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Note - Postscript versions of [30], [31] and [32] are available for anonymous ftp from the ATM Forum ftp site. [30] is in AAL5.ps, [31] is available in 2110.ps and [32] is available in 2130.ps. Compressed versions of these files are also available and are identified by the suffix ".Z" on the file name.

Annex A

Guidelines for Use of ATM Address Formats

The goals of the address formats given in this Implementation Agreement are:

a. to ensure that the addressing scheme is easy to administer,
b. to construct a scalable address structure,
c. to provide the ability to uniquely identify an ATM endpoint,
d. to accommodate public/private interworking using existing technology where appropriate.

The following guidelines are given to clarify the use of addressing in ATM networks from the perspective of users, service providers, and equipment providers:

1. The ATM address contains an Authority and Format Identifier (AFI), and an Initial Domain Identifier (IDI). In ISO 8348, the purpose of the AFI is to specify: the format of the IDI; the network addressing authority responsible for allocating values of the IDI; whether or not leading zero digits in the IDI are significant; and the abstract syntax of the DSP. The IDI specifies: the network addressing domain from which the values of the DSP are allocated; and the network addressing authority responsible for allocating values of the DSP from that domain. Thus, the combination of the AFI and IDI, which form the Initial Domain Part (IDP) of the ATM address, uniquely specify an administrative authority which has responsibility for allocating and assigning values of the DSP.

2. For the ISO ICD IDI format, the International Code Designator (ICD) is allocated and assigned by the ISO 6523 registration authority (i.e., the British Standards Institute). The Administrative Authority (AA) is allocated and assigned by the entity specified by the ICD.

3. For the ISO DCC IDI format, the DCC is allocated and assigned to countries. The ISO National Member Body for that country (or, where no Member Body exists, another appropriate organization) allocates and assigns the Administrative Authority.

4. The ICD and DCC format are useful for organizations that wish to maintain a private numbering plan that is organizationally based.

5. The E.164 format is useful for organizations that may wish to use the existing largely geographically based public ISDN/telephony numbering format. The full ISDN number identifies an authority responsible for allocating and assigning values of the DSP. The authority is some entity within the organization which subscribes to the B-ISDN interface.

Note 1 - For private ATM networks which are attached to one or more public ATM networks, this format must be used topologically (i.e. this format must be used with an E.164 address(es) which identify one or more attachment points of the private network to the public network).

For individual private networks that are connected to multiple public networks, there are several alternative methods which may be used for addressing and routing. The best manner to handle this situation is for further study. NSAP Guidelines (RFC 1237 [36]) discusses several alternatives in this case and describes their relative advantages and disadvantages.

6. At the private UNI, the private ATM address will be carried in the Called Party Number information element. The Called Party Subaddress information element is not used.

7. At the public UNI, when the public network supports only the native (non-NSAP) E.164 address format, the gateway of the private network will signal the appropriate native E.164 number in the Called Party information element and the private ATM address in the Called Party Subaddress information element.

8. At the public UNI, when the public network supports the private ATM address format, the private ATM address will be carried in the Called Party Number information element. The Called Party subaddress information element is not used.

9. A call originated on a Private UNI destined for an endsystem which only has a native (non-NSAP) E.164 address (i.e. a system directly attached to a public network supporting the native E.164 format) will code the Called Party Number information element in the (NSAP) E.164 Private ATM address format, with the DSP field set to zero. The Called Party Subaddress information element is not used.

10. The HO-DSP field of the private ATM address format should be constructed in such a way as to allow hierarchical routing and efficient use of resources. That is, the sub-allocation of fields within the HO-DSP shall be assigned with topological significance. This specification makes no restriction on the number of subfields within the HO-DSP. The total length of the HO-DSP is fixed at 10 octets for the DCC and ICD formats and at 4 octets for the E.164 private address format.

    As an example of how the HO-DSP might be sub-allocated consider the U.S. GOSIP format. This format falls within the ICD format and is indicated by an IDI of 0005. Of the 10 octets of the HO-DSP, GOSIP defines the first octet as a Domain Format Identifier (DFI). For a DFI value of 80, the next three octets are defined as the Administrative Authority (AA). The AA represents an organization to which NIST has delegated the administrative authority to sub-allocate addresses within that unique address prefix (IDP+DFI+AA). The remaining six octets of the HO-DSP can be carved up in whatever manner suits the internal structures of that organization. For example, they might want to structure a hierarchy around divisions, campuses, buildings, and switches. They might designate the first three semi-octets to divisions, the next four to campuses, the next two to buildings, and the last three to switches or groups of switches.

Useful tutorial material and supporting technical information on use of OSI NSAP addresses can be found in RFC 1237 [36].

Annex B

Compatibility Checking

The procedures to perform compatibility checking are implementation dependent. See Annex B of ITU-T draft Recommendation Q.2931 [29] for more information.

Annex C

B-LLI Negotiation

This Annex describes procedures for the use of the Broadband Low Layer Information (B-LLI) information element by endpoint equiment.

C.1 General

The purpose of the B-LLI information element is to provide a means which should be used for conveying information related to lower layer protocols between endpoints. The B-LLI information element is transferred transparently by an ATM network between endpoints.

The user information protocol fields of the B-LLI information element indicate the low layer protocols (i.e., layer 3 and layer 2 protocols above the AAL) used between endpoints. This information is not interpreted by the ATM network and therefore the bearer capability provided by the B-ISDN is not affected by this information.

The B-LLI information element is coded according to §5.4.5.9.

The procedures of this Annex are required in support of some applications (e.g., multiprotocol interconnection). Endpoints should assume that the B-LLI negotiation procedures will be offered by most networks. Therefore it is strongly recommended that networks support all of the procedures of this Annex. At a minimum, all networks shall carry the B-LLI Information Element in the SETUP message.

C.2 B-LLI notification to the called user.

When the calling endpoint wishes to notify the called endpoint of the low layer protocols above the ATM Adaptation Layer (i.e., as identified in octets 6 to 7 of the B-LLI Information element) to be used during the call, then the calling user shall include a B-LLI information element in the SETUP message; this information element is conveyed by the network and delivered to the called user.

C.3 B-LLI negotiation between users

The B-LLI information element supports the indication of certain parameters of acknolwedged mode HDLC elements of procedures. If they are included, parameters(s) may be negotiated for point-to-point calls. In this case, the called endpoint accepting the call may include a B-LLI information element in the CONNECT message if either the endpoint reference information element was not present in the SETUP message or the endpoint reference identifier value was set to 0. This element will be conveyed transparently by the network and delivered to the calling user in the CONNECT message.

Note - The lower layer protocol parameters which may be negotiated by this capability are layer 2 mode (octet 6a), window size (octet 6b), User Specified Layer 2 information (octet 6a), layer 3 mode (octet 7a), default packet size (octet 7b), and packet window size (octet 7c).

If, for any reason, the network is unable to convey this information element, it shall act as described in §5.5.6.8.3 (unexpected recognized information element) except that the cause value #43, *"access information discarded"*, shall be used in the STATUS message. If the called endpoint includes a B-LLI information element in a CONNECT message and it is a leaf (other than the initial leaf) of a point-to-multipoint call, the network shall follow the procedures of §5.5.6.8.3.

If the calling user rejects the B-LLI information element contents in the CONNECT message, the calling user shall initiate clearing with cause #100, *"invalid information element contents"*.

C.4 Alternate requested values

If the calling endpoint wishes to indicate alternative values of B-LLI parameters (i.e., alternative protocols or protocol parameters), the B-LLI information element is repeated in the SETUP message. This procedure applies only for point-to-point calls (and for the initial leaf of a point-to-multipoint call.) Up to three B-LLI information elements may be included in a SETUP message. The first B-LLI information element in the message is preceded by the Broadband Repeat indicator information element specifying "priority list for selection". The order of appearance of the B-LLI information elements indicates the order of preference of end-to-end low layer parameters.

If the network or called endpoint does not support repeating of the B-LLI information element, and therefore discards the Broadband repeat indicator information element and the subsequent B-LLI information elements, only the first B-LLI information element is used in the negotiation. In addition, if the network discards the B-LLI information element, it shall send a STATUS message with cause value #43, *"access information discarded"*.

If the calling endpoint repeats the B-LLI information element in a SETUP message to a leaf (other than the initial leaf) of a point-to-multipoint call, the network shall follow the procedures of §5.5.6.8.3.

The called endpoint indicates a single choice from among the options offered in the SETUP message by including the B-LLI information element in the CONNECT message. Absence of a B-LLI information element in the CONNECT message indicates acceptance of the first B-LLI information element in the SETUP message. If the called endpoint supports none of the choices offered by the calling endpoint (or if acceptable choices have been discarded by the network), it shall clear the call with cause #88, *"incompatible destination"*.

If the calling user rejects the B-LLI information element contents in the CONNECT message, the calling user shall initiate clearing with cause #100, *"invalid information element contents"*.

Annex D

Transit Network Selection

This Annex describes the optional processing of the Transit network selection information element.

Transit network selection procedures are needed in this Implementation Agreement to meet certain regulatory requirements. They may also be used for other reasons.

Only one transit network selection is supported.

D.1 Selection not supported

Some networks may not support transit network selection. In this case, when a Transit network selection information element is received, that information element is processed according to the rules for unimplemented non-mandatory information elements (see §5.5.6.8.1).

D.2 Selection supported

When transit network selection is supported, the user identifies the selected transit network in theSETUP message. One Transit network selection information element is used to convey a single network identification.

The Transit network selection information element is not delivered to the destination user.

When a network cannot route the call due to insufficient bandwidth, the network shall initiate call clearing in accordance with §5.5.4 with cause #37, *"user cell rate not available"*.

If a network does not recognize the specified transit network, the network shall initiate call clearing in accordance with §5.5.4, with cause #2, *"no route to specified transit network"*. The diagnostic field shall contain a copy of the contents of the Transit network selection information element identifying the unreachable network.

If the transit network selection is of an incorrect format, the network shall initiate call clearing in accordance with §5.5.4 with cause #91, *"invalid transit network selection"*.

In addition, some networks may, by bilateral agreement, provide screening to the transit network (e.g., to ensure that a business relationship exists between the transit network and the user). Should such screening fail, the network shall initiate call clearing in accordance with §5.5.4, with cause #91, *"invalid transit network selection"*.

When a user includes the Transit network selection information element, pre-subscribed default Transit network selection information (if any) is overridden.

Annex E

Cause Definitions

Normal class definitions

Cause Number 1: unallocated (unassigned) number

This cause indicates that the called party cannot be reached because, although the number is in a valid format, it is not currently assigned (allocated).

Cause Number 2: no route to specified transit network

This cause indicates that the equipment sending this cause has received a request to route the call through a particular network which it does not recognize. The equipment sending this cause does not recognize the transit network either because the transit network does not exist or because that particular transit network, while it does exist, does not serve the equipment which is sending this cause.

This cause is supported on a network-dependent basis.

Cause Number 3: no route to destination

This cause indicates that the called party cannot be reached because the network through which the call has been routed does not serve the destination desired.

This cause is supported on a network-dependent basis.

Cause Number 10: VPCI/VCI unacceptable

This cause indicates that the virtual channel most recently identified is not acceptable to the sending entity for use in this call.

Cause Number 16: normal call clearing

This cause indicates that the call is being cleared because one of the users involved in the call has requested that the call be cleared.

Under normal situations. the source of this cause is not the network.

Cause Number 17: user busy

This cause is used to indicate that the called party is unable to accept another call because the user busy condition has been encountered. This cause value may be generated by the called user or by the network.

Cause Number 18: no user responding

This cause is used when a called party does not respond to a call establishment message with a connect indication within the prescribed period of time allocated.

Cause Number 21: call rejected

This cause indicates that the equipment sending this cause does not wish to accept this call, although it could have accepted the call because the equipment sending this cause is neither busy nor incompatible.

Cause Number 22: number changed

This cause is returned to a calling party when the called party number indicated by the calling user is no longer assigned. The new called party number may optionally be included in the diagnostic field. If a network does not support this capability, cause number #1, "*unassigned (unallocated) number*", shall be used.

Cause Number 23: user rejects all calls with calling line identification restriction (CLIR)

This cause is returned by the called party when the call is offered without calling party number information and the called party requires this information.

Cause Number 27: destination out of order

This cause indicates that the destination indicated by the user cannot be reached because the interface to the destination is not functioning correctly. The term "not functioning correctly" indicates that a signalling message was unable to be delivered to the remote user; e.g., a physical layer or SAAL failure at the remote user, user equipment off-line.

Cause Number 28: invalid number format (address incomplete)

This cause indicates that the called user cannot be reached because the called party number is not in a valid format or is not complete.

Cause Number 30: response to STATUS ENQUIRY

This cause is included in the STATUS message when the reason for generating the STATUS message was the prior receipt of a STATUS ENQUIRY message.

Cause Number 31: normal, unspecified

This cause is used to report a normal event only when no other cause in the normal class applies.

Resource unavailable class definitions

Cause Number 35: requested VPCI/VCI not available

This cause indicates that the requested VPCI/VCI is not available.

Cause Number 38: network out of order

This cause indicates that the network is not functioning correctly and that the condition is likely to last a relatively long period of time; e.g., immediately re-attempting the call is not likely to be successful.

Cause Number 41: temporary failure

This cause indicates that the network is not functioning correctly and that the condition is not likely to last a long period of time; e.g., the user may wish to try another call attempt immediately.

Cause Number 43: access information discarded

This cause indicates that the network could not deliver access information to the remote user as requested: i.e., ATM adaptation layer parameters, Broadband low layer information, Broadband high layer information, or sub-address as indicated in the diagnostic.

Cause Number 45: no VPCI/VCI available

This cause indicates that there is no appropriate VPCI/VCI presently available to handle the call.

Cause Number 47: resource unavailable, unspecified

This cause is used to report a resource unavailable event only when no other cause in the resource unavailable class applies.

Service or option not available class definitions

Cause Number 49: Quality of Service unavailable

This cause is used to report that the requested Quality of Service cannot be provided.

Cause Number 51: User cell rate not available

This cause is used to report that the requested ATM Traffic Descriptor is unobtainable.

Cause Number 57: bearer capability not authorized

This cause indicates that the user has requested a bearer capability which is implemented by the equipment which generated this cause but the user is not authorized to use.

Cause Number 58: bearer capability not presently available

This cause indicates that the user requested a bearer capability which is implemented by the equipment which generated the cause but which is not available at this time.

