The ATM Forum
Technical Committee

BISDN Inter Carrier Interface (B-ICI) Specification Version 2.0 (Integrated)

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NOTE: *This document (Integrated) supersedes previously issued ATM Forum B-ICI Specification, Version 2.0 (Delta), November 1995, and B-ICI Specification, Version 1.1, September 1994.*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. Introduction

Asynchronous Transfer Mode (ATM) based public networks belonging to different carriers must be interconnected in order to facilitate the end-to-end national and international ATM/BISDN services. Methods are required to support the efficient and manageable multiplexing of multiple services for inter-carrier delivery. This is accomplished by connecting multiple public carrier's networks. The set of specifications required to meet these goals, called a BISDN Inter Carrier Interface (B-ICI)[1], is the subject of this document.

The B-ICI specification in this document will facilitate carrier-to-carrier connection. The ATM Forum B-ICI specification is intended as an implementation agreement that, when followed, will result in increased interoperability. This specification will also result in the early availability of the goals of network interconnection and ubiquitous service offerings.

The B-ICI is an interface between two different public network providers or carriers. It is the demarcation point that designates the boundary between the public carriers' networks. The physical layer of the interface between the two carriers is based on the CCITT[2] defined Network Node Interface (NNI) with the addition of a DS3 and E3 physical layers.

The B-ICI specification also includes service specific functions above the ATM layer required to transport, operate and manage a variety of inter-carrier services across the B-ICI. These functions need not necessarily be physically located at the B-ICI. For example, ATM switching nodes may exist between the network equipment supporting the service specific functions and the B-ICI physical location.

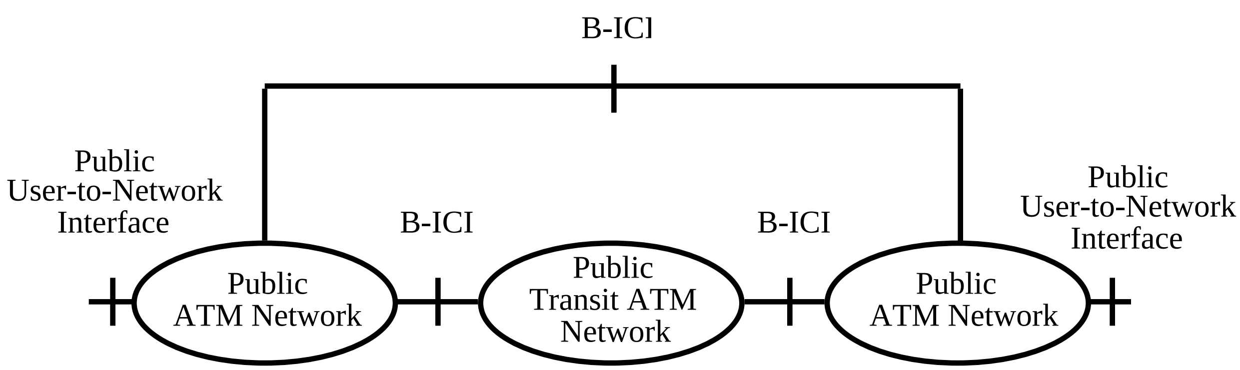

Figure 1.1 The B-ICIs Connecting Public ATM Networks

Figure 1.1 illustrates the reference configuration of the B-ICIs connecting two public ATM networks (belonging to different carriers) via a public transit ATM network. Also, B-ICI is shown to connect directly two public ATM networks belonging to different carriers. The purpose of the B-ICI is to carry traffic between the generic user-to-network interfaces across the public carriers' networks.

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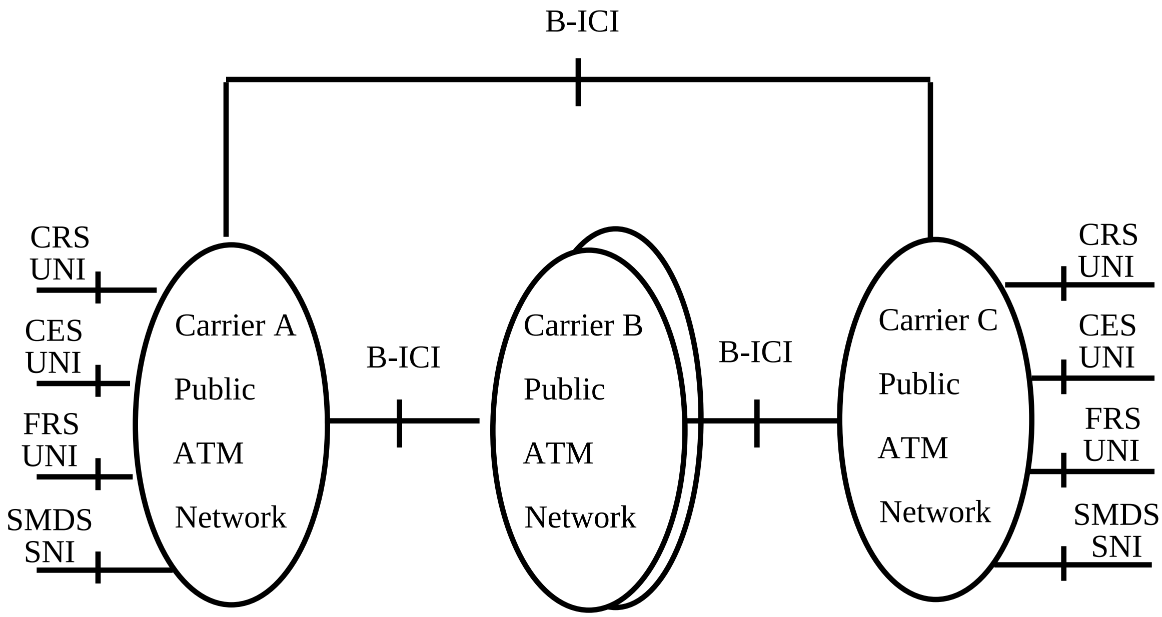
[1] The first release of the specification in this document does not cover all aspects (e.g., signaling) of BISDN. Additional aspects of BISDN will be covered in the future Versions of this document.

[2] CCITT (International Telegraph and Telephone Consultative Committee) is an international standards body. Recently it's name has changed to International Telecommunication Union (ITU)-Telecommunication Standardization Sector (ITU-T).

A generic reference configuration for the multi-service B-ICI is illustrated in Figure 1.2. In this Figure, "UNI" represents an access interface in a general sense, independent of any particular technology. Multiple service specific customer access interfaces (ATM/non-ATM) can be connected to a carrier's ATM network. The B-ICIs are shown as providing inter-carrier network connectivity between the Carrier A, Carrier B, and Carrier C. There may be no tandem ATM network, or multiple ATM networks in tandem. The role(s) which a particular carrier must take can vary in this generic reference model subject to regulations and bilateral agreements.



CRS = Cell Relay Service CES = Circuit Emulation Service
FRS = Frame Relay Service SMDS = Switched Multi-megabit Date Service
UNI = User Network Interface SNI = Subscriber Network Interface

Figure 1.2 Generic B-ICI Reference Configuration

Figure 1.3 illustrates a generic inter-carrier interconnection example, related to the US environment, of the B-ICIs connecting different carrier's public ATM networks. In this example, the B-ICIs provide connectivity between:

- A Local Exchange Carrier (LEC) ATM network and an Inter Exchange Carrier (IEC) ATM network,
- A LEC ATM network and an Independent Local Exchange Carrier (ILEC) ATM network,
- An IEC ATM network and an ILEC ATM network,
- A LEC, an IEC, or an ILEC ATM networks and any other public carrier ATM network.

Figure 1.3 illustrates a generic example which shows that any category of carrier, namely, LEC, IEC, ILEC, and any other Carrier can have a service specific User Network Interface (UNI), and be connected to any other carrier via a B-ICI. This is desirable in order to meet the objective of ubiquitous service offerings. These interconnections are subject to regulation and/or reached by bilateral agreements. This is not an exhaustive example, and other configurations are possible.

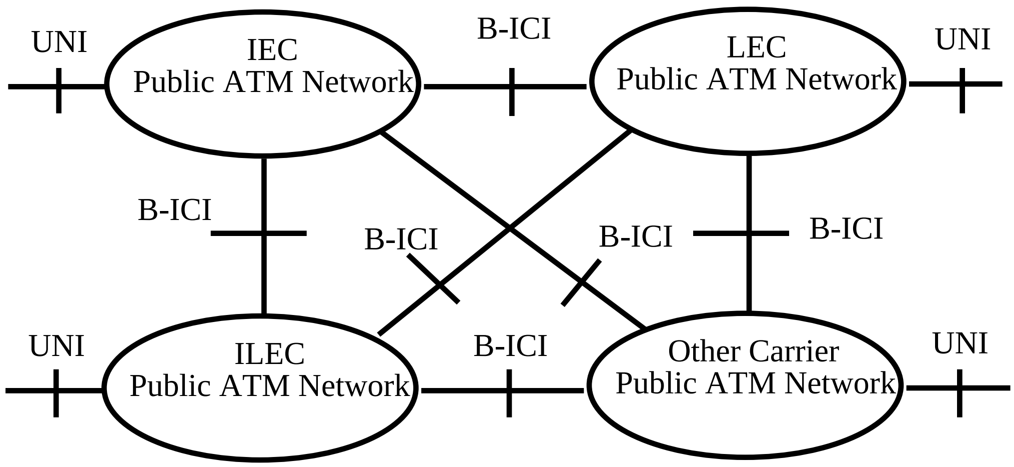


Figure 1.3 An Example of the B-ICIs Connecting Different Carrier's Public ATM Networks

1.1 Purpose

This document provides the initial B-ICI Specification for supporting Permanent Virtual Connection (PVC) services and Switched Multi-megabit Data Service (SMDS) on ATM/BISDN. This will include mostly user plane (U-plane) and management plane (M-plane) communication capabilities, and no control plane (C-plane) communication capabilities.

