisms are needed to achieve the capabilities required for B-ISDN signalling as described in ITU-T Recommendation I.311 [5];

- several attribute values of the service need to be signalled and possibly negotiated during call establishment and possibly during a call such as:

    - QOS parameters;

    - service bit rates for CBR and VBR services;

    - ATM layer parameters (e.g. VCIs and VPIs);
- moreover, negotiated parameters need to be assured. The parameters that can be negotiated are for further study;

    - signalling mechanisms should exist for the transport of parameters associated with layers above ATM (e.g. AAL) up to and including the network layer;

    - signalling mechanisms need to support the interworking requirements;

b) distribution services:

- the signalling requirements for distribution services are characterised by frequent and simultaneous request by several users (e.g. video broadcast programme changes). Other aspects are for further study.

8.9 Service aspects of VCC

Users can utilise two means of connections via B-ISDN, i.e. a VCC and a VPC as described in ITU-T Recommendation I.311 [5].

A VPC is a bundle of VC links with common endpoints. When using a VPC between two endpoints, the identifier of VC-links is transparent through the network. Establishment and release of a VCC derived from VC-links depends on arrangements provided by the user of VP. VCCs sharing the same VPC will go through the same route in the network, hence the difference of delay among VCCs will not be significant compared to the case, where each VCC is established individually.

8.10 Video coding aspects

The ATM aspects, important from a video coding perspective which need to be considered include:

- information will be transported in cells;

- the QOS parameters (cell loss, absolute and relative network delays) will occur within specified limits (the parameters and the limits are for further study and are dependent on connection type);

- network based timing information will be available with performance meeting the requirements of CCITT Recommendation G.822 [20] (the relationship between network timing and service timing may be independent and requires further study);

- the network will support both variable and constant bit rate service;

- the network will offer independent call and connection control facilities.

The implications of the above network aspects include:

- coding studies and service developments need to be consistent with the inherent capabilities provided by the B-ISDN;

- codecs need to be tolerant of cell loss which will also affect codec design in terms of the amount of error control and rate of forced image refresh;

- call establishment and termination, which may require multiple connections, and other network related operation during a call, need to be common across the multiple interworking video services;

- control of the audio and video components of the connection need to also be considered with the differential delay within specific bounds to allow independent support;

- end-to-end delay limits need to be taken into account in both network and codec design for interactive services.

History

Document history	
September 1993	First Edition
February 1996	Converted into Adobe Acrobat Portable Document Format (PDF)