Cause Number 63: Service or option not available, unspecified

This cause is used to report a service or option not available event only when no other cause in the service or option not available class applies.

Service or option not implemented class definitions

Cause Number 65: bearer capability not implemented

This cause indicates that the equipment sending this cause does not support the bearer capability requested.

Cause Number 73: unsupported combination of traffic parameters

This cause indicates that the combination of traffic parameters contained in the ATM traffic descriptor information element is not supported.

Invalid message (e.g., parameter out of range) class definitions

Cause Number 81: invalid call reference value

This cause indicates that the equipment sending this cause has received a message with a call reference which is not currently in use on the user-network interface.

Cause Number 82: identified channel does not exist

This cause indicates that the equipment sending this cause has received a request to use a channel not activated on the interface for a call.

Cause Number 88: incompatible destination

This cause indicates that the equipment sending this cause has received a request to establish a call which has Broadband low layer information, Broadband high layer information, or other compatibility attributes which cannot be accommodated.

Cause Number 89: invalid endpoint reference value

This cause indicates that the equipment sending this cause has received a message with an endpoint reference which is currently not in use on the user-network interface.

Cause Number 91: invalid transit network selection

This cause indicates that a transit network identification was received which is of an incorrect format as defined in Annex D.

Cause Number 92: too many pending add party requests

This cause indicates a temporary condition when the calling party sends an add party message but the network is unable to accept another add party message because its queues are full.

Cause Number 93: AAL parameters can not be supported

This cause indicates that the equipment sending this cause has received a request to establish a call which has ATM adaptation layer parameters which cannot be accommodated.

Protocol Error (e.g., unknown message) class definitions

Cause Number 96: mandatory information element is missing

This cause indicates that the equipment sending this cause has received a message which is missing an information element which must be present in the message before the message can be processed.

Cause Number 97: message type non-existent or not implemented

This cause indicates that the equipment sending this cause has received a message with a message type it does not recognize either because this is a message not defined or defined but not implemented by the equipment sending this cause.

Cause Number 99: information element non-existent or not implemented

This cause indicates that the equipment sending this cause has received a message which includes information element(s) not recognized because the information element identifier(s) are not defined or are defined but not implemented by the equipment sending the cause. This cause indicates that the information element(s) were discarded. However, the information element is not required to be present in the message in order for the equipment sending this cause to process the message.

Cause Number 100: invalid information element contents

This cause indicates that the equipment sending this cause has received an information element which it has implemented; however, one or more of the fields in the information element are coded in such a way which has not been implemented by the equipment ending this cause.

Cause Number 101: message not compatible with call state

This cause indicates that a message has been received which is incompatible with the call state.

Cause Number 102: recovery on timer expiry

This cause indicates that a procedure has been initiated by the expiry of a timer in association with error handling procedures.

Cause Number 111: protocol error, unspecified

This cause is used to report a protocol error event only when no other cause in the protocol error class applies.

Annex F

ATM Adaptation Layer Parameters Negotiation

This Annex describes procedures for the use of the ATM adaptation layer parameters information element by endpoint equipment.

F.1 General

The purpose of the ATM adaptation layer parameters information element is to provide a means which may be used for conveying information related to the ATM adaptation layer between endpoints. The ATM adaptation layer parameters information element is transferred transparently between ATM endpoints by the network.

F.2 ATM adaptation layer parameter indication in the SETUP message

When the calling endpoint wishes to indicate to the called endpoint the AAL common part parameters and service specific part to be used during the call, the calling endpoint shall include an ATM adaptation layer parameters information element in the SETUP message. This information element is conveyed by the network and delivered to the called user.

The ATM adaptation layer parameters information element may include the following parameters for different AAL connection types:

a) for AAL Connection type 1:
- Subtype,
- CBR Rate,
- Source Clock Frequency Recovery Method,
- Error Correction Method,
- Structured Data Transfer Blocksize,
- Partially Filled Cells Method.

b) for AAL Connection type 3/4:
- Forward and Backward Maximum CPCS-SDU Size (Note),
- MID range,
- SSCS Type.

c) for AAL Connection type 5:
- Forward and Backward Maximum CPCS-SDU Size (Note),
- SSCS Type.

d) for User defined AAL :
- User defined AAL information (four octets).

Note - Forward Maximum CPCS-SDU size and Backward Maximum CPCS-SDU Size shall either both be present or both be absent in the ATM adaptation layer parameters information element. For unidirectional (including point-to-multipoint) ATM virtual connections, the Backward Maximum CPCS-SDU size shall be set to 0.

If the called endpoint receives an ATM adaptation layer parameters information element in the SETUP message which contains the forward or backward maximum CPCS-SDU size but not both, the called endpoint should clear the call with cause #100, “invalid information element contents”.

F.3 Maximum CPCS-SDU Size negotiation

When the called user has received an ATM adaptation layer parameters information element in a SETUP message and:

a) the Endpoint reference information element either was not present in the SETUP message or the endpoint reference identifer value was set to 0; and,

b) the AAL type is either AAL 3/4 or AAL5

the ATM adaptation layer parameters information element may be included in the CONNECT message. The ATM adaptation layer parameters information element shall include the Forward Maximum CPCS-SDU Size, indicating the size of the largest CPCS-SDU that the called user is able to receive, and the Backward Maximum CPCS-SDU size, indicating the size of the largest CPCS-SDU that it will transmit. The values of the Forward and Backward Maximum CPCS-SDU Size indicated in the CONNECT message shall not be greater than the values indicated by the calling user in the SETUP message. The ATM adaptation layer parameters information element will be conveyed to the calling user.

Note - For unidirectional ATM virtual connections, the Backward Maximum CPCS-SDU size shall be set to 0.

If the called user does not include the ATM adaptation layer parameters information element in the CONNECT message, the calling user shall assume that the called user accepts the values of the Forward and Backward Maximum CPCS-SDU Size indicated by the calling user in the SETUP message.

If the calling party cannot use the Forward or Backward Maximum CPCS-SDU Size indicated in the CONNECT message (i.e., because the value negotiated by the called party is unacceptably small) then the call shall be cleared with cause #78, “*AAL Parameters can not be supported.*”

If the called endpoint includes an ATM adaption layer parameters information element in a CONNECT message and it is a leaf (other than the initial leaf) of a point-to-multipoint call, the network shall follow the procedures of §5.5.6.8.3.

If the calling endpoint receives an ATM adaption layer parameters information element in the CONNECT message which:

a) contains octet groups other than the forward and backward maximum CPCS-SDU size and/or MID or
b) contains a Maximum SDU length which is greater than the Maximum SDU length which was sent in the SETUP message
c) is missing the Forward or Backward Maximum CPCS-SDU Size or both the calling endpoint should clear the call with cause #100, "*invalid information element contents.*"

When the called user has received an ATM adaptation layer parameter information element in a SETUP message and the AAL type is User defined AAL, the ATM adaptation layer parameter information may be included in the CONNECT message.

If the calling endpoint receives an ATM adaptation layer parameters information element in the CONNECT message which

a) contains octet groups other than the Forward and Backward Maximum CPCS-SDU Size and/or MID, or
b) contains a MID which is greater than the MID which was sent in the SETUP message,

the calling endpoint should clear the call with cause #100, "*invalid information element contents*".

F.4 MID range negotiation

When the called user receives the ATM adaptation layer parameters information element in the SETUP message which indicates AAL type 3/4, the called user shall check the MID range value. If the called user cannot support the indicated MID range but it can support a smaller range, the called user includes an ATM adaptation layer parameters information element in the CONNECT message containing the MID range that it can support.

The calling user will either accept the MID range contained in the CONNECT message or will clear the call with cause #93, "*AAL Parameters can not be supported.*"

If the called user does not include the MID range in the CONNECT message, the calling user shall assume that the called user accepts the MID range indicated by the calling user in the SETUP message.

F.5 Use of Forward and Backward Maximum CPCS-SDU Size by the AAL entity in the user plane

The values of Forward and Backward Maximum CPCS-SDU Size resulting from AAL parameters negotiation shall be used by the AAL entities in the user plane. The AAL entity in the calling user equipment shall not send a CPCS-SDU size larger than the indicated value specified in the Forward Maximum CPCS-SDU Size parameter, and may allocate its internal resources based on the value indicated in the Backward Maximum CPCS-SDU Size parameter. Similarly, the AAL entity in the called user equipment shall not send a CPCS-SDU size larger than the indicated value specified in the Backward Maximum CPCS-SDU Size parameter, and may allocate its internal resources based on the value indicated in the Forward Maximum CPCS-SDU Size parameter.

Appendix A

Quality of Service Guidelines

A.1 Introduction

A.1.1 Objective

The following quotes from Recommendation I.350 [43] state the objectives of the ATM Bearer Service Quality of Service (QoS).

"... the aspects of Quality of Service that are covered are restricted to the identification of parameters that can be directly observed and measured at the point at which the service is accessed by the user." [1, para. 1.2.1]

".. the definition of QoS parameters should be clearly based on events and states observable at service access points and independent of the network processes and events which support the service." [1, para. 3.1.2]

The defined parameters apply to cell streams in which all cells conform to the negotiated traffic contract. The parameter definitions and measurement methods applicable to cell streams in which some cells do not conform with the traffic contract is for further study. Appendix 1 to I.35B [42] contains material relevant to this problem.

The defined performance parameters are intended to characterize ATM connections in the available state. Availability decision parameters and associated availability parameters and their objectives will be the subject of further study.

A.1.2 Approach

The following outline describes the approach taken to the QoS appendix.

Section A.1 - Introduction
  Covering: Objectives, Approach, Terminology

Section A.2 - QoS Reference Configuration

Section A.3 - ATM Performance Parameters
  Covering: Cell Error Parameters, Cell Loss Ratio, Cell Misinsertion Rate, Cell transfer delay, and QoS provided by the ATM layer

Section A.4 - QoS Classes
  Covering: Specified QoS Classes, Unspecified QoS Class

Section A.5 - Measurement Methods

Covering: Cell Error Parameters, Cell Loss Ratio, Cell Misinsertion rate, Cell Transfer Delay

Section A.6 - Factors Affecting ATM QoS Performance Parameters

Covering: Sources of QoS degradation, QoS Performance Parameter guidelines, Principles of allocation

A.1.3 Terminology

A.1.3.1 Cell Event

The following two events are defined based on I.35B [42]. These events will be used in defining the ATM cell transfer performance parameters.

- A "cell exit event" occurs when the first bit of an ATM cell has completed transmission out of an End User Device to a Private ATM network element across the "Private UNI" Measurement Point, or out of a Private ATM network element to a Public ATM network element across the "Public UNI" Measurement Point, or out of an End User Device to a Public ATM network across the "Public UNI" Measurement Point.

- A "cell entry event" occurs when the last bit of an ATM cell has completed transmission into an End User Device from a Private ATM network element across the "Private UNI" Measurement Point, or into a Private ATM network element from a Public ATM network element across the "Public UNI" measurement point or into an End User Device from a Public ATM network element across the "Public UNI" Measurement Point.

A.1.3.2 ATM Cell Transfer Outcome

The following possible cell transfer outcomes between measurement points for transmitted cells are defined based on I.35B.

- Successful Cell Transfer Outcome: The cell is received corresponding to the transmitted cell within a specified time T_{max}. The binary content of the received cell conforms exactly to the corresponding cell payload and the cell is received with a valid header field after header error control procedures are completed.

- Errored Cell Outcome: The cell is received corresponding to the transmitted cell within a specified time T_{max}. The binary content of the received cell payload differs from that of the corresponding transmitted cell or the cell is received with an invalid header field after header error control procedures are completed.

- Lost Cell Outcome: No cell is received corresponding to the transmitted cell within a specified time T_{max}. (Examples include "never showed up" or "late").

- Mis-inserted Cell Outcome: A received cell for which there is no corresponding transmitted cell.

- Severely-Errored Cell Block Outcome: When M or more Lost Cell outcomes, Mis-inserted Cell Outcomes, or Errored Cell outcomes are observed in a received cell block of N cells transmitted consecutively on a given connection.

A.2 QoS Reference Configuration

Recommendation I.350 [Figure 1/I.350] defines Quality of Service (QoS) for Bearer Service and TeleService. The QoS has a direct relationship to the Network Performance (NP) as shown in this figure. The principal difference is that QoS pertains to user oriented performance concerns of an end-to-end service, while NP is concerned with parameters that are of concern to network planning, provisioning and operations activities.

Figure 1-3 of the ATM Forum UNI specification identifies the relationship of the ITU-T reference points to the "Private Local Interface" (i.e., R or S reference points) and the "Public Network Interface" (i.e., T or U reference points).

Draft Recommendation I.35E [42] defines Measurement Points (MPs) and Measurement Points at a T interface (MPT). In this ATM UNI specification the Measurement Points are defined to be either at the Private UNI between the End User Device and a Private network element or at the Public UNI between an End User device / Private network element and a Public network element as shown in Figure 1-3 of the ATM UNI specification. Figure A-1 summarizes the Quality of Service (QoS) reference configurations for this ATM UNI specification.