In the next Version, the work will be directed towards the B-ICI Specification for supporting Switched Virtual Connection (SVC) services on ATM/BISDN. It is expected that the B-ICI specification for supporting SVC services can be generated by adding the control plane communication capabilities (e.g., network signaling) to the B-ICI specification for PVC services generated initially.

1.2 Scope

To satisfy the purpose stated above, the scope of this document can be summarized as follows:

1. The initial B-ICI will support inter-carrier connections to offer services based on the Permanent Virtual Connections (PVC). In the next phase, B-ICIs capabilities will evolve towards supporting carriers connections to offer services based on the Switched Virtual Connections (SVC).

2. The initial B-ICI will support inter-carrier services to offer: (i) PVC-Based Cell Relay Service (CRS), (ii) Circuit Emulation Service (CES), (iii) PVC-Based Frame Relay Service (FRS), and (iv) Switched Multi-megabit Data Service (SMDS). The target B-ICI is a multi-service (e.g., CRS, CES, FRS, SMDS) interface.

3. A multi-service B-ICI can be configured to support either one service, or any combination of the above services to meet the traffic needs.

4. The ATM-based B-ICI is based on the Network Node Interface (NNI).

5. The B-ICI physical layer specification includes both DS3/E3 and SONET/SDH rates.

6. The B-ICI ATM layer specification is common to all the B-ICI physical layers.

7. The B-ICI related service specific functions above the ATM layer include ATM Adaptation Layer (AAL) and network interworking.

8. B-ICI specification includes traffic management and network performance.

9. B-ICI specification includes operations and maintenance.

10. B-ICI specification includes usage measurement.

The scope of the ATM Forum B-ICI Specification, Version 2.0, covers generation of an implementation agreement including principles, guidelines, Requirements (R)s and Options (O)s to support PVC-based inter-carrier services (CRS, CES, FRS), SMDS, and SVC-based inter-carrier services on a multi-service B-ICI. In general, the B-ICI specification to support SVC-based inter-carrier services builds upon the B-ICI specification (Version 1.1, September 1994) completed and published for the PVC-based inter-carrier services support. This document presents an integrated B-ICI specification for supporting both PVC and SVC capabilities.

1.3 Document Organization

This document is organized in four major parts:

- Part I: B-ICI Definition, Scope, and Architecture - Sections 1, 2.
- Part II: B-ICI Common Aspects - Sections 3, 4, 5, 6, 7.
- Part III: B-ICI Inter-Carrier Service Aspects - Sections 8, 9, 10, 11.
- Part IV: Others - Section 12.

• Section 1 (Introduction) provides B-ICI definition, some generic B-ICI reference configurations, purpose, scope, terminology, and related documents.

• Section 2 (Network Aspects) provides relation of a B-ICI to the Network Node Interface (NNI), relation to other interfaces, multi-service aspects, and B-ICI related network interworking functions.

• Section 3 (B-ICI Physical Layer Specification) provides signal formats at the B-ICI, physical layer characteristics of the 155.520 Mbit/s (STS-3c/STM-1), 622.080 Mbit/s (STS-12c/STM-4), 44.736 Mbit/s (DS3) and 34.368 Mbit/s (E3) rates B-ICI.

• Section 4 (B-ICI ATM Layer Specification) provides ATM layer services, services expected from the physical layer, ATM cell structure and encoding, and ATM layer functions (U-Plane) at the B-ICI.

- Section 5 (Common B-ICI Traffic Management and Network Performance) provides B-ICI traffic management and network performance considerations that are common to all inter-carrier services.
- Section 6 (Common B-ICI Operations and Maintenance) provides B-ICI operations for the physical layer and the ATM layer that are common to all inter-carrier services.
- Section 7 (B-ICI Signaling) specifies the B-ICI signaling for supporting switched inter-carrier services.
- Section 8 (PVC-Based Inter-carrier CRS Support on a B-ICI) provides the service definition, service specific functions (U-Plane), traffic management and network performance, and operations for the inter-carrier CRS supported by a B-ICI.
- Section 9 (PVC-Based Inter-Carrier CES Support on a B-ICI) provides the service definition, service specific functions (U-Plane), traffic management and network performance, and operations for the inter-carrier DS1/DS3 CES supported by a B-ICI.
- Section 10 (PVC-Based Inter-Carrier FRS Support on a B-ICI) provides the service definition, service specific functions (U-Plane), traffic management and network performance, and operations for the inter-carrier FRS supported by a B-ICI.
- Section 11 (SMDS Support on a B-ICI) provides the service definition, service specific functions (U-Plane), traffic management and network performance, and operations for the inter-carrier SMDS supported by a B-ICI.
- Section 12 (Usage Measurement) provides considerations for measuring the transfer of service between carriers connecting through a B-ICI.

1.4 Terminology

This document uses two levels for indicating the degree of compliance necessary for specific functions/procedures/coding associated with the B-ICI:

Requirement (R): Functions/procedures/coding necessary to satisfy the inter-carrier service needs of carriers connecting via a B-ICI. Meeting a requirement will facilitate operational compatibility. Requirements are indicated by the word **"shall"** and are labeled by **(R)**.

Option (O): Functions/procedures/coding that may be useful but are not necessary to satisfy the inter-carrier service needs of carriers connecting via a B-ICI. Failure to meet an option is unlikely to hinder the operational compatibility. Options are indicated by the words **"should"**, **"may"**, or "**it is an option**", and are labeled by **(O)**.

Permanent Virtual Connection (PVC) - An ATM connection that is established through provisioning based procedures.

Switched Virtual Connection (SVC) - An ATM connection that is established and torn down through signaling based procedures.

1.5 Related Documents

- CCITT/ITU-T Recommendations:

1. F.811 - *Broadband Connection-Oriented Bearer Services*.
2. F.812 - *Broadband Connectionless Data Bearer Service*.
3. I.150 - *BISDN Asynchronous Transfer Mode Functional Characteristics*.
4. I.211 - *BISDN Service Aspects*.
5. I.311 - *BISDN General Network Aspects*.
6. I.361 - *BISDN ATM Layer Specification*.
7. I.362 - *BISDN ATM Adaptation Layer (AAL) Functional Description*.
8. I.363 - *BISDN ATM Adaptation Layer (AAL) Specification.*
9. I.364 - *Support of Broadband Connectionless Data Service On BISDN*.
10. I.371 - *Traffic Control and Congestion Control in BISDN*.
11. I.610 - *BISDN Operations and Maintenance Principles and Functions*.
12. I.555 - *Frame Relaying Bearer Service Interworking*.
13. I.363 - *AAL Type 5, Section 6*.
14. I.365.1 - *Frame Relaying Service Specific Convergence Sublayer (FR-SSCS)*.

- ANSI-T1 Standards:
  See REFERENCES.

- ETSI Standards:
  See REFERENCES

- Other Industry Documents:
  See REFERENCES.

2. Network Aspects

This section provides network principles, BISDN protocol architecture, relation of the B-ICI to the Network Node Interface (NNI) and other interfaces, multi-carrier network configuration, multi-service aspects of the B-ICI, and related network interworking functions.

2.1 Principles

A BISDN functional principle is the support of a wide range of data, video and voice applications in the same network. A key element of service integration for such a network is the provision of a range of services using a limited number of connection types and multipurpose interfaces. BISDNs support both switched and non-switched connections. BISDNs support services requiring both circuit-mode and packet-mode information transfer capabilities. BISDNs support both connection-oriented and connectionless services. BISDNs will support capabilities for the purpose of providing service features, maintenance, and network management functions.

2.2 BISDN Protocol Architecture

The Protocol Reference Model (PRM) introduces the concept of separated planes for the segregation of user, control, and management functions. A generic BISDN protocol architecture model is shown in Figure 2.1. This architecture model consists of a user plane, a control plane, and a management plane.

- **User Plane:**
  The user plane, with its layered structure provides for user information flow transfer along with associated controls (e.g., flow control and recovery from errors).

- **Control Plane:**
  This plane has a layered structure and it performs the call control and connection control functions. It deals with the signaling functions necessary for call and connection set up, supervision, and release.

- **Management Plane:**
  The management plane provides two types of functions, namely, Layer Management functions and Plane Management functions.

  - Plane Management Functions - The Plane Management performs management functions related to a system as a whole and provides coordination between all the planes; Plane Management has no layered structure.

  - Layer Management Functions - The Layer Management performs management functions related to resources and parameters residing in its protocol layer entities (e.g., meta-signaling is an ATM Layer Management function). Layer Management also handles the Operation and Maintenance information flows specific to the layer concerned.

The layered protocol architecture model can be described on the basis of functions associated with each layers:

- **Physical Layer:** The Physical Layer, for a B-ICI, is based on DS3/E3 and SONET/SDH principles.

