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SERIES I: INTEGRATED SERVICES DIGITAL
NETWORK

General structure – General description of asynchronous
transfer mode

**B-ISDN asynchronous transfer mode functional
characteristics**

ITU-T Recommendation I.150

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION I.150

B-ISDN ASYNCHRONOUS TRANSFER MODE FUNCTIONAL CHARACTERISTICS

Summary

This Recommendation defines the functions of the Asynchronous Transfer Mode (ATM) layer. This ATM layer is common to all services including signalling and OAM.

Source

ITU-T Recommendation I.150 was revised by ITU-T Study Group 13 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 26th of February 1999.

FOREWORD

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Recommendation I.150

B-ISDN ASYNCHRONOUS TRANSFER MODE FUNCTIONAL CHARACTERISTICS

(revised in 1999)

1 Introduction

This Recommendation addresses specifically the functions of the Asynchronous Transfer Mode (ATM) layer. This layer is common to all services including signalling and OAM.

2 Basic principles of ATM

ATM is the transfer mode solution for implementing a B-ISDN. It influences the standardization of digital hierarchies, multiplexing structures, switching and interfaces for broadband signals.

ATM is used in this Recommendation for addressing a specific packet-oriented transfer mode which uses asynchronous time division multiplexing techniques. The multiplexed information flow is organized into blocks of fixed size called cells. A cell consists of an information field and a header. The primary role of the header is to identify cells belonging to the same virtual channel within the asynchronous time division multiplex. Transfer capacity is assigned by negotiation and is based on the source requirements and the available capacity. Cell sequence integrity on a virtual channel connection is preserved by the ATM layer¹.

ATM is a connection-oriented technique. Connection identifiers are assigned to each link of a connection when required and released when no longer needed. In general, signalling and user information are carried on separate ATM connections.

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 ATM Adaptation Layer (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 information field is transported transparently by the ATM layer. No processing, e.g. error control, is performed on the information field at the ATM layer.

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 User-Network Interface (UNI) and the Network-Node Interface (NNI), where the ATM technique is applied.

¹ For a multipoint-to-point virtual channel connection, cell sequence integrity is preserved for cells from each VCC endpoint of the VCC.

3 ATM layer

3.1 ATM connections

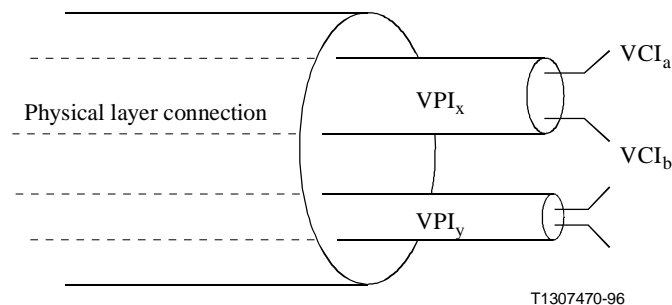
3.1.1 Connection definition

An **ATM connection** consists of the concatenation of ATM layer links in order to provide an end-to-end transfer capability to access points.

3.1.2 Connection identifiers

3.1.2.1 Virtual Path Identifiers (VPIs) and Virtual Channel Identifiers (VCIs)

At a given interface, in a given direction, the different Virtual Path (VP) links multiplexed at the ATM layer into the same physical layer connection are distinguished by the VPI. The different Virtual Channel (VC) links in a Virtual Path Connection (VPC) are distinguished by the VCI as indicated in Figure 1.



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NOTE – VCI_a and VCI_b represent two of the possible values of VCI within the VP link with the value VPI_x. Similarly, VPI_x and VPI_y refer to two of the possible values of VPI within the physical layer connection.

Figure 1/I.150 – ATM connection identifiers

3.1.2.2 VPI-VCI relationships

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.

3.1.2.3 Number of active connections at the UNI

At the UNI, 24 bits are available in the VPI/VCI field for connection identification. The actual number of routing bits in the VPI and VCI fields used for routing is negotiated between the user and the network, e.g. on a subscription basis. This number is determined on the basis of the lower requirement of the user or the network. The rules to determine the position of the routing bits used within the VPI/VCI field are given in 2.2.3/I.361.

NOTE – The number of VCI field routing bits used in a user-to-user VP is negotiated between the users of the VP.