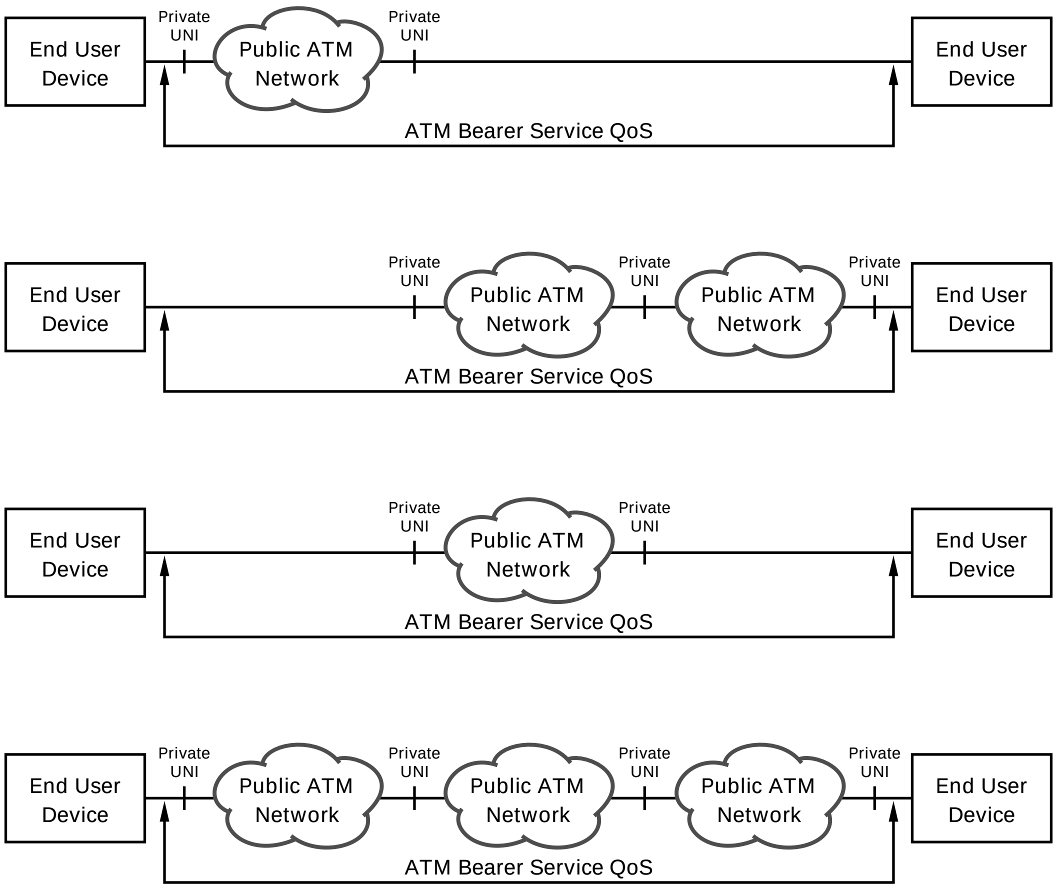


Figure A-1 ATM QoS Reference Configuration

The performance objectives will not be defined in this document. However, alternative means to measure, or estimate the value of performance parameters defined will be described. A Public or Private switch manufacturer should state QoS performance in the terms of the parameters defined in this appendix. A service provider also should state QoS performance objectives in the terms defined in this appendix.

Note, while it is desirable to have the ATM Bearer Service QoS be identical for all of the reference configurations, however, in general, it may be different. Section 6 provides more details on how various factors impact QoS performance parameters.

A.3 ATM Performance Parameters

This section summarizes the set of ATM cell transfer performance parameters defined in I.35B [42]. The cell events and cell transfer outcomes defined in section 1.3 of this appendix are used in defining these performance parameters. This set of ATM cell transfer performance parameters correspond to the generic criteria of the assessment (shown in parentheses) of the QoS (see I.350 [33]), as follows:

Cell Error Ratio	(Accuracy)
Severely-Errored Cell Block Ratio	(Accuracy)
Cell Loss Ratio	(Dependability)
Cell Misinsertion Rate	(Accurarcy)
Cell Transfer Delay	(Speed)
Mean Cell Transfer Delay	(Speed)
Cell Delay Variation	(Speed)

A.3.1 Cell Error Parameters

A.3.1.1 Cell Error Ratio

Cell Error Ratio is defined as follows for an ATM connection:

$$\frac{\text{Errored Cells}}{\text{Successfully Transferred Cells + Errored Cells}}$$

Successfully Transferred Cells and Errored Cells contained in cell blocks counted as Severely Errored Cell Blocks (see §3.1.2) should be excluded from the population used in calculating Cell Error Ratio.

A.3.1.2 Severely-Errored Cell Block Ratio

The Severely Errored Cell Block Ratio for an ATM connection is defined as:

$$\frac{\text{Severely Errored Cell Blocks}}{\text{Total Transmitted Cell Blocks}}$$

A cell block is a sequence of N cells transmitted consecutively on a given connection. A severely errored cell block outcome occurs when more than M error Cells, Lost Cells, or mis-inserted cell outcomes are observed in a received cell block.

For practical measurement purposes, a Cell Block will normally correspond to the number of user information cells transmitted between successive OAM cells. The size of a Cell Block is to be specified.

A.3.2 Cell Loss Ratio

The Cell Loss Ratio is defined for an ATM connection as:

$$\frac{\text{Lost Cells}}{\text{Total Transmitted Cells}}$$

Lost and transmitted cells counted in severely error cell blocks should be excluded from the cell population in computing cell loss ratio.

A.3.3 Cell Misinsertion Rate

The Cell Misinsertion rate for an ATM connection is defined as:

$$\frac{\text{Misinserted Cells}}{\text{Time Interval}}$$

Severely Errored Cell Blocks should be excluded from the population when calculating the cell misinsertion rate. Cell misinsertion on a particular connection is most often caused by an undetected error in the header of a cell being transmitted on a different connection. This performance parameter is defined as a rate (rather than the ratio) since the mechanism producing mis-inserted cells is independent of the number of transmitted cells received on the corresponding connection.

A.3.4 Cell Transfer Delay

The Cell Transfer Delay is defined as the elapsed time between a cell exit event at the measurement point 1 (e.g. at the source UNI) and the corresponding cell entry event at measurement point 2 (e.g. the destination UNI) for a particular connection. The Cell Transfer Delay between two measurement points is the sum of the total inter-ATM node transmission delay and the total ATM node processing delay between MP_1 and MP_2. The following components of the Cell Transfer Delay are described in more detail in Annex B of I.35B [42].

T3 = Cell Transfer Delay (MPT-MPT)

T31 = Total inter-ATM node transmission delay (e.g. propagation delay)

T32 = Total ATM node processing delay (queuing, switching and routing)

A.3.4.1 Mean Cell Transfer Delay

Mean Cell Transfer Delay is defined as the arithmetic average of a specified number of cell transfer delays for one or more connections.

A.3.4.2 Cell Delay Variation (CDV)

There are two performance parameters associated with cell delay variation: 1-point Cell Delay Variation (1-point CDV) and the 2-point Cell Delay Variation (2-point CDV).

The 1-point CDV describes variability in the pattern of cell arrival events observed at a single measurement point with reference to the negotiated peak rate 1/T as defined in I.371 [41].

The 2-point CDV describes variability in the pattern of cell arrival events observed at the output of a connection portion (MP_2) with reference to the pattern of the corresponding events observed at the input to the connection portion (MP_1).

A.3.4.2.1 1-Point CDV

The 1-point CDV for cell k (y_k) at a measurement point is defined as the difference between the cell's reference arrival time (c_k) and actual arrival time (a_k) at the measurement point: $y_k=c_k - a_k$. The reference arrival time (c_k) is defined as follows:

$$c_0 = a_0 = 0$$

$$c_{k+1} = \begin{cases} c_k + T & \text{if } c_k \geq a_k \\ a_k + T & \text{otherwise} \end{cases}$$

Positive values of the 1-point CDV correspond to cell clumping; negative values of the 1-point CDV correspond to gaps in the cell stream. The reference arrival time defined above eliminates the effect of gaps and provides a measurement of cell clumping.

A.3.4.2.2 2-Point CDV

The 2-point CDV for cell k (v_k) between two measurement points (MP_1 and MP_2) is the difference between the absolute cell transfer delay of cell k (x_k) between the two MPs and a defined reference cell transfer delay ($d_{1,2}$) between MP_1 and MP_2: $v_k = x_k - d_{1,2}$.

The absolute cell transfer delay (x_k) of cell k between MP_1 and MP_2 is the same as Cell Transfer Delay defined in §3.4. The reference cell transfer delay ($d_{1,2}$) between MP_1 and MP_2 is the absolute cell transfer delay experienced by a reference cell between the two MPs.

See I.35B [42] for more details.

A.3.5 Quality of Service provided by the ATM Layer

A user of an ATM connection (a VCC or a VPC) is provided with one of a number of QoS classes supported by the network. It should be noted that a VPC may carry VC links of various QoS classes. The QoS of the VPC must meet the most demanding QoS of the VC links carried as defined in I.150 [40]. The QoS class associated with a given ATM connection is indicated to the network at the time of connection establishment and will not change for the duration of that ATM connection.

A.4 QoS Classes

A Quality of Service (QoS) class can have specified performance parameters (Specified QoS class) or no specified performance parameters (Unspecified QoS class). QoS classes are inherently associated with a connection. A Specified QoS class specifies a set of performance parameters and the objective values for each performance parameter identified. Examples of performance parameters that could be in a QoS class are: cell transfer delay, cell delay variation, and cell loss ratio, as currently mentioned in I.371 [41] section 1.5 and Q.2931 [29] section 4.5.15 and 4.5.21.

Within a specified QoS class, at most two cell loss ratio parameters may be specified. If a specified QoS class does contain two cell loss ratio parameters, then one parameter is for all CLP=0 cells and the other parameter is for all CLP=1 cells of the ATM connection. As presently foreseen, other performance parameters besides the cell loss ratio would apply to the aggregate cell flow of the ATM connection. A QoS class could contain, for example, the following performance parameters: mean cell transfer delay, a cell delay variation, a cell loss ratio on CLP=0 cells and a cell loss ratio on CLP=1 cells.

The network may support several QoS classes. At most one (1) unspecified QoS class can be supported. The performance provided by the network should meet (or exceed) performance parameter objectives of the QoS class requested by the ATM end-point. For the purpose of early ATM implementation, both permanent and switched ATM VPCs and VCCs should indicate the requested QoS by a particular class specification. For permanent connections the PVC management can be used by the network to report the QoS classes across the UNI. For a switched connection, signalling protocol's information elements can be used to communicate the QoS class across the UNI.

A.4.1 Specified QoS Classes

A Specified QoS class provides a quality of service to an ATM virtual connection (VCC or VPC) in terms of a subset of the ATM performance parameters defined in Section 3 of this appendix. For each Specified QoS class, there is one specified objective value for each performance parameter identified as defined in section 3 of this appendix.

Initially, each network provider should define objective values for a subset of the ATM performance parameters of section 3 for at least one of the following Service Classes from ITU-T recommendation I.362 in a reference configuration that may depend on mileage and other factors:

Service Class A: Circuit Emulation, Constant Bit Rate Video

Service Class B: Variable bit Rate Audio and Video

Service Class C: Connection-Oriented Data Transfer

Service Class D: Connectionless Data Transfer

In the future, more ‘QoS Classes’ may be defined for a given ‘Service Class’ described above. The following Specified QoS Classes are currently defined:

Specified QoS Class 1: support a QoS that will meet Service Class A performance requirements

Specified QoS Class 2: support a QoS that will meet Service Class B performance requirements

Specified QoS Class 3: support a QoS that will meet Service Class C performance requirements

Specified QoS Class 4: support a QoS that will meet Service Class D performance requirements

The Specified QoS Class 1 should yield performance comparable to current digital private line performance.

Specified QoS Class 2 is intended for packetized video and audio in teleconferencing and multi-media applications.

Specified QoS Class 3 is intended for interoperation of connection oriented protocols, such as Frame Relay.

Specified QoS Class 4 is intended for interoperation of connectionless protocols, such as IP, or SMDS.

A network operator may provide the same performance for all or a subset of Specified QoS Classes, subject to the constraint that the requirements of the most stringent Service Class are met.

A.4.2 Unspecified QoS Class

In the Unspecified QoS class, no objective is specified for the performance parameters. However, the network provider may determine a set of internal objectives for the performance parameters. In fact, these internal performance parameter objectives need not be constant during the duration of a call. Thus, for the Unspecified QoS class there is no explicitly specified QoS commitment on either the CLP=0 or the CLP=1 cell flow. Services using the Unspecified QoS class may have explicitly specified traffic parameters.

An example application of the Unspecified QoS class is the support of “best effort” service. For this type of service, the user selects the Best-Effort Capability, the Unspecified QoS class and only the traffic parameter for the Peak Cell Rate on CLP=0+1. As indicated in Section 3.6.2.4, this capability can be used to support users that are capable of regulating the traffic flow into the network and to adapt to time-variable available resources.

The Unspecified QoS class is identified by the integer zero (0) in the ILMI MIB or a code point in a signaling message for the requested QoS class.

A.5 Measurement Methods

In this section at least one method to measure each QoS performance parameter in either an in-service or out-of-service mode is defined. Other alternative measurement methods or estimates are possible.

Either in-service or out-of-service methods may be used to estimate values for the ATM cell transfer performance parameters. In-service methods are based on performance monitoring OAM flows which may be introduced into the user cell stream at any VP or VC termination or connecting point, and may then be copied or extracted at any similar point downstream. Details of OAM functions supporting performance measurement are provided in Recommendation I.610. Out-of-service methods consist of establishing a test virtual path or connection at an appropriate measurement point, introducing a cell stream of known content and timing at that point, and then observing the cell stream at a remote measurement point.

A.5.1 Cell Error Parameters

A.5.1.1 Cell Error Ratio

A method using test stream for out-of-service measurement is described in Annex C of I.35B [42]. It basically involves transferring a known data stream into the network at the source measurement point and comparing the received data stream with the known data stream at the destination measurement point.

An in-service measurement is desirable. Annex C of I.35B [42] suggests a BIP-16 indicator to estimate the cell error ratio over a block of N cells.

A.5.1.2 Severely Errored Cell Block Ratio

Severely errored cell block ratio can be estimated in service for a set of S consecutive or non consecutive cell blocks by computing the number of lost cell or mis-inserted cell outcomes in each cell block, identifying cell blocks with more than M lost cell or mis-inserted cell outcomes as severely errored cell blocks and dividing the total number of such severely errored cell blocks by S. This in-service measurement method will undercount severely errored cell blocks to some degree, since it does not include delivered errored cells in the estimation of M. A more accurate estimate of severely errored cell block ratio can be obtained by comparing transmitted and received data in an out-of-service measurement.

A.5.2 Cell Loss Ratio

A method using OAM cells for in-service measurement is described in Annex C of I.35B [42]. The transmitter inserts OAM cells into a transmitted user information cell stream at suitable intervals. Each OAM cell contains a count of the number of user information cells transmitted since the last OAM cell. The receiver keeps a running count of the number of user information cells transmitted (N_t) and received (N_r). Cell loss ratio can then be calculated as $(N_t - N_r) / N_t$ if $N_t - N_r$ is positive. This method will under count cell loss events if misinsertion occurs during the measurement period. It will over count loss if SECB events are not excluded.

A.5.3 Cell Misinsertion Rate

A method using OAM cells for in-service measurement is described in Annex C of I.35B [42]. It is similar to that defined for cell loss ratio measurement. Over a measurement interval, T_m, if (N_r- N_t) is positive, then the cell misinsertion rate is estimated as (N_r - N_t) / T_m. Cell misinsertion events will be under counted if cell loss events occur.