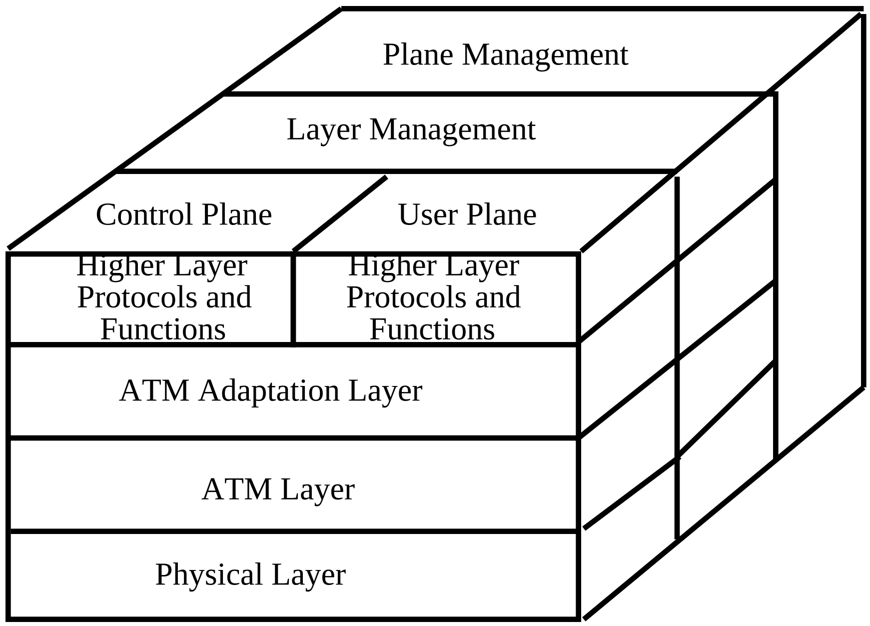


Figure 2.1 BISDN Protocol Architecture Model

- **ATM Layer:** The ATM Layer, above the Physical Layer, provides the cell transfer capability and is common to all services. The cell information field is transported transparently by the ATM layer of the network; no processing (e.g., error control) is performed on the information field at the ATM layer. The cell header and the information field each consists of a fixed number of octets (5 and 48 octets, respectively) at a given reference point. The ATM cell header format for NNI/B-ICI will be described in a later section. The information field length is the same for all connections at all reference points where the ATM technique is applied. ATM is a connection-oriented technique that can be used for supporting both connection-oriented and connectionless services. Signaling and user information are carried on separate virtual channels. ATM is designed to offer a flexible transfer capability common to all services.

- **ATM Adaptation Layer (AAL):** ATM Adaptation Layer (AAL) provides service-dependent functions to the layer above the AAL. The boundary between the ATM layer and the service-dependent AAL corresponds to the boundary between functions devoted to the cell header and functions devoted to the cell information field, respectively. The AAL supports higher layer functions of the User and Control planes. Information is mapped by the AAL into ATM cells. At the transmitting end, the information units are segmented or collected to be inserted into ATM cells. At the receiving end, the information units are reassembled or read-out from ATM cells. Any AAL specific information (e.g., information field length, sequence number) that must be passed between peer AAL is contained in the information field of each ATM cell. The AAL could be terminated in Terminal Equipment (TE), Terminal Adaptor (TA), NT2, NT1, Exchange Termination (ET), and Network Adaptor (NA). NA function includes those adaptation functions that are necessary between ATM and non-ATM networks. The AALs are terminated in the network for connectionless service, signaling, etc..

- **Layers above the AAL:** The layers above the AAL in the control plane provides call control and connection control. The management plane provides network supervision functions. Layers above the AAL in the user plane are service dependent. Examples of functions provided by this layer include inter-carrier service specific functions.

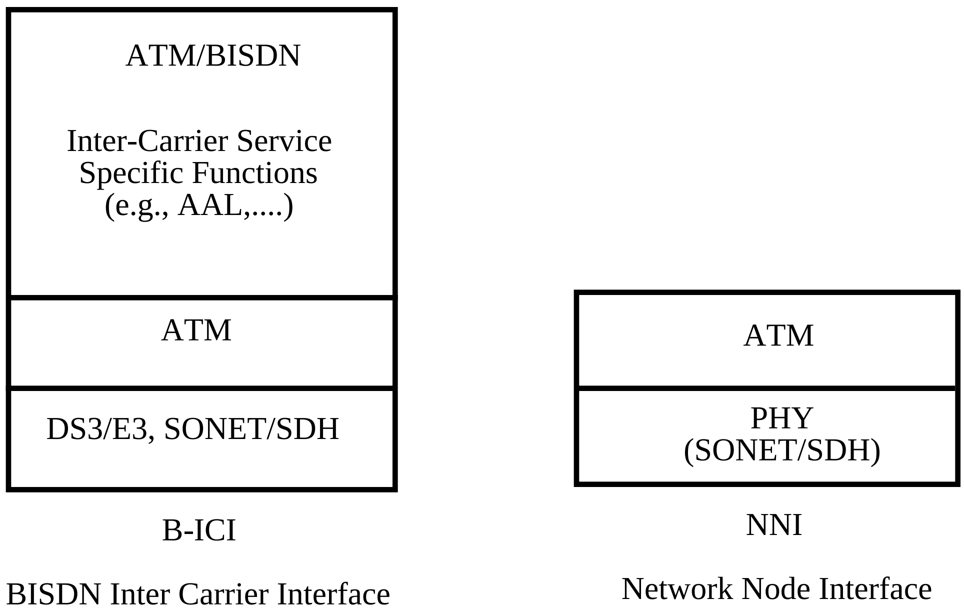


Figure 2.2 Relation of a B-ICI to the NNI

2.3 Network Node Interface

(R) 2-1 B-ICI specification shall be based on the CCITT defined[1][2][3] Network Node Interface (NNI) and shall include DS3/E3 PDH rates defined in CCITT Recommendation G.702[56].

Figure 2.2 illustrates the relation between a B-ICI and the NNI. The NNI specification includes Synchronous Optical network (SONET)/Synchronous Digital Hierarchy (SDH) physical layer and the ATM layer. The B-ICI specification includes SONET/SDH and DS3/E3 physical layer, and the ATM layer. The B-ICI specification also includes layers above the ATM (e.g., AAL, other inter-carrier service specific layers) when supporting CES, FRS, and SMDS. The B-ICI is specified for both electrical and optical media to meet the near-term and long-term business needs.

2.4 Multi-Carrier Network Configuration

A B-ICI may provide inter-carrier services directly by means of service specific functions located inside the network, or it may provide an interconnection among service specific networks based on ATM and/or non-ATM technologies.

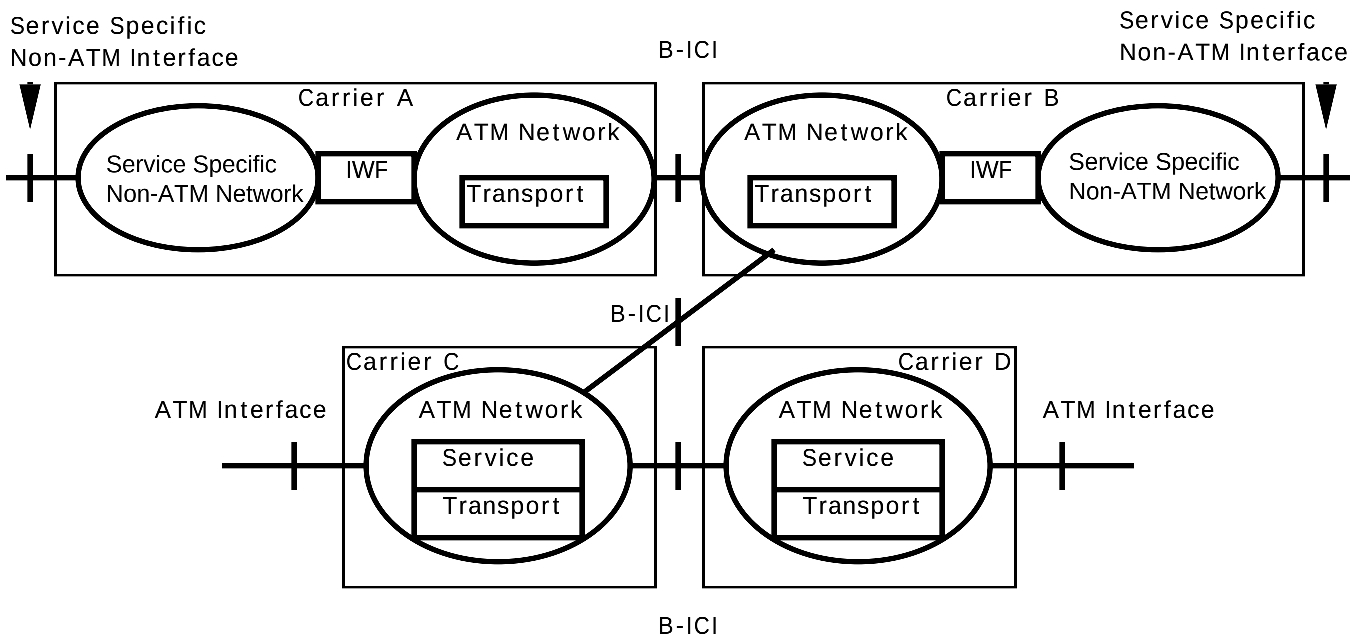


Figure 2.3 An Example of a Multi-Carrier Network Configuration

Figure 2.3 shows an example of a generic multi-carrier network configuration which includes B-ICIs, service specific (non-ATM) and ATM access interfaces, service specific (non-ATM) and ATM networks, and network Inter-Working Functions (IWF).

Figure 2.3 shows three different configurations for the B-ICI:

(1) In the first case, the B-ICI between Carrier A and Carrier B interconnects two ATM networks which provide transport between two service specific non-ATM networks. In this configuration, the ATM network in Carrier A may also represent an ATM Link. In that case, the ATM IWF must support the B-ICI.

(2) In the second case, the B-ICI between Carrier C and Carrier D interconnects two ATM networks which provide transport and service specific functions.

(3) In the third case, the B-ICI between Carrier B and Carrier C interconnects two ATM networks. One providing transport service for a service specific non-ATM network, and the other providing transport and service specific functions."

2.5 Relation of the B-ICI to Other Interfaces

Figure 2.4 shows a B-ICI in relation to other interfaces supporting inter-carrier service offerings of the carriers A and B. On the trunk side, FRS and SMDS specific non-ATM interfaces - FRS NNI and SMDS ICI, respectively, and multi-service ATM-based B-ICI are shown. This document specifies an ATM-based multi-service B-ICI. The FRS NNI and SMDS ICI are beyond the scope of this document.