3.1.2.4 Number of active connections at the NNI

At the NNI, 28 bits are available in the VPI/VCI field for connection identification. The actual number of routing bits in the VPI and VCI fields used for routing across the interface is established at installation. This number is determined on the basis of the requirement of each entity. The rules to determine the position of the routing bits used within the VPI/VCI field are given in 2.2.3/I.361.

3.1.3 Aspects of Virtual Channel Connections (VCCs)

3.1.3.1 General characteristics of VCCs

The definition of a VCC is given in Recommendation I.113. This subclause provides additional explanations to facilitate the understanding of the following topics:

- a) *Quality Of Service* – A user of a VCC is provided with a Quality Of Service specified by parameters such as cell loss ratio and cell delay variation.
- b) *Switched and (semi-) permanent VCCs* – VCCs can be provided on a switched or (semi-) permanent basis.
- c) *Cell sequence integrity* – Cell sequence integrity is preserved within a VCC.

NOTE – Whether this applies to all resource management (RM) cells is for further study (see Recommendation I.371).

- d) *Traffic parameter negotiation and usage monitoring* – When a user requests from the network the establishment of a VCC, traffic parameters shall be negotiated between a user and a network for each VCC at VCC establishment and may be subsequently renegotiated. Input cells from the user to the network may be monitored to ensure that the negotiated traffic parameters are not violated. Traffic contracts and conformance to traffic contracts are specified in Recommendation I.371.

At a B-ISDN interface (e.g. UNI or NNI), there are two directions of transmission. When a routing 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. The routing field value used in one direction is only to be used in the opposite direction to identify the VC link involved in the same communication. 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 could be large enough to carry ATM layer management information (unidirectional communication with reverse management information).

Within a user-to-user VPC, the network passes the VCI field transparently with the exception of some standardized VCI values (see Recommendation I.361). The routing field assignment is under the control of the user (e.g. user-to-user signalling procedures, user-to-user management procedures, etc.).

3.1.3.2 Establishment and release of a VCC

3.1.3.2.1 Establishment/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 (see Recommendation I.311), e.g. by using a meta-signalling VCC to establish/release a VCC 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) standardization.

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 initialization, 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 UNIs in order to simplify initialization of the terminal equipment.

3.1.3.2.2 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. Thus, 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- and intra-network signalling procedures; other methods are also possible.

3.1.3.3 Pre-assigned VCIs

Information concerning the use of the following VCI values in combination with VPI values can be found in Tables 1/I.361, 2/I.361 and 3/I.361.

Pre-assigned VCI values are used for:

- a) unassigned cell identification and physical layer cell identification;
NOTE – For the 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 any other purposes.
- b) meta-signalling VC identification;
- c) general broadcast signalling VC identification;
- d) point-to-point signalling VC identification, (see Recommendation I.311);
- e) F4 OAM flows;
- f) other uses are for further study.

3.1.3.4 Signalling VCs

See Recommendation I.311.

3.1.3.5 OAM VCs

See Recommendation I.610.

3.1.4 Aspects of Virtual Path Connections (VPCs)

3.1.4.1 General characteristics of VPCs

The definition of a VPC is given in Recommendation I.113. This subclause provides additional explanations to facilitate the understanding of the following topics:

- a) *Quality Of Service* – A user of a VPC is provided with a Quality Of Service specified by parameters such as cell loss ratio and cell delay variation.
- b) *Switched and (semi-) permanent VPCs* – VPCs can be established on a switched or (semi-) permanent basis.
- c) *Cell sequence integrity* – Cell sequence integrity is preserved within a VPC.

NOTE – Whether this applies to all resource management (RM) cells is for further study (see Recommendation I.371).

- d) *Traffic parameters negotiation and usage monitoring* – Traffic parameters will be negotiated between a user and the network for each VPC at VPC establishment and may be subsequently renegotiated. Input cells from the user to the network will be monitored to ensure that the negotiated traffic parameters are not violated; traffic contracts and conformance to traffic contracts are specified in Recommendation I.371.
- e) *VCI restrictions within a VPC* – The use of some VCI values within a VPC is restricted (see Table 2/I.361 and 2.3.2/I.361). A categorization of such VCI values is given below and is based on whether the cells having these VCI values are monitored by the VP OAM procedures defined in Recommendation I.610. This method of categorizing VCI values is required to ensure proper operation of the VP Performance Monitoring (PM) mechanisms defined in Recommendation I.610. Because these mechanisms compare the number of "PM user cells" transmitted at the source with the number of "PM user cells" received at the sink of the VP, it must be ensured that cells classified as "PM user cells" are never inserted, extracted, or modified between the end points of the VPC.