An out-of-service measurement method is described in Annex C of I.35B [42]. Basically a VP or VC is maintained for a known period of time, however, no cells are transmitted on it. Any cells received on this VP or VC are mis-inserted cells.

A.5.4 Cell Transfer Delay

A method using OAM cells for in-service measurement is described in Annex C of I.35B [42]. Time stamped OAM cells are transmitted through the network on an established connection. The transmitted OAM cell payload contains the time stamp of cell exit event. The receiver subtracts the received time stamp from the time stamp of the cell entry event to obtain the delay for that cell on that connection. Individual cell transfer delay observations may be combined to calculate statistics of the cell transfer delay distribution. This method requires synchronized clocks at the two MPs, or a suitable reporting mechanism at the receiver, for example a loopback at the receiver.

A.5.5 Measuring Cell Non Conformance Ratio

For the case of a virtual connection described only by Peak Cell Rate and for a single cell flow (such as the aggregate CLP=0+1 cell flow), consider negotiated values for peak emission interval T and CDV Tolerance t. Consider the variable c_k and y_k which are defined as follows:

$$c_0 = a_0$$

$$c_{k+1} = \begin{cases} c_k & \text{if } c_k > a_k + \tau \\ a_k + T & \text{if } c_k \le a_k \\ c_k + T & \text{otherwise} \end{cases}$$

$$y_k = c_k - a_k$$

where a_k is the observed arrival time of cell k at the measurement point. Figure B-1 of I.35B illustrates a measurement method that calculates, for a cell stream received at a MP, the number of cells that do not comply with a specified peak emission interval and a CDV Tolerance. The virtual scheduling algorithm and continuous-state leaky bucket described in section 3.6.2.4.1 as equivalent versions of the GCRA may be used to implement the cell non conformance ratio. The mapping between the variables of the two equivalent algorithms are summarized in table B-1 of I.35B.

A.5.6 Measuring of Range of Cell Transfer Delay

Buffering procedures to implement AAL1 at the receiving side to compensate for cell delay variation are based on the expected maximum range of cell transfer delay. The actual range of cell transfer delay observed in a set of consecutive cells may be measured using the 1-point CDV parameter y_k which is defined in section 4.4.2 of I.35B. This parameter describes the variability in the pattern of cell arrival events at a MP with reference to the negotiated peak emission interval T. The 1-point CDV y_k for cell k at an MP is the difference between the cell's reference arrival time c_k and the actual arrival time a_k : $y_k = c_k - a_k$. The reference arrival pattern is defined as follows:

$$c_0 = a_0$$

$$c_{k+1} = \begin{cases} a_k + T & \text{if } c_k \le a_k \\ c_k + T & \text{otherwise} \end{cases}$$

A positive value for y_k corresponds to a cell which experienced a smaller delay than the maximum delay experienced up to cell (k-1). A negative value for y_k corresponds to a cell which experienced the largest delay experienced by cells up to cell k. The following figure provides a method of estimating the range of cell transfer delay for a succession of transferred cells. This method assumes that cells are input uniformly at the Peak Cell Rate.

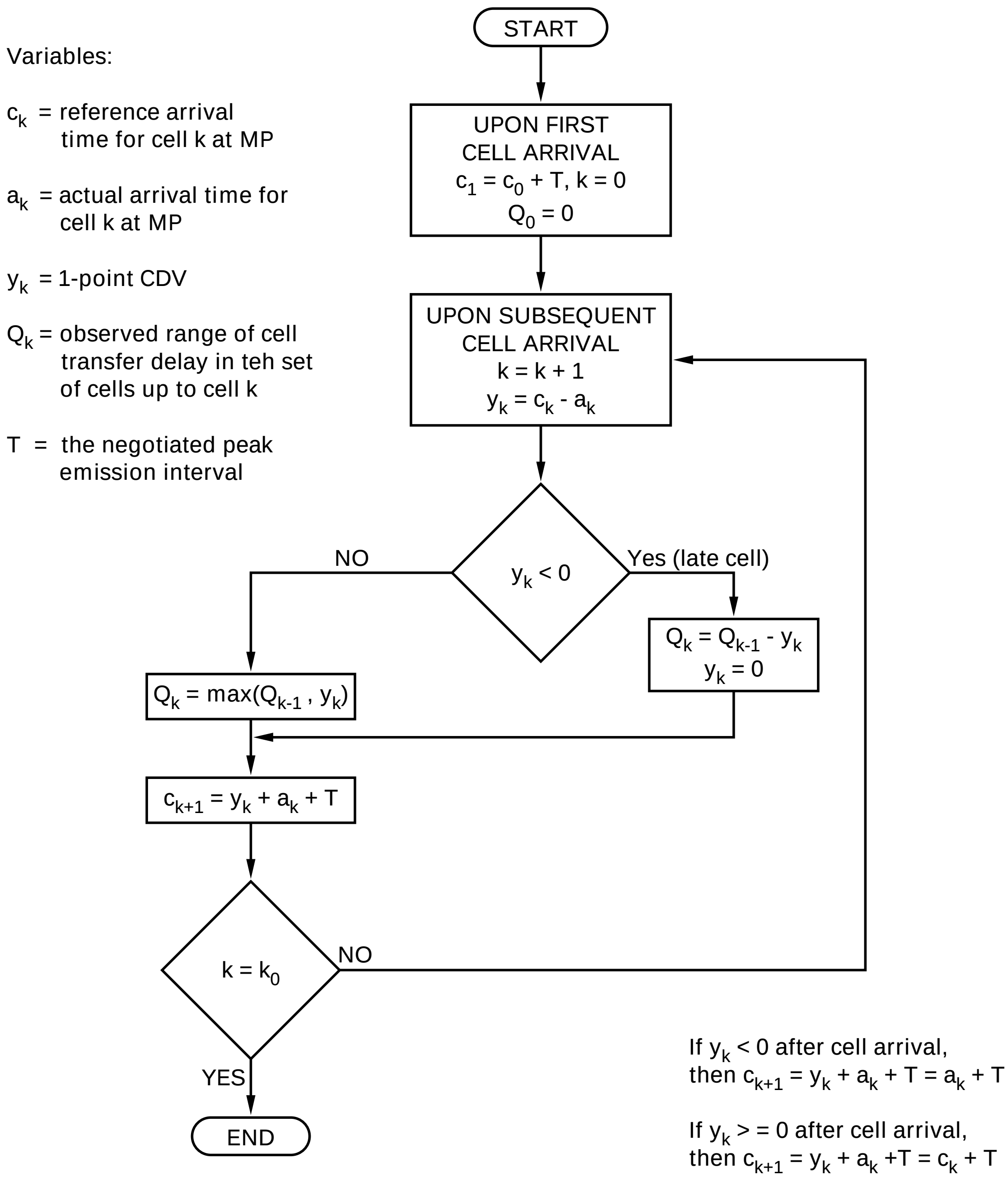


Figure A-2 Estimation of 2-point CDV from 1-point CDV for Connections providing CBR service

A.6 Factors Affecting ATM QoS Performance Parameters

This section provides a list of items to be considered in setting QoS performance parameter objectives dependent upon characteristics that can exist in either private or public networks, or combinations thereof as indicated in Figure A-1. The objective is to have maximum commonalty between public and private networks.

A.6.1 Sources of QoS Degradation

A.6.1.1 Propagation Delay

This is the delay caused by the Physical media which transports the bits comprising ATM cells between UNIs and between ATM switches. This equally impacts public and private networks, dependent upon distance only. Private networks may extend from the desktop to international distances, while public networks generally extend from metropolitan to international distances.

A.6.1.2 Media Error Statistics

This is the random and/or bursty bit errors that are introduced on the physical media.

A.6.1.3 Switch Architecture

The overall architecture of the switch can have significant impacts on performance. Some aspects to consider are the switch matrix design, buffering strategy and the switch characteristics under load. The switch matrix design may range from blocking to non-blocking. The strategy in which the buffer capacity of a port supporting the UNI on an ATM switch is managed may differ significantly across switch architectures. The buffer capacity may be dedicated to a single port, it may be shared between multiple ports, or some combination thereof. The management of this buffer capacity may range from a single First In First Out (FIFO) queue to a more complex, multiple queue system with an algorithmically defined service rule, that could operate based upon priorities. The switch matrix design may introduce some loss under heavy load conditions.

A.6.1.4 Buffer Capacity

This is the actual capacity of the buffer in units of cells at a port supporting the UNI, within an ATM matrix, or in other elements of an ATM switch.

A.6.1.5 Traffic Load

This is the load offered by the set of ATM VPC/VCCs on the same route as the VPC/VCC under consideration.

A.6.1.6 Number of Nodes in Tandem

This is the number of ATM switching nodes that a particular VPC or VCC traverses.

A.6.1.7 Resource Allocation

This is the capacity allocated to a VPC/VCC or to a set of VPC/VCCs, such as the set of VPC/VCCs on a given route that are assigned a given QoS class.

A.6.1.8 Failures

These are events that impact availability, such as port failures, switch failures or link failures. Switch overs between failing equipment or circuits may introduce cell loss.

A.6.2 Impact of QoS Degradation on Performance Parameters

In this section the impact of each of the sources of QoS degradation from section 6.1 on each of the Performance Parameters of section 3 is analyzed in a subjective manner as a guideline for what degradations and factors should be considered in determining a value for the performance parameter. Note that the scope of QoS is from UNI to UNI as defined in section 3. These impacts are summarized in a figure at the end of this section.

A.6.2.1 Cell Error Ratio and Severely Errored Cell Block Ratio

The cell error ratio is expected to be primarily influenced by the error characteristics of the physical media. The severely errored cell block ratio is also expected to be influenced by the error characteristics of the physical media and by buffer overflows.

Error characteristics may also be a function of the physical distance and the characteristics of the media. Operational effects such as transmission protection switching and rearrangements may also introduce errors.

A.6.2.2 Cell Loss Ratio

The Cell Loss Ratio is expected to be influenced by errors in the cell header, buffer overflows, and the non-ideal UPC actions. Loss due to the noncompliance of a connection should be excluded when network caused losses are to be estimated.

Errors detected in the cell header at the physical layer affect the Cell Loss Ratio. Cells may also be lost due to failures, protection switching and path reconfiguration.

Different buffering and resource allocation strategies will cause buffer overflow characteristics to differ.

Queuing implementations in some networks may not provide large buffers, or multiple levels of priority since transmission capacity and resources will be relatively inexpensive. Therefore, cell loss ratios may be higher than in a more complicated network. A lost higher level PDU can be detected in a much shorter period of time in a local area than in a wide area, so that higher layer protocol re-transmissions can be initiated sooner and thus will have less impact on higher layer application throughput in local area networks than in wide area networks.

Buffering strategies in wider area or lower speed networks may be much more complex than that in local, high speed networks. Transmission capacity resources will be relatively more expensive. Multiple levels of delay priority, and possibly relatively large buffers, may be implemented. Within a delay-priority level the CLP bit may also be used to indicate two levels of loss priority. High delay-priority levels will likely have low loss rates, while lower delay-priority levels may have higher loss rates during periods of buffer congestion.

The number of nodes in tandem will also impact the Cell Loss Ratio due to the possibility of overflow in any buffer between the source and destination.

Path reconfiguration from a long to a shorter route is also a possible cause of cell losses, due to the difference in propagation delay. Path reconfiguration is a process at the physical layer used when a path needs to be taken out-of-service to perform maintenance. A possible cause is as follows, after a new path is set up, traffic is transmitted on both paths until it can be verified (at the physical layer) that the new path is operating properly. At this time, a physical layer switch is made at the receiving end of the path. This process is intended to minimize the interruption to the customer service.

A.6.2.3 Cell Misinsertion Rate

The cell misinsertion rate is expected to be primarily influenced by undetected/miscorrected errors in the cell header, which in turn is primarily influenced by the transmission error rate. The likelihood that an undetected/miscorrected cell header error maps into a valid VPI/VCI is also dependent upon the number of VPI/VCI values that are assigned and being actively used.

The cell error ratio will be dependent upon the factors defined in 6.2.1. The number of active ATM sources is likely to be less for a private network than for a public network. This should decrease the likelihood of an undetected/miscorrected cell header error resulting in a cell which is incorrectly mis-inserted into some other VPI/VCI cell stream at the destination UNI.

The number of sources which can be mapped into another cell address will likely be much larger in a public network than in a private network.

A.6.2.4 Cell Transfer Delay

Cell transfer delay is affected by propagation delay, queuing, routing and switching delays, which are likely to differ for local and wide-area networks.

A.6.2.4 1 Mean Cell Transfer Delay

The mean cell transfer delay will likely be dominated by propagation, emission, queuing and routing times in a local private network environment. The propagation delay for local networks will be on the order of 0.1 to 10 microseconds. Queuing delays may likely be very small in high-performance ATM LANs, as long as statistical multiplexing procedures do not induce burst scale congestion. Depending on the media and on distance, the emission time may dominate the propagation time, for example for media operating at the DS-3 rate, the emission time of a cell is roughly 9 microseconds. Additional services, such as ATM cell routing, may introduce additive delay that ranges from insignificant, to something on the order of microseconds. Routing of higher layer protocols will require many microseconds.

In wider area networks the mean cell transfer delay will likely be dominated by propagation delay over longer distances for the highest priority class. Over shorter distances, or for lower priority classes, delay may be significant during periods of high network load. Mean cell transfer delay is expected to be on the order of tens of microseconds for metropolitan areas to tens of milliseconds for national and international areas due to propagation delay.

A.6.2.4.2 Cell Delay Variation (CDV)

Specification of CDV is essential for Constant Bit Rate (CBR) connection performance. Its value is necessary for the dimensioning of the elastic buffer required at the terminating end of the connection for absorbing the accumulated CDV, regardless of whether the network is public or private. Bellcore TA-NWT-001110 issue 1 proposes an objective value of 750 µs delay for absorbing the accumulated CDV (the 10^{-10} quantile) from the ingress public UNI to the egress public UNI for both DS1 and DS3 circuit emulation services.

A common, maximum cell delay variation value for private, public and hybrid private/public networks is essential. As an implementation guideline the receiver CDV tolerance should be designed to handle the case where a connection traverses three networks, each having three switches in tandem.

A.6.2.5 Degradation of QoS Parameters Summary

The following figure summarizes how various sources of degradation can impact the Performance Parameters.