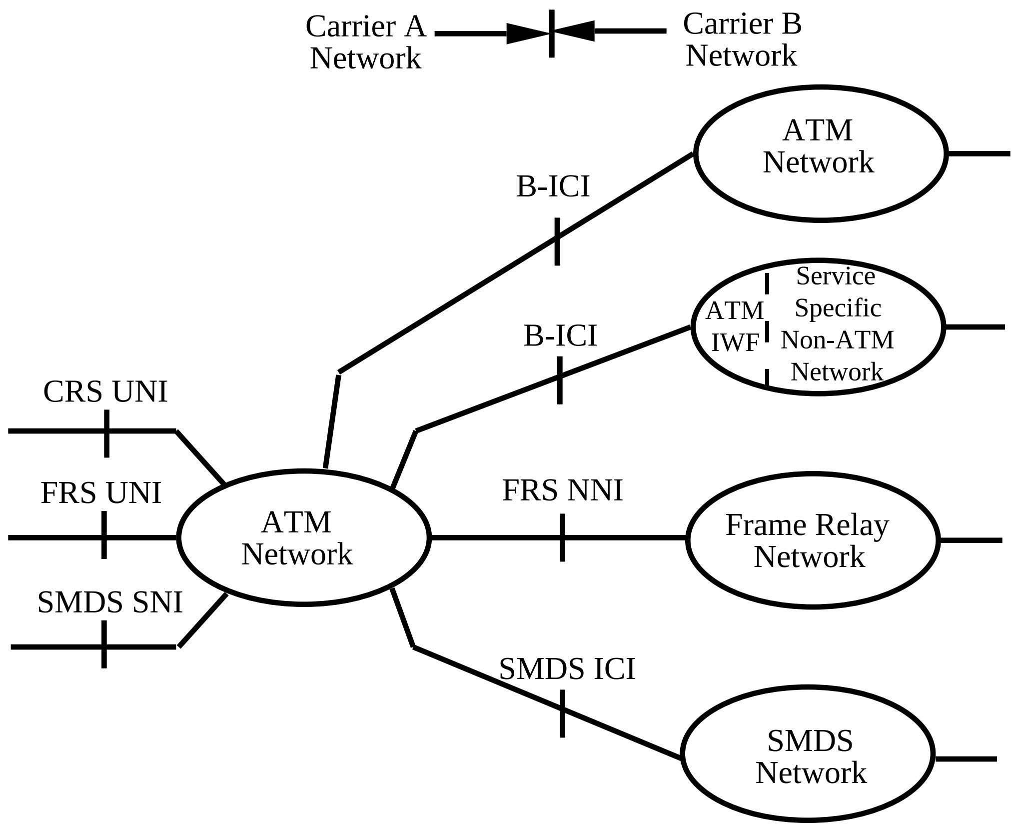


Figure 2.4 Interfaces Supporting Inter-Carrier Service Offerings

2.6 Multi-Service Aspects of the B-ICI

A multi-service B-ICI allows the transfer of cell structured information to support inter-carrier services for end-users utilizing CRS, CES, FRS, or SMDS. End-user traffic is accepted by the serving carrier in the form of ATM cells, DSn frames, FRS frames, or SMDS L3_PDUs, and when necessary, converted into a standard 53-octet ATM cell format for transmission over DS3/SONET and E3/SDH trunks to another carrier. The conversion will be transparent to the end-user. No conversion is required for the CRS end-users accessing the ATM network, since the end-user traffic is already in the ATM cell format. A multi-service concept applicable to the B-ICI is illustrated in Figure 2.5.

The end-user service characteristics and features for each of these services should be preserved across the B-ICI. End-users will negotiate with carriers for particular performance parameters and QOS, and these parameters and QOS should be preserved across the B-ICI.

A B-ICI supports an inter-carrier multi-service interface between carriers transporting:

1. CRS ATM cells over PVCs;

2. CES DSn frames encapsulated in AAL Type 1 PDUs;

3. FRS frames and functions encapsulated in AAL Type 5 and/or mapped to ATM cells;

4. SMDS Interface Protocol (SIP) L3_PDUs or SIP CLS_PDUs encapsulated in Inter Carrier Interface Protocol (ICIP) Connectionless Service (ICIP_CLS) PDUs and AAL Type 3/4, and/or mapped to ATM cells.

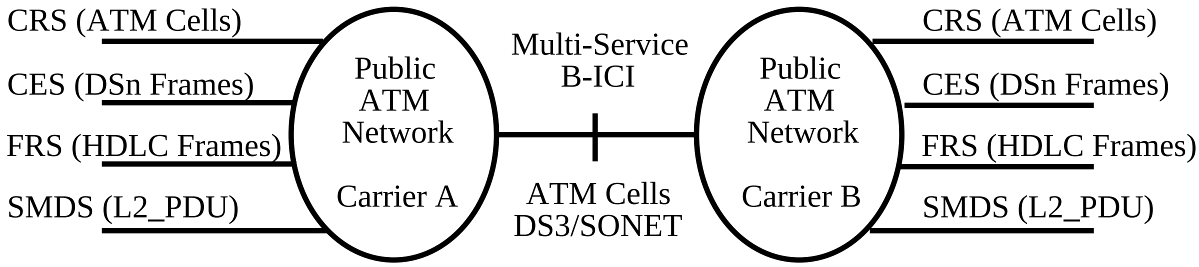


Figure 2.5 Multi-Service B-ICI

These ATM cells are multiplexed together and passed to another carrier over DS3/E3, or SONET/SDH facilities. The B-ICI supports multiple services by the ATM network establishing one or more Virtual Path Connections (VPC) or Virtual Channel Connections (VCC) via bilateral agreement from a set of available VPI/VCI values supported on the interface.

(R) 2-2 A multi-service B-ICI shall be capable to support one service, or any combination of the inter-carrier services (i.e., CRS, CES, FRS, SMDS) to meet the traffic needs.

Details of supporting inter-carrier services (i.e., CRS, CES, FRS, SMDS) are provided in Sections 8 through 11 of this document.

Channel bandwidth may be assigned based on the traffic contracts for the CRS, Committed Information Rate (CIR) and Excess Information Rate (EIR) for the FRS, and access class for the SMDS. No dynamic bandwidth allocation will occur in the initial service.

Either traffic and/or usage measurements may be conducted at both the sides of the B-ICI. These include the following:

- End-user cells corresponding to CRS, CES, FRS frames, or SMDS packets metered;
- Cells transported from one carrier to another carrier metered;
- Time-of-day usage patterns, burstiness, etc. recorded.

Details of the B-ICI usage measurements are for further study.

In Figure 2.6, a B-ICI is shown connecting a source Carrier A and a destination Carrier C. Multiple inter-carrier services are supported by a B-ICI. At the B-ICI, different sets of VPC/VCC (not necessarily contiguous) are assigned for the transfer of traffic related to different inter-carrier services according to the following *guidelines:*

1. CRS requires some relation between a B-ICI VPC and a UNI VPC. CRS VCCs should be translated to unique VCCs on the B-ICI by bilateral agreement (for example, to account for the "collisions" on VPI/VCI usage that are likely to occur on the CRS UNIs).

2. CES (DS1/DS3 frames) requires some relation between a B-ICI VPC and a UNI VPC. CES VCCs should be translated to unique VCCs on the B-ICI by a bilateral agreement (for example, to account for the "collisions" on VPI/VCI usage that are likely to occur on the CES UNIs).

3. FRS frames may be encapsulated in AAL Type 5, where the DLCI would be carried from end-to-end. If the FRS frames are encapsulated, then a set of VPCs may be appropriate. FRS frames may be mapped to the ATM layer, where the DLCI is translated to a VPI/VCI. If the FRS frames are mapped, then a set of VCCs may be appropriate.

4. SMDS SIP L3_PDUs or SIP CLS_PDUs may be encapsulated in ICIP_CLS_PDUs and AAL Type 3/4, or SMDS L2_PDUs may be mapped to specific VPC or VCC values for delivery to the destination carrier's network. Depending on how and whether SMDS is mapped or encapsulated, a set of VPCs or VCCs may be appropriate.

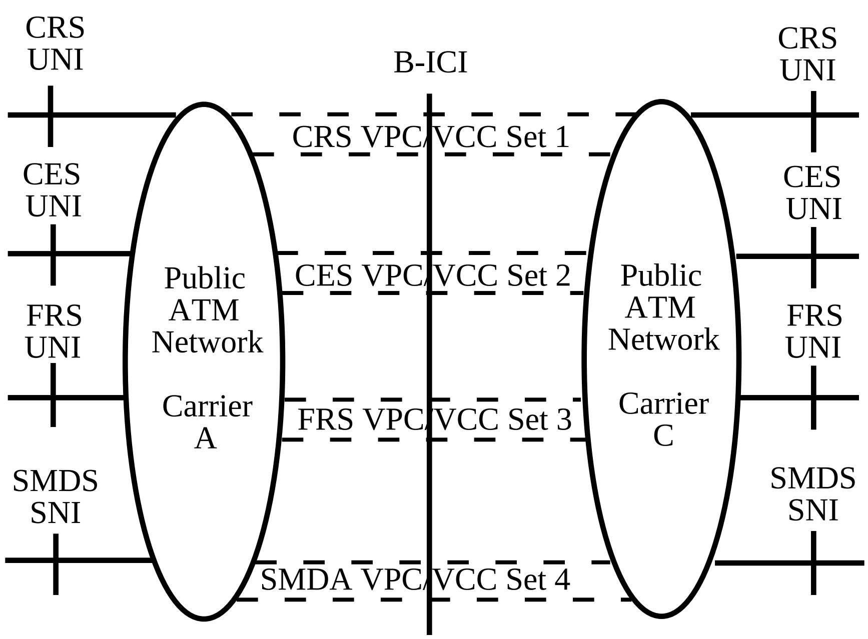


Figure 2.6 Multi-Service B-ICI Supporting Inter-Carrier Services (Example 1)

The appropriate process undertaken by the Carrier A from a source user access interface to the B-ICI for delivery to Carrier C for eventual delivery to the destination user access interface are considered in later sections.

As appropriate, Network Parameter Control (NPC) may be done on a VPC and/or VCC basis. The NPC is further discussed in later sections.

Depending on the bandwidth associated with each VPC/VCC and the service bandwidth, multiple VPCs/VCCs may carry the same service types.

Mixing of ATM cells corresponding to different service types on the same VP should be studied, in particular, for relatively lower bandwidth services.