- Cells with VCI values which are not monitored:

Five VCI values within this category are for the internal use of the ATM layer and are used for the following functions: unassigned cell indication, F4 end-to-end and segment OAM flows, VP resource management and one for a reserved future function.

Eight other VCI values are reserved for future standardization. Prior to the standardization of the use of the reserved VCI values, if a cell should have a VCI matching one of the reserved values then this cell should be conveyed transparently between the end points of the VPC.

- Cells with VCI values which are monitored:

Nineteen VCI values within this category have been reserved for specific standardized functions (e.g. point-to-point signalling). All cells with VCI values within this category are conveyed transparently between the end points of the VPC.

At a B-ISDN interface (e.g. UNI or NNI), there are two directions of transmission. When a routing field value (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 routing field value used in one direction is only to be used in the opposite direction to identify the VP link involved in the same communication. 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 could be large enough to carry ATM layer management information (unidirectional communication with reverse management information).

3.1.4.2 Establishment and release of a VPC

A VPC may be established/released between VPC endpoints by one of the following methods. These methods are for further study:

- 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.

3.1.4.3 Pre-assigned VPIs

Information concerning the use of VPI values in combination with VCI values can be found in Tables 1/I.361, 2/I.361 and 3/I.361.

3.1.5 Pre-assigned cell header values

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

3.2 Service characteristics

3.2.1 Services expected from the physical layer

For further study.

3.2.2 Services provided to the higher layer

For further study.

3.3 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 would support the management plane to perform management functions related to a system as a whole and to provide coordination between all the planes.

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 bidirectional 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.

3.4 Functions of the ATM layer

3.4.1 Cell multiplexing and switching

In the case of more than one ATM connection, the ATM layer is responsible for the multiplexing function.

The basic ATM routing entity for switched services is the VC. It is handled in VC multiplexers/demultiplexers and switches. VCs are aggregated in VPCs which may be routed as such through VP multiplexers/demultiplexers and VP switches/cross-connects (see Figure 2).

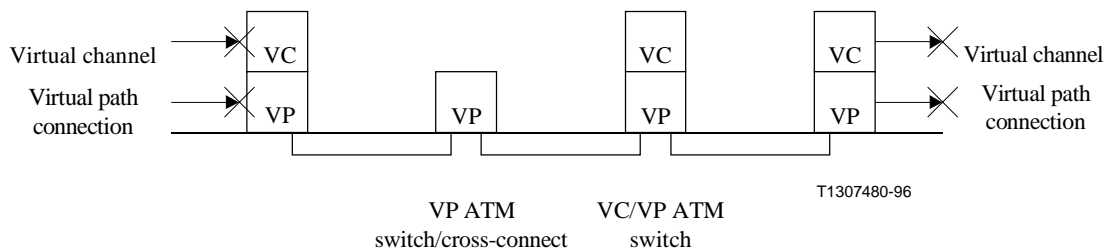


Figure 2/I.150 – Types of ATM connections

3.4.2 Quality Of Service provided by the ATM layer

3.4.2.1 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. Renegotiation of the QOS class may require the establishment of a new connection.

3.4.2.2 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.

It should be noted that a VPC will carry VC links of various QOS classes. The QOS of the VPC must meet the most demanding QOS of the VC links carried.

3.4.2.3 QOS related to Cell Loss Priority

Some services may require a certain QOS for one part of the cell flow and a lower QOS for the remainder. Exact use of the CLP bit and network mechanisms to monitor connections and to provide different levels of network performance are described in Recommendation I.371. The network may selectively discard cells by making use of the CLP bit.

Depending on network conditions and for some ATM transfer capabilities, cells where the CLP is set (CLP value is 1) are subject to discard prior to cells where the CLP is not set (CLP value is 0). (See Recommendation I.371 for further details about the use of the CLP bit.)

3.4.3 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.