Attribute	CER	CLR	CMR	MCTD	CDV
Propagation Delay				X	
Media Error Statistics	X	X	X		
Switch Architecture		X		X	X
Buffer Capacity		X		X	X
Number of Tandem Nodes	X	X	X	X	X
Traffic Load		X	X	X	X
Failures		X			
Resource Allocation		X		X	X

Figure A-3 Degradation of QoS Parameters

CER = Cell Error Ratio

CLR = Cell Loss Ratio

CMR = Cell Misinsertion Rate

MCTD = Mean Cell Transfer Delay

CDV = Cell Delay Variation

A.6.3 Principles of Allocation

There should be a mapping between the QoS of the bearer service and the network performance of connection elements supporting this service. In hybrid private/public networks the end user sees the combined effects of network performance in the networks that are traversed from end user to end user. One basic principle of performance allocation is that no network provider should bear a disproportionate cost in establishing and operating a service.

Appendix B

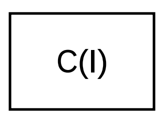
Conformance Examples in a Traffic Contract

B.1 Introduction

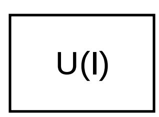
In the traffic contract, the Cell Delay Variation tolerance specified at the UNI is defined in relation to the PCR by the GCRA (see section 3.6.2.4.1) and the Burst Tolerance specified at the UNI is defined in relation to the SCR also by the GCRA. Additionally, a Conformance Definition that defines the combination of GCRAs in relation to the different cell streams and cell rates of a connection at the UNI is also specified in the Traffic Contract. Depending upon the services provided, different Conformance Definitions could be specified. In this appendix, a few examples are given for information purposes.

For each example described herein, the service needs are summarized and then followed with a Conformance Definition that *could* be used to accommodate the service needs. Specifically, the examples illustrate how one can emulate the traffic definitions of various services by appropriately mapping them into parameters of various GCRAs. The specific Conformance Definition used is for illustrative purposes. Figures are also provided in the form of block diagrams to depict how various GCRAs interact with each other. Two functional blocks are used to represent the high level flowchart of a GCRA(I, L) algorithm and are labeled by C(I) and U(I):

1. Conformance Checking Functional Block:



2. Update Functional Block:



The conformance checking functional block represents functions performed in order to determine whether a cell is conforming or not. The update functional block represents the update function performed if a cell is identified as conforming. Note that the only purpose of the block diagrams are to test conformance to the traffic descriptors as defined by the Conformance Definition. The Conformance Definitions indicated in these examples should not be interpreted as the UPC algorithms. Hence, non-conformance does not imply a discard or tagging decision.

B.2 Example 1: Switched Multi-megabit Data Service (SMDS)[44]

SMDS allows customers to send bursts at the full access link rate (e.g. DS3 PLCP). To control the sustainable information rate, an I_{inc}, a N_{inc}, and a C_{max} are specified. I_{inc} is the interval (in number of 53-octet slot times) between increments to the credit. N_{inc} is the number of credits (in user information octets) increase per increment. I_{inc} and N_{inc} together determine a maximum sustainable information rate. C_{max} is the maximum credits that can be accrued. C_{max} is 9188 octets for all access classes. An arriving message will be discarded, if the current accrued credits are less than the estimated user information length.

For an ATM connection supporting the above SMDS application, the following Conformance Definition in relation to a Source Traffic Descriptor that specifies the PCR for the CLP=0 cell stream and SCR for the CLP=0 cell stream *could* be specified in the Traffic Contract *if a proper minimum user information length that the SMDS user could submit is imposed*:

For an ATM connection supporting the above SMDS application, the following Conformance Definition *could* be specified in the Traffic Contract:

1. One GCRA(T_0, τ) defining the CDV Tolerance in relation to the PCR of the CLP=0 cell stream.

2. One GCRA(T_{s0}, τ_{s0}+τ) defining the sum of the Burst Tolerance and CDV Tolerance in relation to the SCR of the CLP=0 cell stream.

A cell that is conforming to both GCRAs (1) and (2) above is said to be conforming to the Connection Traffic Descriptor. The tagging option is not applicable to this Conformance Definition.

PCR could be chosen to emulate the original SMDS access line rate. The values of PCR and SCR should be chosen to include the extra margin required to accommodate the overhead introduced in transferring the user information via an ATM network in order to deliver an equivalent maximum sustainable information rate to the user. This overhead is closely related to the SMDS message length distribution. The Burst Tolerance τ_{s0} should be set to allow the maximum burst accepted in SMDS to be passed at the PCR.

Figure B-1 depicts this Conformance Definition in terms of the GCRA functional block diagrams. Although traffic conformance at the UNI is defined by this definition, the network provider may use any UPC mechanism as long as the QoS objectives are met for compliant connections.

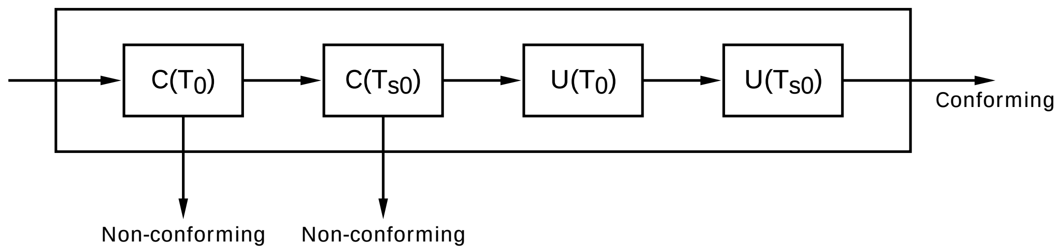


Figure B-1 Example 1

B.3 Example 2a: Frame Relay Service (FRS)[45]

FRS allows customers to send burst at the full access link rate (e.g. DS1). To control the sustainable information rate, a B_c, a B_e, and a *CIR* are specified. The measurement interval *T* is derived and is equal to B_c/CIR. The excessive information rate (*EIR*) is also derived and is equal to B_e/T.

- When a frame with discard eligibility indication not set arrives,

  a. if the current accrued credits for *CIR* is greater than or equal to the frame length, send the frame;

  b. if the current accrued credits for *CIR* is less than the frame length, but the current accrued credits for *EIR* is greater than or equal to the frame length, the frame is sent with discard eligibility indication set;

  c. if the current accrued credits for *CIR* is less than the frame length and the current accrued credits for *EIR* is also less than the frame length, the frame is discarded.

- When a frame with discard eligibility indication set arrives and,

  a. if the current accrued credits for *EIR* is greater than or equal to the frame length, send the frame,

  b. if the current accrued credits for *EIR* is less than the frame length, discard the frame.

The maximum number of credits that can be accrued for *CIR* is B_c. And, the maximum number of credits that can be accrued for *EIR* is B_e.

This example is intended to emulate the Frame Relay traffic parameters (B_c, B_e and *CIR* and the Frame Relay access line rate. For an ATM connection supporting the above FRS application, the following Conformance Definition in relation to a Source Traffic Descriptor that specifies PCR for the CLP=0+1 cell stream, SCR for the CLP=0 cell stream and SCR for the CLP=1 cell stream *could* be specified in the Traffic Contract *if a proper minimum frame length that the FRS user could submit is imposed*:

1. One GCRA(T_{0+1}, τ) defining the CDV Tolerance in relation to the PCR of the aggregate CLP=0+1 cell stream.

2. One GCRA(T_{s0}, $\tau_{s0}+\tau$) defining the sum of Burst Tolerance and the CDV Tolerance in relation to the SCR of the CLP=0 cell stream.

3. One GCRA(T_{s1}, $\tau_{s1}+\tau$) defining the sum of Burst Tolerance and the CDV Tolerance in relation to the SCR of the CLP=1 cell stream .

A CLP=0 cell that is conforming to both GCRAs (1) and (2) is said to be conforming to the connection Traffic Descriptor. A CLP=1 cell that is conforming to both GCRAs (1) and (3) is said to be conforming to the Connection Traffic Descriptor. A CLP=0 cell that is not conforming to GCRA (2) above but is conforming to GCRAs (1) and (3) above is considered to have the CLP bit changed to 1 and said to be conforming to the Connection Traffic Descriptor.

PCR could be chosen to emulate the original FRS access line rate. The values of PCR and SCR should be chosen to include the extra margin required to accommodate the overhead introduced in transferring the FRS frames via an ATM network in order to deliver an equivalent *CIR* and *EIR* to the user. This overhead is closely related to the FRS message length distribution. The Burst Tolerance (τ_{s0}) should be set to allow the maximum burst accepted in FRS to be passed at the PCR. The Burst Tolerance (τ_{s1}) should be set to allow the maximum excessive burst accepted in FRS to be passed at the PCR.

Figure B-2 depicts this Conformance Definition in terms of the GCRA functional block diagrams. Although traffic conformance at the UNI is defined by this definition, the network provider may use any UPC mechanism as long as the QoS objectives are met for compliant connections.

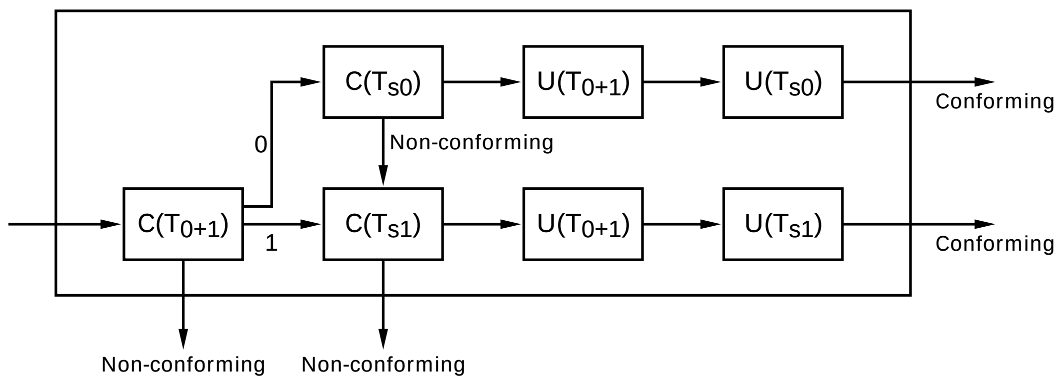


Figure B-2 Example 2a

The Conformance Definition that defines the traffic descriptor can be such that cells that are not conforming with the CLP=0 Sustainable Cell Rate descriptor may or may not be submitted as CLP=1 cells through marking at the source. In this case, the single CLP bit in the ATM header carries two meanings; one for user marked CLP=1 cells and the other for the tagged cells. The network (i.e., the switches) cannot distinguish between the two meanings. Therefore, the same QoS objectives are supported for both the user marked CLP=1 cells and the network tagged CLP=1 cells.

In I.371 it is stated that:

> "If a user requests two levels of priority for an ATM connection, as indicated by the CLP bit value, the intrinsic traffic characteristics of both cell flow components have to be characterized in the Source Traffic Descriptor. This is by means of a set of traffic parameters associated with the CLP=0 component and a set of traffic parameters associated with the CLP=0+1 component."

It should be noted that in this example a Sustainable Cell Rate for the CLP=1 cell stream is specified to model the Frame Relay traffic parameters as described above.

B.4 Example 2b: Frame Relay Service (FRS)

The intent of this section is to provide an example of the interworking of ATM and Frame Relay where the ATM connection is described by only two GCRAs as opposed to three. This restriction to two GCRAs leads to a limitation in matching the ATM parameter to the *EIR* or the Frame Relay access line rate.

For an ATM connection supporting the above FRS application, the following Conformance Definition in relation to a Source Traffic Descriptor that specifies PCR for the CLP=0+1 cell stream, SCR for the CLP=0 cell stream *could* be specified in the Traffic Contract *if a proper minimum frame length that the FRS user could submit is imposed.*

1. One GCRA(T_{0+1}, τ) defining the CDV Tolerance in relation to the PCR of the aggregate CLP=0+1 cell stream.

2. One GCRA(T_{s0}, $\tau_{s0}+\tau$) defining sum of the Burst Tolerance and CDV Tolerance in relation to the SCR of the CLP=0 cell stream.

A CLP=0 cell that is conforming to both GCRAs (1) and (2) above is said to be conforming to the Connection Traffic Descriptor. A CLP=1 cell that is conforming to GCRA (1) above is said to be conforming to the Connection Traffic Descriptor. A CLP=0 cell that is not conforming to GRCA (2) above but is conforming to GCRA (1) above is considered to have the CLP bit changed to 1 and said to be conforming to the Connection Traffic Descriptor.

The values of PCR and SCRs should be chosen to include the extra margin required to accommodate the overhead introduced in transferring the FRS frames via an ATM network. When the PCR is chosen to emulate the FRS access line rate, the *EIR* that is allowed is the difference between the access line rate and the *CIR*. Therefore, the *EIR* that is allowed possibly exceeds the *EIR* negotiated for the FRS. However, using traffic shaping, the PCR may be chosen to be the higher of either the required value to achieve the Transfer Delay objectives, or the required value to achieve the sum of *CIR* and *EIR* to the user. The Burst Tolerance (τ_{s0}) should be set to allow the maximum committed burst accepted in FRS to be passed at the PCR.

Figure B-3 depicts this Conformance Definition in terms of the GCRA functional block diagrams. Although traffic conformance at the UNI is defined by this definition, the network provider may use any UPC mechanism as long as the QoS objectives are met for compliant connections.

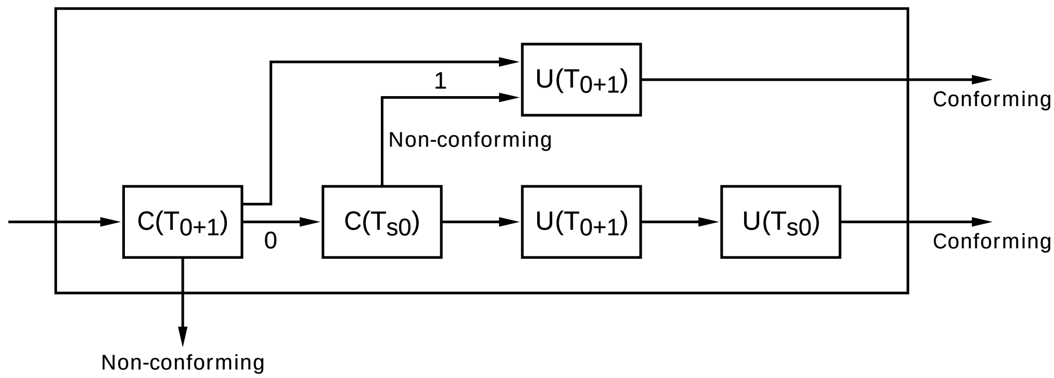


Figure B-3 Example 2b

The Conformance Definition that defines the Traffic Descriptor can be such that cells that are not conforming with the CLP=0 Sustainable Cell Rate parameter set may or may not be submitted as CLP=1 cells through marking at the source. In this case the single CLP bit in the ATM header carries two meanings; one for user marked CLP=1 cells and the other for the tagged cells. The network (i.e., the switches) cannot distinguish between the two meanings. Therefore, the same QoS objectives are supported for both the user marked CLP=1 cells and the network tagged CLP=1 cells.