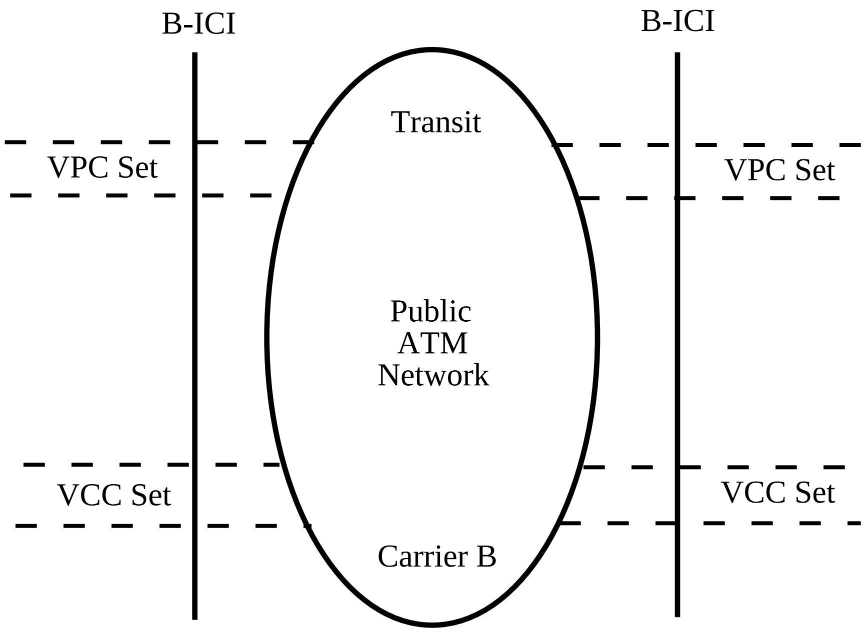


Figure 2.7 Multi-Service B-ICI Supporting Inter-Carrier Services (Example 2)

In Figure 2.7, a transit carrier B is shown as supporting multiple inter-carrier services via the B-ICIs. In this role, the Carrier B relays services from one B-ICI to another B-ICI. The various sets of VPC/VCC used across the B-ICI for different inter-carrier services may be assigned by a bilateral agreement between the carriers.

In Figures 2.6 and 2.7, the specific VCI/VPI value assigned is, in general, independent of the service provided over that VCC/VPC in accordance with the CCITT Recommendations I.150 and I.361. To guarantee the uniqueness of the VPI/VCI values across the B-ICI, and in the transit/destination ATM network, a translation of VPI/VCI is applied at the B-ICI.

Figure 2.8 illustrates an example of VPC/VCC grooming by the destination Carriers. In this example, Carrier B is grooming VPCs/VCCs originating from the Carrier A's network and going to the destination Carrier C's network and/or Carrier D's network.

2.7 Network Interworking Functions and the Multi-Service B-ICI

An example of a functional network architecture illustrating B-ICI functions is shown in Figure 2.9. The multi-service B-ICI functions include both common functions (e.g., Physical Layer, ATM Layer) and the service-specific functions (e.g., AAL).

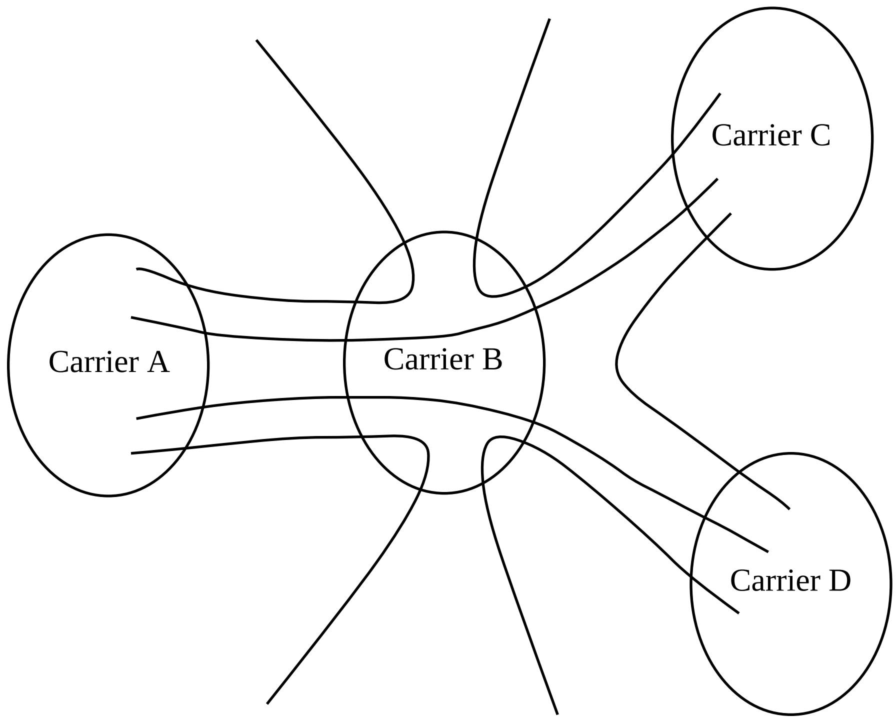


Figure 2.8 An Example Of VPCs/VCCs Grooming by the Destination Carrier

Furthermore, for connecting a CES DSn interface to an ATM network, for connecting a FRS network to an ATM network, and for connecting a SMDS network to an ATM network, network interworking functions need to be defined. Some of the network interworking functions may also relate to service interworking which is not considered within the scope of the B-ICI specification.

The impact of the B-ICI related service specific network interworking functions on the multi-service B-ICI specification, and the related Requirements/Options are covered in later sections.

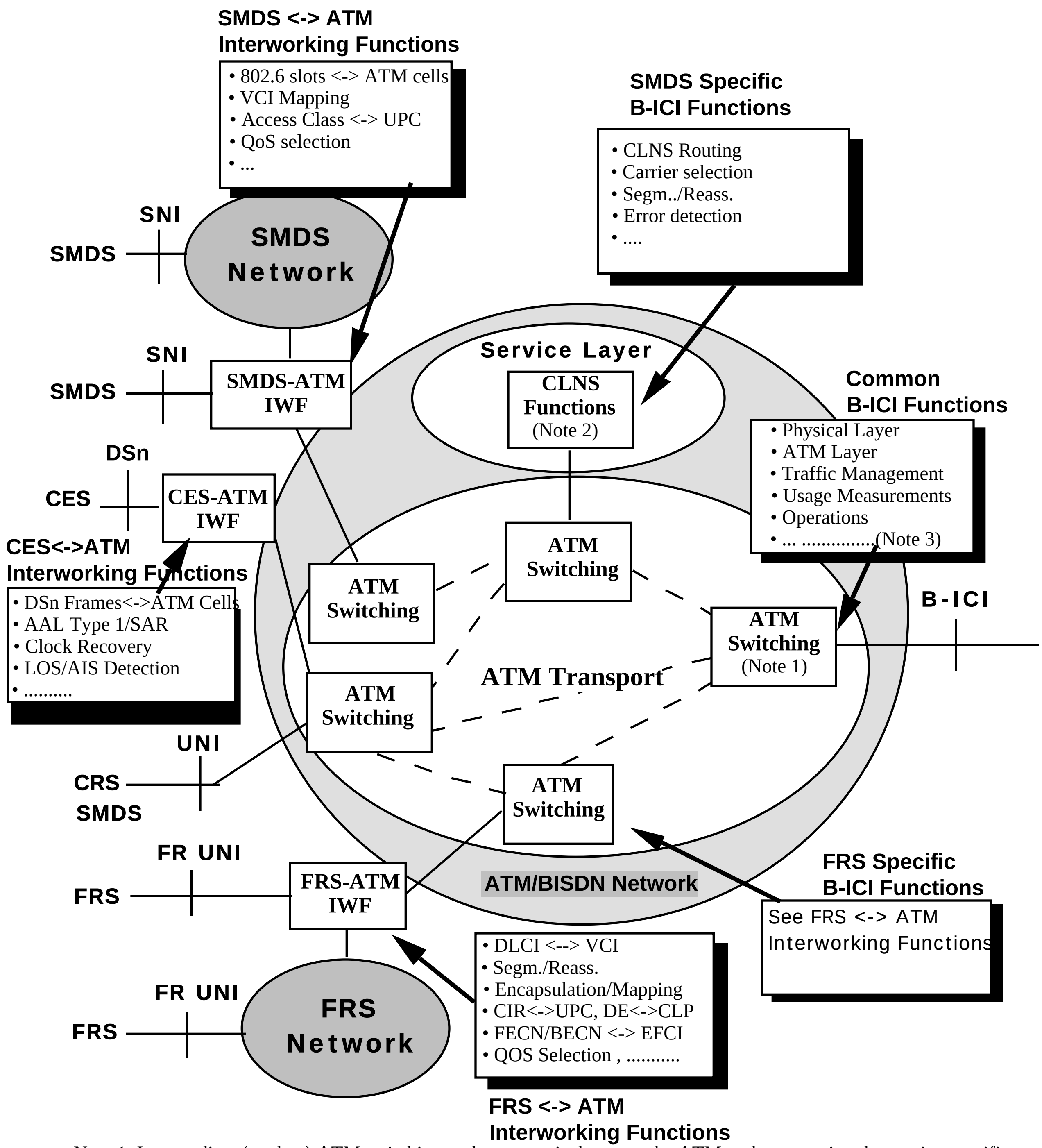
Note 1: Intermediate (tandem) ATM switching nodes may exist between the ATM node supporting the service specific functions and the B-ICI physical location.

Note 2: Service specific function(s) associated with interfaces (e.g., B-ICI, SNI) may be located on a single node.

Note 3: The initial set of functions will meet the requirements of PVC-based services and SMDS. Additional C-Plane functions will be required for supporting SVC-based services.

Note 4: The list of interworking functions identified in Figure 2.9 does not imply any physical location.