The payload type field codings for ATM user information are used to provide two additional indications. They are:

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

In user information cells, the payload consists of user information. In management information cells, the payload does not form part of the user's information transfer.

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

- OAM F5 end-to-end associated cells (Recommendation I.610);
- OAM F5 segment associated cells (Recommendation I.610);
- resource management cells (Recommendation I.371).

When the payload type field does not indicate user information, further information concerning the type of layer management will be found in the information field of the cell.

3.4.4 Generic Flow Control (GFC) at the UNI

The GFC mechanism 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 at the S_B , SSB , T_B interfaces; or in a cyclic manner, to limit the effective ATM transport capacity. GFC is only available at the user-to-network interface. Any end user-to-end user flow control will require additional network facilities.

There are two sets of procedures for use within the GFC field: "uncontrolled transmission" procedures and "controlled transmission" procedures (defined in 4.1/I.361). The "uncontrolled transmission" procedures can be used across the interfaces at the S_B and T_B reference points. The "uncontrolled transmission" procedures may not be usable in shared medium configurations. The "controlled transmission" procedures can be used across the SSB (see Recommendation I.413) interface and the interface at the S_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 may choose to only implement the "uncontrolled transmission" set of procedures.

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

- a) The flow control at the UNI is supported by the ATM 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 coming from the network. The use of GFC at S_B and T_B is as follows:
 - i) GFC at S_B

The GFC field is present at the interface at the S_B reference point and the SSB interface. 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 interface at the S_B reference point and the SSB interface. Operation of the GFC mechanism within the B-NT2 to control the traffic in the B-NT2-to-terminal direction is for further study.
 - ii) GFC at T_B

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 may choose to only implement the "uncontrolled transmission" set of procedures.
- d) The GFC mechanism resides in the ATM layer and is independent of the physical layer.
- e) The GFC mechanism applies at UNIs and should support the configurations of 2.2/I.413.
- f) The GFC mechanism must allow a terminal to achieve an assured capacity of bandwidth allocated by the network to both CBR and VBR calls. In the case of VBR services, the GFC mechanism must be able to partition fairly and efficiently the capacity above that guaranteed for all active connections.
- g) The GFC mechanism should not compromise terminal interchangeability.

3.4.4.1 Generic Flow Control (GFC) at the point-to-point UNI

This subclause applies at point-to-point UNIs (i.e. at interfaces at S_B and T_B) and applies to the following classes of equipment:

- uncontrolled equipment (e.g. terminal, NT2, LEX) where GFC is ignored;
- controlled equipment (e.g. terminals and NT2s) where the emissions of assigned ATM layer cells are controlled by GFC signals;
- controlling equipment (e.g. NT2s LEX) where GFC signals are used to control the emission of assigned ATM layer cells from controlled equipment.

The use of GFC signals between controlling and controlled equipment results in two classes of ATM connections, namely:

- controlled ATM connections where the cell emission from the terminal to the NT2 or from the NT2 to the public network is controlled through GFC signals. Up to two groups (Group A and Group B) of controlled ATM connections are supported, with the default of one group (Group A) of controlled ATM connections.
- uncontrolled ATM connections where the cell emission from the terminal towards the NT2 or from the NT2 towards the public network is not controlled by GFC signals, except for the HALT signals (see 4.1.1/I.361).

Uncontrolled equipment may be connected to the interfaces at S_B and T_B reference points, irrespective of whether controlling equipment is present or not at the same interface. In this case controlled GFC procedures do not apply.

Any equipment (controlled or uncontrolled) connected to an interface where there is no controlling equipment shall not execute the controlled procedures. The controlled set of procedures applicable at UNI (S_B , T_B) are defined in Recommendation I.361.

On power up, a terminal will start in the uncontrolled mode and scan the receive cell stream for GFC signals, i.e. cyclic HALT, SET_A or SET_B. On receipt of GFC signals, the controlled equipment will set the GFC_ENABLE flag and switch to controlled GFC mode.