B.5 Example 3: Constant Bit Rate Services

For an ATM connection supporting a Constant Bit Rate service, the following definition in relation to a Source Traffic Descriptor that specifies PCR for the CLP=0 cell stream *could* be specified in the Traffic Contract:

1. One GCRA(T_0, τ) defining the CDV Tolerance in relation to the PCR of the CLP=0 cell stream.

A cell that is conforming to this GCRA is said to be conforming to the Connection Traffic Descriptor.

PCR is chosen to emulate the constant bit rate of the service.

Figure B-4 depicts this Conformance Definition in terms of the GCRA functional block diagrams. Although traffic conformance at the UNI is defined by this definition, the network provider may use any UPC mechanism as long as the QoS objectives are met for compliant connections.

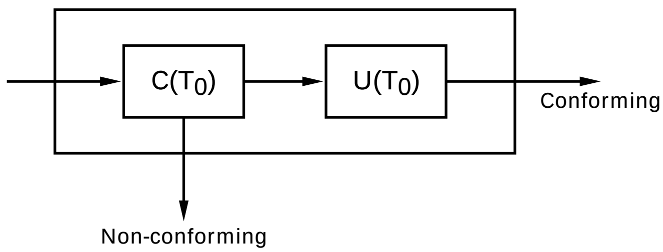


Figure B-4 Example 3

B.6 Example 4: LAN Interconnection

In applications such as LAN interconnection, multiple workstations on a LAN can send data over a public or private ATM WAN to other workstations in other LANs. These LANs can be interconnected through VPs across the ATM backbone. In such applications, the user's packets typically have the same level of importance and therefore are submitted to the ATM network as CLP=0 cells (after being processed at the AAL). Since traffic from multiple workstations are multiplexed on a given VP, there may not be a traffic shaper on the user side of the UNI (this may particularly be the case at the private-UNI). In such applications, it is desirable for the network to tolerate some amount of non-conformance of the CLP=0 stream by tagging these non-conforming cells as CLP=1 cells. This allows the users not to be very pessimistic in their traffic description and therefore may avoid excessive "over-allocation" for bursty data applications.

For an ATM connection supporting the above LAN Interconnection application, a Conformance Definition similar to what is given in Example 2a above *could* be specified in the Traffic Contract.

Appendix C

Point-to-Multipoint Signalling Procedures Using Separate State Machines (Informative)

C.1 Introduction

This Appendix shows the separation of the state machines for the basic point-to-point connections and for the extensions needed for point-to-multipoint communication (ADD PARTY, DROP PARTY, etc); the big advantages of such split being the reuse of the ITU-T Q.2931 state machine, as adopted in this document for the basic part, and also the possibility to add further extensions with regard to the requirements of the future signalling agreements (e.g. multi-connection calls).

C.2 Description of the Separate State Machines

C.2.1 Control Model

The basic idea of the control model is that the root and leaf terminals, and networks which support the Phase 1 Signalling Protocol is able to maintain two different types of state machines: A point-to-multipoint state machine which maintains states for each party participating in a call; and a link-state machine which maintains the states defined in §5.2.1.

Figure C-1 illustrates the basic control model using this separation of state machines. This model shows the root terminal, a network, and a leaf terminal involved in a call. It is assumed that this leaf terminal will never terminate more than one party of a point-to-multipoint call and therefore only needs to maintain the link-states.

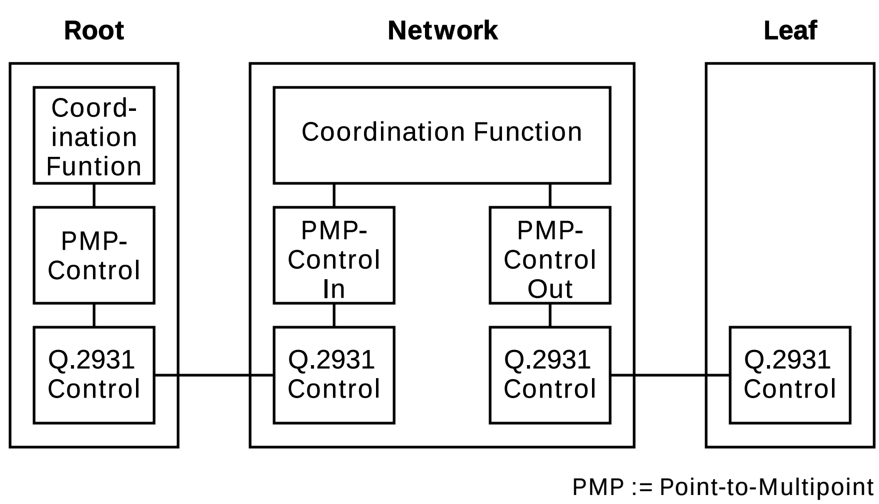


Figure C-1 Control Model with Separated State Machines

Figure C-2 shows that a network involved in a given call uses point-to-multipoint state machines (“In” and “Out”), keeping the PMP-states of each party (identified by an Endpoint Reference, or ER). Further it maintains a link-state machine for the incoming interface where it receives messages related to this call coming from the root, and one link-state machine for each outgoing interface involved in this call. It should be noted that this does not mean that one link-state machine is used for each party of a multipoint call: if several parties of a call are linked to this network via the same outgoing interface, only one link-state machine is maintained for those.

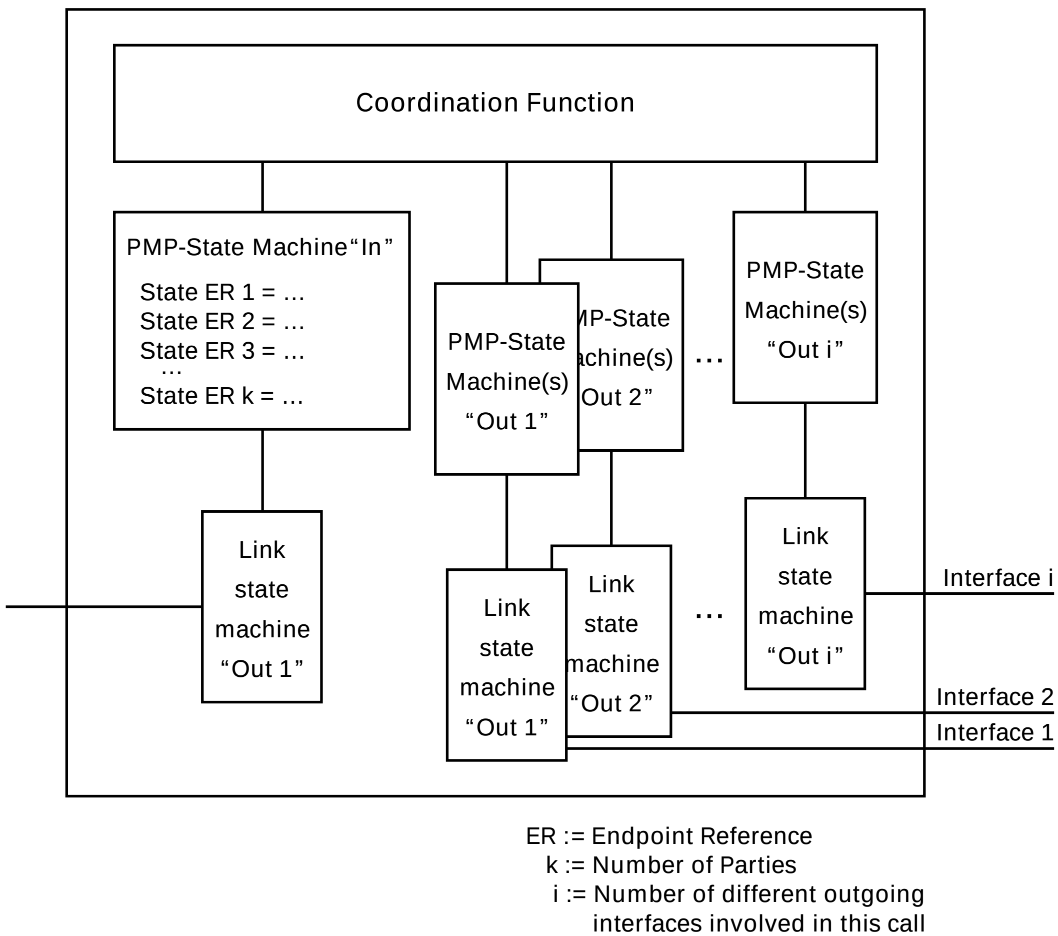


Figure C-2 State Machines of a Network involved in a Point-to-Multipoint Call

C.2.2 Party States and Link States

The following Party States and Link States are specified:

- Party States: “Null”, “AP-initiated”, “AP-received”, “DP-initiated”, DP-received”, “Active”.

- Link States: Call / Connection States as defined in §5.2.1.

C.2.3 Primitives between the Multi-Party Control and the Link Control

The two control processes communicate via primitives with each other; the party control sends “requests” to the link control, and receives “indications” from it. The primitives listed below are used for this communication; in the general description below, only “types” of primitives are summarized, i.e., e.g. the primitive “Q.2931-SETUP-Req.” is included in the type “Q.2931-<Msg.x>-Req.”.

Two types of primitives with the following generic names are used:

- “PMP-<Msg.x>”-primitives, where <Msg.x> may be any message of the Phase 1 signalling protocol which is not used in Q.2931, e.g. “ADD PARTY ACKNOWLEDGE”

- “Q.2931-<Msg.x>”-primitives, where <Msg.x> may be a message of Q.2931 (possibly from a subset).

Table C-1 shows which primitives are derived from these generic names:

Generic Name	Request	Indication
PMP-<Msg.x>	X	X
Q.2931-<Msg.x>	X (Note)	X

Note: only for messages with global significance

Table C-1 Primitives Used between Link Control and Point-to-Multipoint Control

C.2.4 Primitives between Point-to-Multipoint Control and Coordination Function

The same primitives are used as between Link Control and Point-to-Multipoint Control.

C.3. Information Flows for Point-to-Multipoint Communication

For illustrative purposes, the model in this section assumes that the UNI 3.0 signalling is used between all nodes within the example network. The UNI 3.0 signalling specification is, of course, normative only at the UNI interface. The model, however, is equally applicable to a concatenation of networks joined by UNI interfaces. For instance, the ‘PMP-Node’ and ‘SP-Node’ could represent private ATM LANs, while the ‘LC-Node’ could represent a Public ATM Network.

C.3.1 Functional Blocks used for the Description of Information Flows

For a given call, the description of the information flows for the establishment and release of point-to-multipoint connections uses the following five functional blocks:

a) Root

This is the functional block which initiates the point-to-multipoint call.

b) PMP-Node (Point-to-multipoint Node)

This is a network node where the information flow uses a connection already established for the information to a party participating in a call.

c) LC-Node (Last Common Node)

This is a network node where the information flow uses a connection already established for the information to another party of a call on the incoming side of the node; on the outgoing side the information flow uses an interface which is not used by any other party of this call.

d) SP-Node (Single Party Node)

This is a network node where the connection is only used for the information flow to/from one single party of a call.

e) B-TE (B-ISDN Terminal Equipment)

This functional block represents the equipment of a user receiving information sent from the root.

Figure C-3 illustrates the description of a point-to-multipoint call using these functional blocks. As usual for functional descriptions, functional blocks only appear once in this figure, although the physical entities which are represented by the functional descriptions may appear more than once for a given call, or may not be present at all. It should also be noted that the functional description is only related to a certain call at a specific point of time: an LC-node may e.g. be an PMP-node for another call or even for the same call at a later point of time.

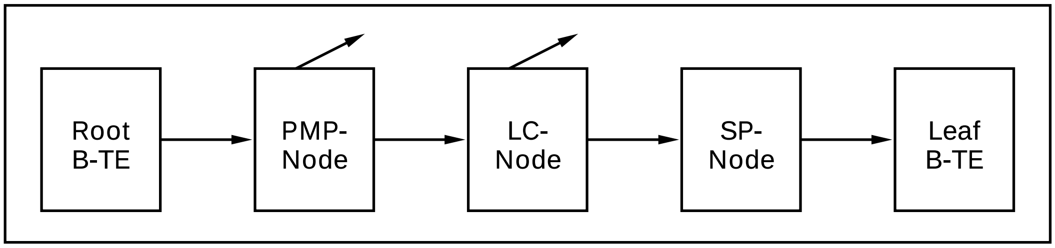


Figure C-3 Functional Blocks of a Point-to-Multipoint Call

C.3.2 Information Flows for the Successful Adding of a Party to an already Existing Call

C.3.2.1 Overall Description of Information Flows

The description of the information flows uses the functional model as specified in section C.3.1, and the separation of the state machines as described in Figures 1 and 2. The information flows summarized in Figure 4 only show the successful adding of a party to an already existing call; a possible rejection of a call attempt and possible error cases are described further below.

The root initiates the addition of a new party by sending an ADD PARTY message which is forwarded by the PMP-Nodes to the LC-Node. The LC-Node sends a SETUP message containing an Endpoint-Reference of the new party to the next SP-Node. The SP-Nodes forward the SETUP message, and the last SP-Node sends the SETUP message to the B-TE. The SETUP message is locally acknowledged by the CALL PROCEEDING message. The B-TE accepts the call by sending a CONNECT message, which is then converted by the LC-Node to become an ADD PARTY ACKNOWLEDGE, sent towards the Root.