Note 5: The B-ICI in Figure 2.9 still applies when the users access the network through a multi-service ATM-based UNI.



Note 1: Intermediate (tandem) ATM switching nodes may exist between the ATM node supporting the service specific functions and the B-ICI physical location.

Note 2: Service-specific function associated with many interfaces (e.g., UNI, B-ICI) may be concentrated on a singl node.

Note 3: The initial set of functions will meet the requirements of PVC-based services and SMDS. Additional C-Plane functions will be required for supporting SVC-based services.

Figure 2.9 Multi-Service B-ICI and the Network Interworking Functions

3. B-ICI Physical Layer Specifications

This section provides media, rates, and formats for the B-ICI. The U-plane is specified in this section, and the M-plane is specified in a later section.

This section specifies B-ICI physical layer requirements. These requirements are closely aligned with existing BISDN UNI requirements and are consistent with the NNI requirements. The term NNI originated in CCITT and referred to Synchronous Digital Hierarchy (SDH) frame formats and related recommendations. By adopting this term for use in BISDN requirements, it should be noted that its meaning has been expanded to include non-SONET interfaces such as DS3.

The physical layer characteristics at the B-ICI depend on implementation specific details of the actual inter-carrier circuit connection. As examples, the B-ICI may be realized as an optical mid-span meet, or as an electrical or short-reach optical interface. The B-ICI signal at the physical carrier-to-carrier demarcation point may be realized as an embedded tributary of a higher rate, multiplexed signal. These possibilities impact such physical layer issues as protection switching and control communications. Whenever appropriate, related aspects are incorporated into the following specifications.

3.1 Signal Formats at the B-ICI

The logical frame structure at the B-ICI can take several forms depending on traffic rate experienced and on whether the interface allows the transport of multiplexed signals. The SONET STS-3c and STS-12c frame structures are focused in this document.

In addition, during the early stages of the B-ICI deployment, DS3 frame structure is also considered, and is specified in this document.

3.2 Physical Layer Characteristics of the 155.520 Mbit/s STS-3c B-ICI

The B-ICI at 155.520 Mbit/s is SONET-based and utilizes the concatenated STS-3 payload structure (STS-3c).

3.2.1 Bit Rate

(R) 3-1 The bit rate of the line signal shall be nominally 155.520 Mbit/s. (Also see (R) 3-14).

(R) 3-2 The bit rate available for user information cells, signaling cells and ATM layer OAM cells, excluding Physical Layer related OAM information transported in overhead bytes shall be nominally 149.760 Mbit/s.

149.760 Mbit/s is equivalent to the STS-3c Synchronous Payload Envelope (SPE) information bandwidth (i.e., the total STS-3c SPE bandwidth minus the bandwidth portion allocated to POH).

3.2.2 Signal Format

(R) 3-3 The 155.520 Mbit/s B-ICI shall utilize the SONET STS-3c frame structure as specified in ANSI-T1.105[4].

3.2.2.1 Framing Information

(R) 3-4 Framing information shall be contained in the A1 and A2 bytes.

(R) 3-5 Equipment on either side of the B-ICI shall meet the requirements for -
• Going from an in-frame condition to an out-of-frame condition, and
• Going from an out-of-frame condition to an in-frame condition as specified in TR-NWT-000253[5].

3.2.2.2 Overhead Bytes Active Across the B-ICI

The overhead bytes applicable at the B-ICI are specific to the implementation details of the physical inter-carrier circuit connection. To maintain flexibility while still allowing specific requirements on overhead activation and functionality, the diagram of Figure 3.1 is introduced. In this Figure, the points are identified where B-ICI characteristics are relevant. They are labeled B-ICI, B-ICI', B-ICI" and are explained below in detail.

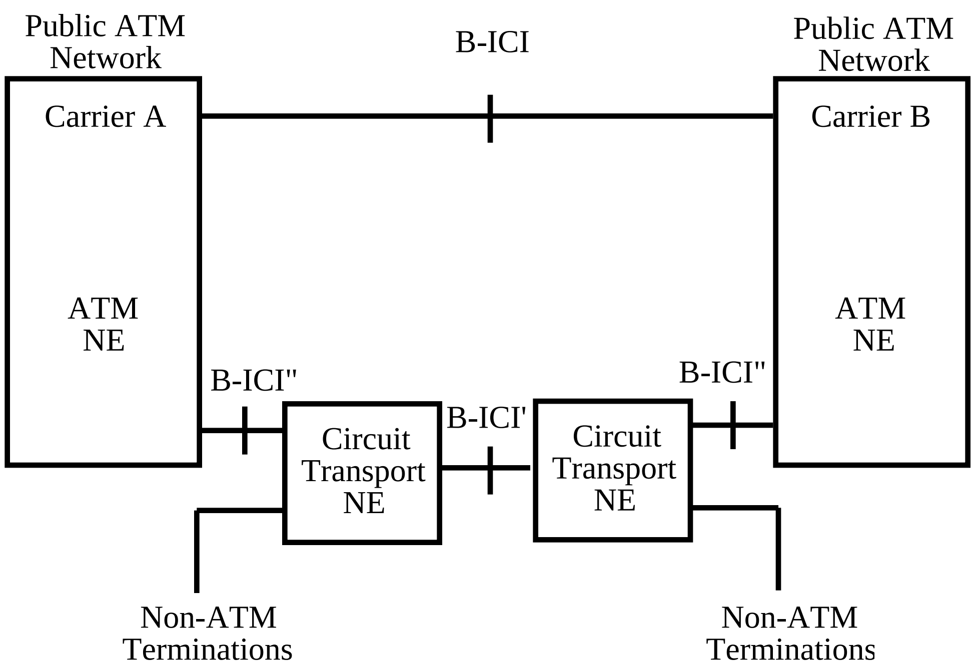


Figure 3.1 Physical Realization of the B-ICI

In Figure 3.1, the B-ICI is defined as the logical interface between two carrier's public ATM networks. The B-ICI is physically realized in three types of interconnection:

B-ICI: A direct inter-office interconnection between two ATM Network Elements (NEs) belonging to different network operators (e.g., OC-3 interconnection with STS-3c structure).

B-ICI corresponds to the physical realization of a 155.520 Mbit/s SONET interface at the carrier boundary (the demarcation point between two carriers). As such, specific requirements are specified below and take into account the various arrangements under which the B-ICI is realized (e.g., intra-office versus inter-office).

B-ICI': An interconnection that is part of a multiplexed inter-office interconnection between two transport NEs (e.g., multiplexer or cross-connect) belonging to different network operators (e.g., an STS-3c in a OC-12 signal).

The interpretation of B-ICI' corresponds to realizations of inter-carrier circuit connections involving intermediate transport systems (e.g., a multiplex system). In this case, there exists an underlying logical channel, or a tributary that traverses the carrier boundary. Although the section and line level functionality at the carrier boundary is dictated by the specific transport system and is, consequently, by arrangements beyond the scope of this document, the path level overhead activation for B-ICI' is preserved and must be specified.

B-ICI'': An interconnection (usually intra-office) between the transport NE and the ATM NE. Both of these NEs typically belong to the same network operator, and in this sense the B-ICI" is a reflection of the B-ICI' on the ATM NE (e.g., STS-3c interconnection).

Also, important in the overall carrier-to-carrier interconnection is the physical realization of the logical B-ICI' channel within each carrier's network and likely at the ATM switching system interface. This physical interface is labeled B-ICI''. Although this interface occurs within a carrier's network, its characteristics directly impact the overall interconnection and B-ICI', as described above. Therefore, specific information and guidance is provided here so that ATM switch trunk side interface design can proceed in a consistent and standard manner.

In all the above realizations, the following requirement applies:

(R) 3-6 The overhead bytes active across the B-ICI (including B-ICI' and B-ICI" as described above) shall be consistent with the specifications given in ANSI-T1.105[4]. [Note: Except for some differences between ANSI T1.105 and B-ICI specification, for example, Path RDI (Remote Defect Indicator), Line FEBE].

A summary of the SONET overhead bytes and their requirement status is provided in Table 3.1.

In User Channels (F1 and F2), "user" refers to the network operator. This channel is reserved for use by an individual carrier. Therefore, this channel is not activated across administrative boundaries as it would be then subject to use by multiple users, inconsistent with the intent of the SONET specifications.

3.2.3 Powering Arrangements

(R) 3-7 Power shall not be provided across the B-ICI.

3.2.4 HEC Generation and HEC Check

(R) 3-8 The HEC generation and error checking functions (specified in Section 3.5) shall be implemented for the 155.520 Mbit/s SONET STS-3c based B-ICI.

Table 3.1 B-ICI SONET Physical Layer Overhead Requirements

Function	Signal	B-ICI"	B-ICI'	B-ICI
Section Overhead*				
Framing	A1, A2	R	&	R
Error Monitoring	B1	R @	&	R
Data Communication	D1-D3	NA	&	#
STS ID	C1	R	&	R
Order Wire	E1	NA	&	O
User Channel	F1	NA	NA	NA
Line Overhead*				
Error Monitoring	B2	R	&	R
Data Communication	D4-D12	O	&	O
Order Wire	E2	NA	&	O
SPE Pointer	H1-H3	R	&	R
Path AIS	H1, H2	R	&	R
APS	K1, K2	O	&	O
Line AIS	K2 (6-8)	R @	&	R
Line RDI (FERF)	K2 (6-8)	R	&	R
Line FEBE	3 Z2 (1-8)	R	&	R
Sync. Messages	Z1	O	&	O
Path Overhead*				
Trace	J1	O	O	O
Error Monitoring	B3	R	R	R
Signal Label	C2	R	R	R
Path FEBE	G1 (1-4)	R	R	R
Path RDI (FERF)	G1 (5)	R	R	R
User Channel	F2	O	NA	NA

R = Required, NA = Not Activated, O = Optional; * = All other overheads of the layer are NA; # = STEs and LTEs in an application requiring communications over the SONET interfaces shall support the Section DCC; & = As dictated by the multiplex/transport system; @ = Not applicable for interconnection without regenerators.