3.4.4.2 Generic Flow Control (GFC) at the multi-access UNI

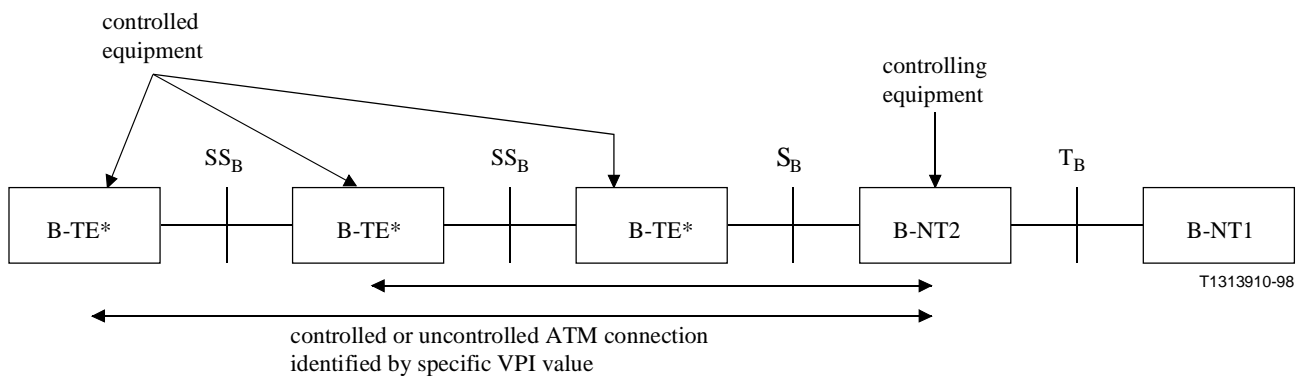
Specific VPI values are assigned to designate the specific end-user terminals. The method of assigning specific VPI values to end-user terminals is for further study.

This subclause applies at multi-access UNIs (e.g. at SSB interface, see Figure 3/I.413) and applies to the following classes of equipment:

- controlled equipment (e.g. a B-TE) where the emission of ATM layer cells are controlled by GFC signals received in cell with a VPI value that has been assigned to it;
- controlling equipment (e.g. NT2) where GFC signals are sent to a specific terminal by using cells with VPI values assigned to the specific terminal.

The use of GFC signals between controlling and controlled equipment results in two classes of ATM connections (Figure 3), namely:

- controlled ATM connections where the cell emission from the terminal to the NT2 is controlled through GFC signals and the specific VPI value. Up to two groups of controlled connections are supported;
- uncontrolled ATM connections where the cell emission from the terminal towards the NT2 is not controlled by GFC signals, except for the halt signals (4.1.1/I.361) and identified by the specific VPI value.



B-TE* Broadband terminal equipment with shared medium access function

Figure 3/I.150 – GFC at the multi-access UNI

A terminal will be assigned one or more specific VPI values from the controlling equipment. The controlled equipment will start in the uncontrolled mode, and scan the received cell stream for GFC signals i.e., cyclic HALT, SET_A, or SET_B. On receipt of GFC signals, the controlled equipment will set the GFC_ENABLE flag, and switch to controlled GFC mode.

ANNEX A

Alphabetical list of abbreviations contained in this Recommendation

This Recommendation uses the following abbreviations:

AAL	ATM Adaptation Layer
ATM	Asynchronous Transfer Mode
CBR	Constant Bit Rate
CLP	Cell Loss Priority
GFC	Generic Flow Control
NNI	Network-Node Interface
OAM	Operation And Maintenance
QOS	Quality Of Service
RM	Resource Management
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

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- Series B Means of expression: definitions, symbols, classification
- Series C General telecommunication statistics
- Series D General tariff principles
- Series E Overall network operation, telephone service, service operation and human factors
- Series F Non-telephone telecommunication services
- Series G Transmission systems and media, digital systems and networks
- Series H Audiovisual and multimedia systems
- Series I Integrated services digital network**
- Series J Transmission of television, sound programme and other multimedia signals
- Series K Protection against interference
- Series L Construction, installation and protection of cables and other elements of outside plant
- Series M TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
- Series N Maintenance: international sound programme and television transmission circuits
- Series O Specifications of measuring equipment
- Series P Telephone transmission quality, telephone installations, local line networks
- Series Q Switching and signalling
- Series R Telegraph transmission
- Series S Telegraph services terminal equipment
- Series T Terminals for telematic services
- Series U Telegraph switching
- Series V Data communication over the telephone network
- Series X Data networks and open system communications
- Series Y Global information infrastructure and Internet protocol aspects
- Series Z Languages and general software aspects for telecommunication systems