To fully show the information flows would require showing three dimensions:

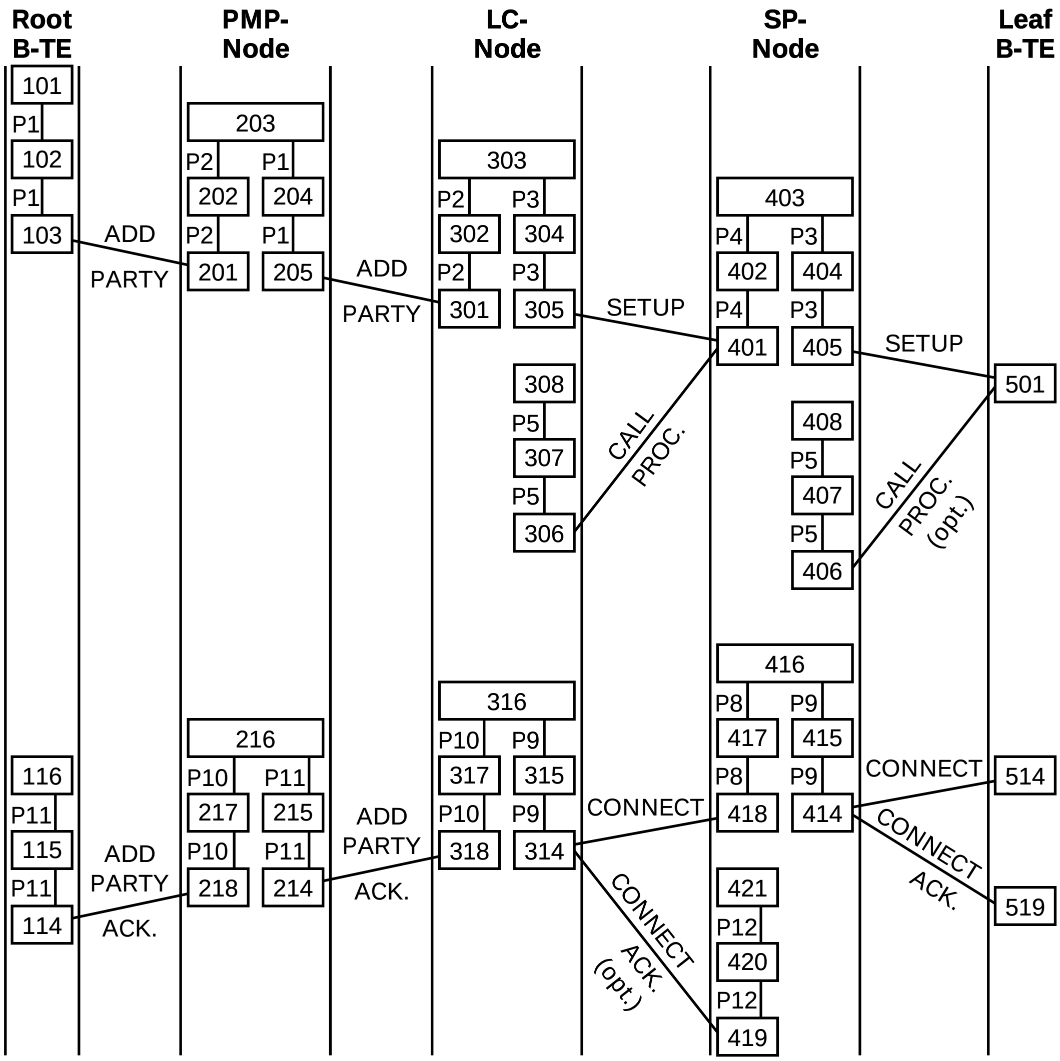
a) time

b) horizontal info flow between the link-state machines

c) vertical info flow between PMP-state machine and link-state machine.

Figure C-4 shows the 2 dimensions a) and b). Additionally, it indicates the local vertical primitives by using primitive numbers (P “n”, where “n” is an integer) which are described in detail below, ath the functional entity actions, which are labeled by the number within the functional block.

For reasons of simplicity, the requests and indications from / to the user are not shown in Figure C-4.



Opt := Optional

Figure C-4 Information Flows for Successful Adding of a New Party to a Point-to-Multipoint Call

C.3.2.2 Primitives between Point-toMultipoint Control and Link Control and between Coordination Function and Point-toMultipoint Control

P1: PMP - ADD PARTY - Req.

P2: PMP - ADD PARTY - Ind.

P3: Q.2931 - SETUP - Req.

P4: Q.2931 - SETUP - Ind.

P5: Q.2931 - CALL PROCEEDING - Ind.

P8: Q.2931 - CONNECT - Req.

P9: Q.2931 - CONNECT - Ind.

P10: PMP - ADD PARTY ACKNOWLEDGE - Req.

P11: PMP - ADD PARTY ACKNOWLEDGE - Ind.

P12: Q.2931 - CONNECT ACKNOWLEDGE - Ind.

C.3.2.3 Functional Entity Actions (FEAs)

Note: Implementations using this description will use timers to control the information flows; however, this is not indicated in this overall description. The acronym “PMP-control” is used in this section for “Point-to-Multipoint Control”

FEA 101:

- Receive and Process Add Party Request from User
- Check: Add Party possible? (“Yes” is assumed here)
- Allocate Endpoint Reference for new party
- Check: Outgoing interface already in use for another party participating in this call? (“Yes” is assumed here.)
- Initiate sending of ADD PARTY message to next node

FEA 102:

- Receive ADD PARTY request from Coordination Function
- Change party state of this party (ER = x) within this call to “AP-initiated”
- Forward P1 to Link control

FEA 103:

- Receive P1 from PMP-Control
- Send ADD PARTY message to next node

FEA 201:

- Receive ADD PARTY message
- Forward this message via P2 to PMP-Control

FEA 202:

- Receive Add Party Indication from incoming Link control
- Change incoming party state to “AP-received”

- Forward this message via P2 to Coordination Function

FEA 203:

- Receive and process ADD PARTY indication
- Select outgoing interface for new party
- Check: Outgoing interface already in use for another party participating in this call?
  (Note: As this is an PMP-node, the assumed answer is “yes”; otherwise, actions as described in FEAs 303 or 403 would be taken)
- Initiate sending of ADD PARTY message to next node

FEA 204: (as for FEA 102)

FEA 205: (as for FEA 103)

FEA 301: (as for FEA 201)

FEA 302: (as for FEA 202)

FEA 303:

- Receive and process ADD PARTY indication
- Select outgoing interface for new party
- Check: Outgoing interface already in use for another party participating in this call?
  (Note: As this is the LC-node, the assumed answer is “no”).
- Initiate sending of SETUP message to next node

FEA 304:

- Receive SETUP request from Coordination Function
- Change outgoing party state of this party within this call to “AP-initiated”
- Forward P3 to Link control

FEA 305:

- Receive P3 from PMP-control
- Send SETUP message (with ER) to next node
- Change link-state to “Call Initiated”

FEA 401:

- Receive and process SETUP message
- Detect trigger for point-to-multipoint call (e.g. presence of an ER)

- Enter “Call Present” state
- Acknowledge the received SETUP message by sending CALL PROCEEDING
- Inform PMP-control using P4
- Enter “Incoming Call Proceeding” state.

FEA 402:

- Receive SETUP indication
- Change incoming party state to “AP-received”
- Inform Coordination Function using P4

FEA 403:

- Receive and process SETUP indication with ER via P4
- Select outgoing interface for new party and check availability of resources
  (Note: As the scope of this section is to describe the successful adding of a new party, it is assumed that such an interface with sufficient available resources can be selected).
- Initiate sending of SETUP to next node or to B-TE

FEA 404: (as for FEA 304)

FEA 405:

- Receive P3 from PMP control
- Send SETUP message to next node or to B-TE
- Change link-state to “Call Initiated”.

FEA 501:

- Receive and process SETUP message (as described in Q.2931 [29])
- Perform compatibility checking (Note: Assumed result is: “successful”)
- Enter “Call Present” state
- Inform user on receipt of SETUP message
- (opt.:) Acknowledge receipt of SETUP by sending back CALL PROCEEDING
- (opt.:) Enter the “Incoming Call Proceeding” state.

FEA 306:

- Receive CALL PROCEEDING message
- (opt.:) Inform PMP-control via P5
- Change link-state to “Outgoing Call Proceeding”

FEA 307 (opt.):

- Receive and process CALL PROCEEDING message

- Forward to Coordination Function

FEA 308:
- (opt.:) Receive information on CALL PROCEEDING via P5

FEA 406 (opt.):
- Receive CALL PROCEEDING message
- Inform PMP-control via P5
- Enter "Incoming Call Proceeding" state

FEA 407 (opt.): (as for FEA 307)

FEA 408 (opt.): (as for FEA 308)

FEA 514:
- Receive and process indication of call acceptance by the user
- Send CONNECT message back to last node
- Change state to "Connect Request"

FEA 414:
- Receive CONNECT message
- Acknowledge by sending CONNECT ACKNOWLEDGE
- Inform PMP-control using P9
- Enter "Active" state

FEA 519:
- Receive and process CONNECT ACKNOWLEDGE message
- Enter "Active" state.

FEA 415:
- Receive CONNECT message indication
- Change "outgoing party state" to "active"
- Forward to Coordination Function

FEA 416:
- Receive and process CONNECT message indication

- Check: Another party within this call active at the interface back towards the root? (Note: As this node is an SP-node, the answer is assumed to be "no")
- Initiate sending of CONNECT back towards the root

FEA 417:

- Receive CONNECT message via P8 from Coordination Function
- change incoming party state of the party to "active"
- Forward this message to Link control

FEA 418:

- Receive P8 from PMP-control
- Send CONNECT back to last node
- Change link-state to "active".

FEA 314:

- Receive CONNECT message
- (opt.) Acknowledge by sending CONNECT ACKNOWLEDGE
- inform PMP-control using P9
- Change link-state to "active".

FEA 315: (as for FEA 415)

FEA 316:

- Receive and process CONNECT message
- Check: Another party within this call active at the interface back towards the root? (Note: As this node is the LC-node, the answer is assumed to be "yes").
- Initiate sending of ADD PARTY ACKNOWLEDGE towards the root

FEA 317:

- Receive CONNECT message via P10 from Coordination Function
- Change incoming party state to "active"
- Forward this message to Link control via P10

FEA 318:

- Receive P10 from PMP-control
- Send ADD PARTY ACKNOWLEDGE back to last node

FEA 214:

- Receive ADD PARTY ACKNOWLEDGE message

- Forward this message to PMP-control

FEA 215:

- Receive ADD PARTY ACKNOWLEDGE indication from Link control
- Change “outgoing party state” to “active”
- Forward to Coordination Function

FEA 216

- Receive and process ADD PARTY ACKNOWLEDGE indication from PMP-control
- Initiate sending of ADD PARTY ACKNOWLEDGE towards the root

FEA 217:

- Receive ADD PARTY ACKNOWLEDGE via P10 from Coordination Function
- Change incoming party state to “active”
- Forward to Link control

FEA 218: (as FEA 318).

FEA 114: (as FEA 214).

FEA 115:

- Receive and process ADD PARTY ACKNOWLEDGE indication from Link control
- Change party state to “active”
- Forward to Coordination Function

FEA 116:

- Receive information on ADD PARTY ACKNOWLEDGE via P11

FEA 419 (opt.):

- Receive CONNECT ACKNOWLEDGE message
- Inform PMP-control via P12

FEA 420 (opt.):

- Receive CONNECT ACKNOWLEDGE indication from Link control
- Forward to Coordination Function

FEA 421 (opt.):

- Receive information on CONNECT ACKNOWLEDGE via P12

C.3.3 Dropping of a Party from an Existing Point-to-Multipoint Call by the Root.

C.3.3.1 Overall Description of Information Flows

The description of the information flows uses the functional model as specified in section C.3.1, and the separation of the state machines as described in Figures C-1 and C-2. The information flows summarized in Figure C-5 only show the dropping of a party from an already existing call initiated by the root.

The root initiates the dropping of a party by sending a DROP PARTY message which is forwarded by the PMP-Nodes to the LC-Node. The PMP-Nodes and the LC-Node locally acknowledged the dropping of the party. The LC-Node sends a RELEASE message containing an Endpoint-Reference of the party to the next SP-Node, which forwards the RELEASE message. The last SP-Node sends the RELEASE message to the B-TE. The RELEASE message is locally acknowledged as specified in Q.2931 [29].

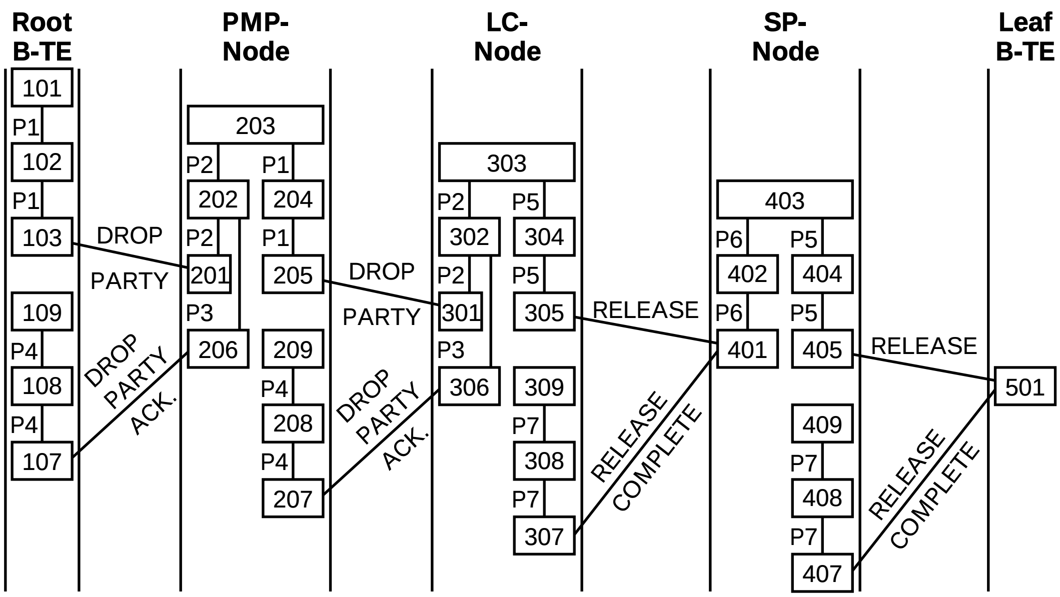


Figure C-5 Information Flows for a Local Acknowledgement of DROP PARTY from an Existing Point-to-Multipoint Call

C.3.3.2 Primitives between Point-to-Multipoint Control and Link Control

P1: PMP - DROP PARTY - Req.