3.2.5 Cell Payload Scrambler

(R) 3-9 The cell payload (self-synchronous) scrambler (specified in Section 3.5) shall be implemented for the 155.520 Mbit/s SONET STS-3c based B-ICI.

3.2.6 Cell Mapping and Delineation

The mapping of ATM cells is performed by aligning by row the byte structure of every cell with the byte structure of the SONET STS-3c payload capacity (i.e., Synchronous Payload Envelope less POH). The entire STS-3c payload capacity is filled with cells, yielding a transfer capacity for ATM cells of 149.760 Mbit/s. Because the STS-3c payload capacity is not an integer multiple of the cell length, a cell may be mapped across a SPE boundary.

(R) 3-10 Equipment supporting a B-ICI shall map ATM cells into the SONET STS-3c signal as specified in ANSI T1.624[6] and ANSI T1.105[4] (see also CCITT Recommendation I.432[7] and G.709[2]).

(R) 3-11 The cell delineation functions (specified in Section 3.5) shall be implemented for the 155.520 Mbit/s B-ICI.

(R) 3-12 For the 155.520 Mbit/s B-ICI, the time to declare Sync state (specified in Section 3.5) shall be less than 150 micro-seconds. This requirement pertains to an in-frame SONET condition and supplements the re-frame requirements given earlier to specify total time from out-of-frame to cell delineation.

3.2.7 PMD Characteristics of the 155.520 Mbit/s STS-3c B-ICI

(R) 3-13 The B-ICI shall meet the PMD specifications given in TR-NWT-000253 for either the short-reach, intermediate-reach or long-reach optical OC-3 or the electrical STSX-3 application. The choice of interface parameter set is application specific.

3.2.8 Synchronization, Timing and Jitter

3.2.8.1 Synchronization and Timing

(R) 3-14 In normal operation, the signal at the B-ICI shall be synchronized by a source traceable to a Primary Reference Source (PRS, or Stratum 1 clock) as described in ANSI T1.101[8] When the system is not synchronized (e.g., free running mode), a failure sync condition exists, and shall be rectified according to a bilateral agreement.

3.2.8.2 Jitter

(R) 3-15 At the B-ICI, the network output jitter limits specified in ANSI T1X1/LB-93-03[9] shall apply.

3.2.9 Connectors

(R) 3-16 Optical connectors shall meet the performance criteria specified in Bellcore's TR-NWT-000326.[10]

The selection of a particular connector type for application at the B-ICI is a matter for bilateral agreement.

3.3 Physical Layer Characteristics of the 622.080 Mbit/s STS-12c B-ICI

The B-ICI at 622.080 Mbit/s is SONET-based and utilizes the concatenated STS-12 payload structure (STS-12c).

3.3.1 Bit Rate

(R) 3-17 The bit rate of the line signal shall be nominally 622.080 Mbit/s. (Also see (R) 3-30).

(R) 3-18 The bit rate available for user information cells, signaling cells and ATM layer OAM cells, excluding Physical Layer related OAM information transported in overhead bytes shall be nominally 599.040 Mbit/s.

599.040 Mbit/s is equivalent to STS-12c Synchronous Payload Envelope (SPE) information bandwidth (i.e., total STS-12c SPE bandwidth minus the bandwidth portion allocated to POH).

3.3.2 Signal Format

(R) 3-19 The 622.080 Mbit/s B-ICI shall utilize the SONET STS-12c frame structure specified in ANSI T1.624[6].

3.3.2.1 Framing Information

(R) 3-20 Framing information shall be contained in the A1 and A2 bytes.

(R) 3-21 Equipment on either side of the B-ICI shall meet the requirements for:
• Going from an in-frame condition to an out-of-frame condition, and
• Going from an out-of-frame condition to an in-frame condition as specified in TR-NWT-000253[5].

3.3.2.2 Overhead Bytes Active Across the B-ICI

See Section 3.2.2.2.

(R) 3-22 The overhead bytes active across the B-ICI (including B-ICI' and B-ICI" as described in Section 3.2.2.2) shall be consistent with the specifications given in ANSI T1.105[4]. [Note: Except for some differences between ANSI T1.105 and B-ICI specification, for example, Path RDI, Line FEBE].

3.3.3 Powering Arrangements

(R) 3-23 Power shall not be provided across the 622.080 Mbit/s B-ICI.

3.3.4 HEC Generation and HEC Check

(R) 3-24 The HEC generation and error checking functions (specified in Section 3.5) shall be implemented for the 622.080 Mbit/s SONET STS-12c based B-ICI.

3.3.5 Cell Payload Scrambler

(R) 3-25 The cell payload (self-synchronous) scrambler (specified in Section 3.5) shall be implemented for the 622.080 Mbit/s SONET STS-12c based B-ICI.

3.3.6 Cell Mapping and Delineation

The mapping of ATM cells is performed by aligning by row the byte structure of every cell with the byte structure of the SONET STS-12c payload capacity (i.e., Synchronous Payload Envelope less POH). The entire STS-12c payload capacity is filled with cells, yielding a transfer capacity for ATM cells of 599.040 Mbit/s. Because the STS-12c payload capacity is not an integer multiple of the cell length, a cell may be mapped across a SPE boundary.

(R) 3-26 Equipment supporting a B-ICI shall map ATM cells into the SONET STS-12c signal as specified in ANSI T1.624[6] and ANSI T1.105[4] (see also CCITT Recommendation I.432[7] and G.709[2]).

(R) 3-27 The cell delineation functions (specified in Section 3.5) shall be implemented for the 622.080 Mbit/s B-ICI.

(R) 3-28 For the 622.080 Mbit/s B-ICI, the time to declare Sync state (defined in Section 3.5) shall be less than 150 micro-seconds. This requirement pertains to an in-frame SONET condition and supplements the re-frame requirements given earlier to specify total time from out-of-frame to cell delineation.

3.3.7 PMD Characteristics of the 622.080 Mbit/s STS-12c B-ICI

(R) 3-29 The B-ICI shall meet the PMD specifications given in TR-NWT-000253 for either the short-reach, intermediate-reach or long-reach optical OC-12 application. The choice of interface parameter set is application specific.

3.3.8 Synchronization, Timing and Jitter

3.3.8.1 Synchronization and Timing

(R) 3-30 In normal operation, the signal at the B-ICI shall be synchronized by a source traceable to a PRS (Stratum 1 clock) as described in ANSI T1.101[8]. When the system is not synchronized (e.g., free running mode) a failure sync condition exists, and shall be rectified according to a bilateral agreement.

3.3.8.2 Jitter

(R) 3-31 At the B-ICI, the network output jitter limits specified in ANSI T1X1/LB-93-03[9] shall apply.

3.3.9 Connectors

(R) 3-32 Optical connectors shall meet the performance criteria specified in Bellcore's TR-NWT-000326[10].

The selection of a particular connector type for application at the B-ICI is a matter for bilateral agreement.

3.4 Physical Layer Characteristics of the 44.736 Mbit/s (DS3) B-ICI

(R) 3-33 The Physical Layer Convergence Procedure (PLCP)-based ATM mapping format shall be used for the 44.736 Mbit/s (DS3) B-ICI.

This approach is similar to the specification for the DS3 ATM UNI, and uses an embedded PLCP frame. This makes use of the DS3 multiframe format with C-bit parity application. The physical layer specification for the PLCP-based ATM mapping follows.

3.4.1 PLCP-Based ATM Mapping

3.4.1.1 Bit Rate

(R) 3-34 The bit rate at the B-ICI shall be 44.736 Mbit/s ± 20 PPM.

(R) 3-35 The transfer capacity available for the transport of ATM cells in the DS3 PLCP-based format shall be nominally 40.704 Mbit/s.

3.4.1.2 Frame Structure

The basic frame structure at 44,736 kbit/s is partitioned into M (multi)-frames of 4760 bits each. The M frames are divided into seven M-subframes having 680 bits each. Each M-subframe is further divided into 8 blocks of 85 bits with 84 of the 85 bits available for payload and one bit is used for frame overhead. The DS3 Multi Frame structure[11] is shown in Figure 3.2.

Frame Overhead: There are 56 overhead bits per multiframe. They are divided into M frame alignment channels (M1, M2 and M3), M subframe channels (F1, F2, F3 and F4), a P-bit channel (P1 and P2), X-bit channel (X1 and X2), and the C-bit channel (the Cxy bits). The DS3 basic frame possesses the following characteristics:

— Length of M frame = 4760 bits (4704 information bits + 56 overhead bits)

— Total bit rate = 44,736 kbit/s

— Repetition frequency = $\frac{44,736}{4760}$ = 9.3983193 kHz = 106.402 micro-seconds

◄— — — — — — — — — — 680 Bits — — — — — — — — — — ►

85 Bits	85 Bits	85 Bits	85 Bits	85 Bits	85 Bits	85 Bits	85 Bits
X1 [84]	F1[84]	C1 [84]	F2 [84]	C2 [84]	F3 [84]	C3 [84]	F4 [84]
X2 [84]	F1[84]	C4 [84]	F2 [84]	C5 [84]	F3 [84]	C6 [84]	F4 [84]
P1 [84]	F1[84]	C7 [84]	F2 [84]	C8 [84]	F3 [84]	C9 [84]	F4 [84]
P2 [84]	F1[84]	C10 [84]	F2 [84]	C11 [84]	F3 [84]	C12 [84]	F4 [84]
M1 [84]	F1[84]	C13 [84]	F2 [84]	C14 [84]	F3 [84]	C15 [84]	F4 [84]
M2 [84]	F1[84]	C16 [84]	F2 [84]	C17 [84]	F3 [84]	C18 [84]	F4 [84]
M3 [84]	F1[84]	C19 [84]	F2 [84]	C20 [84]	F3 [84]	C21 [84]	F4 [84]

2X bits: indicate received errored multi-frames to the remote end in case of LOS or LOF
2P bits: provide section performance monitoring information
3M bits: indicate the location of M-subframes in a M-frame (M1= 0, M2=1, M3=0)
28F bits: identify the overhead bit positions in Multi-subframe (F1=1, F2=0, F3=0, F4=1)
21C bits: used for the C-bit parity application

4704 Information bits

Figure 3.2 DS3 Multi-Frame Structure

3.4.1.3 C-Bit Channel Definition

The DS3-based B-ICI is defined to use the C-bit parity format. This format has 21 bits per DS3 frame that is referred to as the C-bit channel. Within the C-bit channel there are a number of functions. The bit functions and uses are defined below[11]:

• C1 - Application Identification Channel

(R) 3-36 For the C-bit parity application, this bit shall be set to "1" at the transmitter and verified at the receiver.