P2: PMP - DROP PARTY - Ind.

P3: PMP - DROP PARTY ACKNOWLEDGE - Req.

P4: PMP - DROP PARTY ACKNOWLEDGE - Ind.

P5: Q.2931 - RELEASE - Req.

P6: Q.2931 - RELEASE - Ind.

P7: Q.2931 - RELEASE COMPLETE - Ind.

C.3.3.3 Functional Entity Actions (FEAs)

Note: Implementations using this description will use timers to control the information flows; however, this is not indicated in this overall description. The acronym “PMP-control” is used in this section for “Point-to-Multipoint Control”.

FEA 101:

- Receive and Process Drop Party Request from User
- Check: Drop Party possible? (“Yes” is assumed here)
- Check: Outgoing interface in use also for another party participating in this call? (“Yes” is assumed here.)
- Initiate sending of DROP PARTY message to next node

FEA 102:

- Receive DROP PARTY request from Coordination Function
- Change party state of this party within this call to “DP-initiated”.
- Forward P1 to Link control

FEA 103:

- Receive P1 from PMP-Control
- Send DROP PARTY message to next node

FEA 201:

- Receive DROP PARTY message
- Forward this message via P2 to PMP-Control

FEA 202:

- Receive Drop Party Indication from incoming Link control
- Change incoming party state to "DP-received"
- Initiate sending of DROP PARTY ACKNOWLEDGE to last node
- Change incoming party state to "Null"
- Forward P2 to Coordination Function

FEA 203:

- Receive and process DROP PARTY indication
- Check: Outgoing interface in use also for another party participating in this call? (Note: As this is an PMP-node, the assumed answer is "yes"; otherwise, actions as described in FEAs 303 or 403 would be taken)
- Initiate sending of DROP PARTY message to next node

FEA 204: (as for FEA 102)

FEA 205: (as for FEA 103)

FEA 206:

- Receive DROP PARTY ACKNOWLEDGE message via P3 from PMP-Control
- Send DROP PARTY ACKNOWLEDGE message to last node

FEA 107:

- Receive DROP PARTY ACKNOWLEDGE message
- Forward this message via P4 to PMP-control

FEA 108:

- Receive and process DROP PARTY ACKNOWLEDGE indication from Link control
- Change party state to "Null"
- Forward P4 to Coordination Function

FEA 109:

- Receive information on DROP PARTY ACKNOWLEDGE via P4

FEA 301: (as for FEA 201)

FEA 302: (as for FEA 202)

FEA 303:

- Receive and process DROP PARTY indication
- Check: Outgoing interface in use also for another party participating in this call? (Note: As this is the LC-node, the assumed answer is “no”).
- Initiate sending of RELEASE message to next node

FEA 304:

- Receive RELEASE request
- Change outgoing party state of this party within this call to “Null”.
- Forward to Link control via P5

FEA 305:

- Receive P5 from PMP-control
- Send RELEASE message to next node
- Change link-state to “Release indication”

FEA 306: (as for FEA 206)

FEA 207: (as for FEA 107)

FEA 208: (as for FEA 108)

FEA 209: (as for FEA 109)

FEA 401:

- Receive RELEASE message
- Acknowledge the received RELEASE message by sending RELEASE COMPLETE to last node
- Detect trigger for point-to-multipoint call (e.g. presence of an ER)
- Inform PMP-control using P6
- Enter “Null” state.

FEA 402:

- Receive and process RELEASE indication with ER via P6
- Change incoming party state to “Null”
- Forward this message via P6 to Coordination Function

FEA 403:

- Receive and process RELEASE indication
- Select outgoing interface for the party
- Initiate sending of RELEASE to next node or to B-TE

FEA 404: (as for FEA 304)

FEA 405:

- Receive P5 from PMP control
- Send RELEASE message to next node or to B-TE
- Change link-state to “Release Indication”

FEA 501:

- Receive and process RELEASE message (as described in Q.2931 [29])
- Inform user on receipt of RELEASE message
- Acknowledge the received RELEASE by sending back RELEASE COMPLETE
- Enter the “Null” state.

FEA 307:

- Receive and process RELEASE COMPLETE message
- (optionally) Inform incoming PMP-control using P7
- Change link-state to “Null”

FEA 308: (optionally)

- Receive and process RELEASE COMPLETE Indication from Link control
- Forward P7 to Coordination Function

FEA 309: (optionally)

- Receive information on RELEASE COMPLETE via P7

FEA 407: (as for FEA 307)

FEA 408: (as for FEA 308)

FEA 409: (as for FEA 309)

Appendix D

Example Signalling Codings

This Appendix gives examples of typical codings for information elements. Selection of particular codings to appear in this Appendix is not intended endorse particular applications or higher layer protocols to the exclusion of other applications or higher layer protocols. The values relevant to the examples and their binary codings in the protocol are shown in **boldface** type.

> *Note* - In the event of discrepancies between the text of §5.4 and this Appendix, the text of §5.4 takes precedence.

D.1 ATM Adaptation Layer Parameters

D.1.1 Example of information element coding for AAL1

This example shows how the ATM adaptation layer parameters information element may be coded for a typical video conferencing application.

Bits 8	7	6	5	4	3	2	1	Octet
ATM adaptation layer parameters								
0	**1**	**0**	**1**	**1**	**0**	**0**	**0**	1
Information element identifier								
1 ext	Coding Standard **= ITU-T Specified**		IE Instruction Field = **Not Significant**					2
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Length of AAL parameter contents								3
Length of AAL parameter contents (continued) = **12** octets								4
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**1**	**1**	**0**	**0**	
AAL Type **= AAL1**								5
0	**0**	**0**	**0**	**0**	**0**	**0**	**1**	
Subtype Identifier								6
1	**0**	**0**	**0**	**0**	**1**	**0**	**1**	
Subtype = **Video signal transport**								6.1
0	**0**	**0**	**0**	**0**	**1**	**0**	**1**	
CBR Rate Identifier								7
1	**0**	**0**	**0**	**0**	**1**	**1**	**0**	
CBR Rate **= n x 64 kbit/s**								7.1
0	**1**	**0**	**0**	**0**	**0**	**0**	**0**	
Multiplier Identifier								8
1	**0**	**0**	**0**	**0**	**1**	**1**	**1**	
Multiplier								8.1
Multiplier (continued) = **2**								8.2
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**0**	**0**	**1**	**0**	
Source Clock Frequency Recovery Method Identifier								9
1	**0**	**0**	**0**	**1**	**0**	**0**	**0**	
Source Clock Frequency Recovery Method = **Adaptive Clock Method**								9.1
0	**0**	**0**	**0**	**0**	**0**	**1**	**0**	
Error Correction Method Identifier								10
1	**0**	**0**	**0**	**1**	**0**	**0**	**1**	
Error Correction Method = **Null**								10.1
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	

D.1.2 Example of information element coding for AAL5

This example shows how the ATM adaptation layer parameters information element may be coded for a typical data application using AAL5.

Bits 8	7	6	5	4	3	2	1	Octet
ATM adaptation layer parameters								
0	**1**	**0**	**1**	**1**	**0**	**0**	**0**	1
Information element identifier								
1 ext	Coding Standard **= ITU-T Specified**		IE Instruction Field = **Not Significant**					2
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Length of AAL parameter contents								3
Length of AAL parameter contents (continued) = **11** octets								4
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**1**	**0**	**1**	**1**	
AAL Type **= AAL5**								5
0	**0**	**0**	**0**	**0**	**1**	**0**	**1**	
Forward Maximum CPCS-SDU Size Identifier								6
1	**0**	**0**	**0**	**1**	**1**	**0**	**0**	
Forward Maximum CPCS-SDU Size								6.1
Forward Maximum CPCS-SDU Size (continued) **= 1542 octets**								6.2
0	**0**	**0**	**0**	**0**	**1**	**1**	**0**	
0	**0**	**0**	**0**	**0**	**1**	**1**	**0**	
Backward Maximum CPCS-SDU Size identifier								7
1	**0**	**0**	**0**	**0**	**0**	**0**	**1**	
Backward Maximum CPCS-SDU Size								7.1
Backward Maximum CPCS-SDU Size (continued) **= 1542 octets**								7.2
0	**0**	**0**	**0**	**0**	**1**	**1**	**0**	
0	**0**	**0**	**0**	**0**	**1**	**1**	**0**	
SSCS-type identifier								8
1	**0**	**0**	**0**	**0**	**1**	**0**	**0**	
SSCS-type = **NULL**								8.1
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	

D.2 Broadband Bearer Capability

D.2.1 Example of information element coding for variable bit rate, connection oriented service with no timing requirements

This example shows how the Broadband bearer capability information element may be coded for a typical variable bit rate data application.

<table>
<tr><td colspan="8">Bits</td><td></td></tr>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>Octet</td></tr>
<tr><td colspan="8">Broadband bearer capability</td><td></td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td colspan="8">Information element identifier</td><td></td></tr>
<tr><td>1
ext</td><td colspan="2">Coding
Standard
= ITU-T Specified</td><td colspan="5">IE Instruction Field
= Not Significant</td><td>2</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td colspan="8">Length of B-BC contents</td><td>3</td></tr>
<tr><td colspan="8">Length of B-BC contents (continued)
= 2 octets</td><td>4</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td></td></tr>
<tr><td>0/1
ext</td><td>0</td><td>0</td><td colspan="5" rowspan="2">Bearer class
= BCOB-C</td><td>5</td></tr>
<tr><td></td><td colspan="2">Spare</td><td></td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td></td></tr>
<tr><td>1
ext</td><td colspan="2">Susceptibility
to clipping
= Not susceptible</td><td>0</td><td>0
Spare</td><td>0</td><td colspan="2">User plane
connection
configuration
= pt-to-pt</td><td>6</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
</table>

D.3 Broadband Low Layer Information

D.3.1 Example of information element coding for multiprotocol interconnect using the LLC encapsulation

This example shows how the B-LLI information element may be coded when multiprotocol interconnection using the LLC encapsulation is to be used on the VCC (see Internet RFC draft, *Multiprotocol Encapsulation over ATM/AAL5*)

Bits

8	7	6	5	4	3	2	1	Octet
Broadband low layer information								
0	**1**	**0**	**1**	**1**	**1**	**1**	**1**	1
Information element identifier								
1 ext	Coding Standard = **ITU-T Specified**		IE Instruction Field = **Not Significant**					2
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Length of B-LLI contents								3
Length of B-LLI contents (continued) = **1** octet								4
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**0**	**0**	**0**	**1**	
0/1 ext	1 Layer 2 id	0	User information layer 2 protocol = **LAN logical link control (ISO 8802/2)**					6
1	**1**	**0**	**0**	**1**	**1**	**0**	**0**	

D.3.2 Example of information element coding for transport of IP datagrams using the "Null encapsulation" over AAL5

This example shows how the B-LLI information element may be coded when IP datagrams are to be transported within an AAL service data unit without any multiprotocol encapsulation ("Null Encapsulation" — see Internet RFC draft, *Multiprotocol Encapsulation over ATM/AAL5*). Note that no encoding for User Information Layer 3 protocol exists for IP. Therefore, the ISO/IEC TR 9577 Network Layer Protocol Identifier (NLPID) value for IP is used instead.

Bits

8	7	6	5	4	3	2	1	Octet
Broadband low layer information								
0	**1**	**0**	**1**	**1**	**1**	**1**	**1**	1
Information element identifier								
1 ext	Coding Standard = **ITU-T Specified**		IE Instruction Field = **Not Significant**					2
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Length of B-LLI contents								3
Length of B-LLI contents (continued)								4
= **3** octets								
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**0**	**0**	**1**	**1**	
0/1 ext	1	1	User information layer 3 protocol = **ISO/IEC TR 9577**					7
	Layer 3 id							
0	**1**	**1**	**0**	**1**	**0**	**1**	**1**	
0 ext	ISO/IEC TR 9577 Initial Protocol Identification (IPI) (bits 8-2) = **Internet Protocol**							7a
0	**1**	**1**	**0**	**0**	**1**	**1**	**0**	
1 ext	IPI (bit1)	0	0	0	0	0	0	7b
		Spare						
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	

D.3.3 Example of information element coding for transport of bridged frames using the "Null encapsulation" over AAL5

This example shows how the B-LLI information element may be coded when bridged LAN frames are to be transported within an AAL service data unit without any multiprotocol encapsulation ("Null Encapsulation — see Internet RFC draft, *Multiprotocol Encapsulation over ATM/AAL5*). Note that no encoding for User Information Layer 3 protocol exists for SNAP identifier. Therefore, the ISO/IEC TR 9577 Network Layer Protocol Identifier (NLPID) value for SNAP is used as an escape to include the SNAP identifier in the B-LLI information element. In this example, the SNAP identifier '00-80-C2-00-0A' indicates bridged FDDI frames without a preserved FCS. Similar coding principles apply for other kinds of bridged MAC frames and for routed frames which can only be identified using the SNAP convention (e.g., Appletalk™, XNS™, and IPX™).

Bits

8	7	6	5	4	3	2	1	Octet
Broadband low layer information								
0	**1**	**0**	**1**	**1**	**1**	**1**	**1**	1
Information element identifier								
1 ext	Coding Standard = **ITU-T Specified**		IE Instruction Field = **Not Significant**					2
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
Length of B-LLI contents								3
Length of B-LLI contents (continued)								4
= **9** octets								
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**1**	**0**	**0**	**1**	
0/1 ext	1 Layer 3 id	1	User information layer 3 protocol **= ISO/IEC TR 9577**					7
0	**1**	**1**	**0**	**1**	**0**	**1**	**1**	
0 ext	ISO/IEC TR 9577 Initial Protocol Identification (IPI) (bits 8-2) **= SNAP Identifier**							7a
0	**1**	**0**	**0**	**0**	**0**	**0**	**0**	
1 ext	IPI (bit1)	0	0	0	0	0	0	7b
		Spare						
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
1 ext	0 SNAP ID	0	0	0	0	0	0	8
			Spare					
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
SNAP Organization Unique Identifier (octet 1)								8.1
OUI octet 2								8.2
OUI octet 3								8.3
= **IEEE 802.1**								
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
1	**1**	**0**	**0**	**0**	**0**	**1**	**0**	
PID (octet 1)								8.4
PID octet 2								8.5
= **FDDI without preserved FCS**								
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	
0	**0**	**0**	**0**	**1**	**0**	**1**	**0**	