Note: If C1 is received as "0", at a minimum, a report to an Operations System (OS) should be made.

• C2 - Network Requirement Bit

(R) 3-37 This bit shall be set to "1" at the transmitter and ignored at the receiver.

• C3 - Far End Alarm and Control Channel

The FEAC channel has two parts: (i) alarm/status channel, and (ii) command (or control) channel. The FEAC support is desirable.

(O) 3-1 The FEAC channel implementation should support seven (7) alarm/status messages. The Alarms/Status Conditions and associated Codewords are given in Table 3.2.

Table 3.2 FEAC Alarm/Status Conditions and Codewords

Alarm/Status Conditions	Codeword
DS3 Equipment Failure (SA)	0011001011111111
DS3 LOS	0001110011111111
DS3 Out-Of-Frame	0000000011111111
DS3 AIS Received	0010110011111111
DS3 IDLE Received	0011010011111111
DS3 Equipment Failure (NSA)	0001111011111111
Common Equipment Failure (NSA)	0011101011111111

SA = Service Affecting; NSA = Not Service Affecting; LOS = Loss Of Signal

(O) 3-2 The three (3) FEAC Command Functions and Codewords applicable for the B-ICI are listed in Table 3.3, and should be supported if there is a bilateral agreement between the carriers.

Table 3.3 FEAC Command Functions and Codewords

Command Function	Codeword
Line Loopback Activate	0000111 0 11111111
Line Loopback Deactivate	0011100 0 11111111
DS3 Line	0011011 0 11111111

Note 1 - The rightmost bit of each Codeword shall be transmitted first.
Note 2 : All other codewords are to be ignored.

• C4-C6 - Not Used
These bits are not used and should be set to "1" by the transmitter and ignored by the receiver.

• C7-C9 - CP-bit

(R) 3-38 These bits are used to indicate the parity of the DS3 payload. They shall be set by the transmitter the same as the P-Bits and compared to the recalculated parity by the receiver according to the procedures specified in T1.107a[11]. If an error is detected, it is indicated with the FEBE (C10-C12).

• C10-C12 - FEBE Function

(R) 3-39 These bits are used to indicate the received Far End Block Errors of the DS3 payload. They shall be set by the transmitter whenever an error is detected by the receiver in the CP-Bits, according to the procedures specified in T1.107a[11]. The receiver should count the number of received FEBEs.

• C13-C15 - Terminal-to-Terminal Path Maintenance Data Link

(O) 3-3 These bits are for a terminal-to-terminal path maintenance data link and are optional. If used, this function should comply to the ANSI T1.107a[11] definition.

• C16-C18 - Not Used
These bits are not used and should be set to "1" by the transmitter and ignored by the receiver.

• C19-C21 - Not Used
These bits are not used, and should be set to "1" by the transmitter and ignored by the receiver.

The B-ICI DS3 C-bit parity Requirements are summarized in Table 3.4. Further details on C-bit parity are given in[11].

Table 3.4 B-ICI DS3 C-Bit Parity Requirements

Function	Signal	B-ICI''	B-ICI'	B-ICI
Application ID	C1	R	R	R
Network	C2	R	R	R
FEAC Command	C3	O	O	O
FEAC Control	C3	O	O	O
Error Monitoring	C7, C9	R	R	R
FEBE	C10-C12	R	R	R
Path Data link	C13-C15	O	O	O
Remaining C-bits	C4-C6, C16-C21	NA	NA	NA

R = Required, NA = Not Activated, O = Optional

3.4.1.4 Signal Format

As there is no need to use the stuffing indicator bits (C-bits) for frequency justification (because this is done by the PLCP), the C-bits can be used for other purposes. The use of the freed C-bits is defined in the C-bit parity DS3 standard T1.107a. The B-ICI uses C-bit parity DS3 according to T1.107a, but with one difference. T1.107a[11] specifies that all seven stuff time slots of a DS3 frame shall always be stuffed. This application requires that all stuffing bit locations be used as data bits. This is necessary to allow the PLCP to be nibble-aligned when mapped onto the DS3.

(R) 3-40 The interface format at the physical layer for the B-ICI shall be based on asynchronous DS3 using the C-Bit Parity application as defined in ANSI T1.107a[11]. This unchannelized payload application of C-bit parity DS3 requires that all stuffing bit locations be used as data bits.

(R) 3-41 ATM traffic shall be carried over DS3 44.736 Mbit/s communication facilities by utilizing the PLCP frame This PLCP is a subset of the PLCP defined in IEEE P802.6 and is the same as that used at the User-Network Interface.

Mapping of ATM cells into the DS3 is accomplished by inserting the 53 byte ATM cells into the DS3 PLCP. The PLCP shall then be mapped into the DS3 information payload. Note that the 125 micro-seconds PLCP sub-frame is longer than the 106.4 micro-seconds DS3 frame.

3.4.1.4.1 PLCP Format

The DS3 PLCP consists of a 125 micro-seconds frame within a standard DS3 payload. Note there is no fixed relationship between the DS3 PLCP frame and the DS3 frame, i.e., the DS3 PLCP may begin anywhere inside the DS3 payload. The DS3 PLCP frame consists of 12 rows of ATM cells, each preceded by 4 octets of overhead. Nibble[3] stuffing is required after the twelfth cell to fill the 125 micro-seconds PLCP frame. Although the DS3 PLCP is not aligned to the DS3 framing bits, the octets in the DS3 PLCP frame are nibble aligned to the DS3 payload envelope. Nibbles begin after the control bits (F, X, P, C or M) of the DS3 frame. Octets comprising the DS3 PLCP frame are described below.

(R) 3-42 The following PLCP overhead bytes/nibbles are required to be activated across the B-ICI:

A1 - Frame Alignment

A2 - Frame Alignment

B1 - Bit Interleaved Parity

C1 - Cycle/Stuff Counter

G1 - PLCP Path Status

Px - Path Overhead Identifier

Zx - Growth Octets

Trailer Nibbles

[3] A nibble is 4 bits.

The DS3 PLCP frame is shown in Figure 3.3.

PLCP Framing		**POI**	**POH**	**PLCP Payload**	
A1	A2	P11	Z6	First ATM Cell	
A1	A2	P10	Z5	ATM Cell	
A1	A2	P9	Z4	ATM Cell	
A1	A2	P8	Z3	ATM Cell	
A1	A2	P7	Z2	ATM Cell	
A1	A2	P6	Z1	ATM Cell	
A1	A2	P5	X	ATM Cell	
A1	A2	P4	B1	ATM Cell	
A1	A2	P3	G1	ATM Cell	
A1	A2	P2	X	ATM Cell	
A1	A2	P1	X	ATM Cell	
A1	A2	P0	C1	Twelfth ATM Cell	Trailer
1 Octet	1 Octet	1 Octet	1 Octet	53 Octets	13 or 14 Nibbles

POI = Path Overhead Indicator
POH = Path Overhead
BIP-8 = Bit Interleaved Parity - 8
X = Unassigned - Receiver required to ignore

Figure 3.3 DS3 PLCP Frame (125 micro-seconds)

Framing Octets (A1, A2)

(R) 3-43 The PLCP framing octets shall use the same framing pattern used in SONET. These octets are A1=11110110, A2 = 00101000.

(R) 3-44 Equipment at a B-ICI shall support the PLCP framing requirements described in TR-TSV-000773[12].

Bit Interleaved Parity (BIP)-8 (B1)

(R) 3-45 The BIP-8 (B1) field supports PLCP path error monitoring, and shall be calculated over a 12 x 54 octet structure consisting of the POH field and the associated ATM cells (648 octets) of the previous PLCP frame.

Cycle/Stuff Counter (C1)

The Cycle/Stuff Counter Provides a nibble stuffing opportunity and Trailer length indicator for the PLCP frame.

(R) 3-46 A stuffing opportunity shall occur every third frame of a 3 frame (375 micro-seconds) stuffing cycle. The value of the C1 code shall be used as an indication of the phase of the 375 micro-seconds stuffing opportunity cycle.

PLCP Path Status (G1)

(R) 3-47 The PLCP Path Status shall be allocated to convey the received PLCP status and performance to the transmitting far-end. This octet permits the status of the full receive/transmit PLCP path to be monitored at either end of the path. The G1 octet subfields are as follows: a 4-bit Far End Block Error (FEBE), a 1-bit RAI (Yellow), and 3 X bits (receivers shall be capable of ignoring the value of X bits).

Path Overhead Identifier (P0-P11)

(R) 3-48 The POI bytes shall index the adjacent POH octet of the DS3 PLCP. Table 3.5 provides the coding for each of the POI octets.

Growth Octets (Z1-Z6)

(R) 3-49 The Growth Octets shall be reserved for future use. These octets shall be set to Zi=00000000, by the transmitter (i = 1, 2..., 6). The receiver shall be capable of ignoring the value contained in these fields.

Trailer Nibbles

(R) 3-50 The contents of each of the 13/14 Trailer nibbles shall be 1100.

3.4.1.5 Timing

(R) 3-51 The PLCP frame must have timing traceable to a PRS.

3.4.1.6 HEC Generation and HEC Check

(R) 3-52 The HEC functionality (specified in Section 3.5) shall be supported at the B-ICI.

Table 3.5 POI Code Definitions

POI	POI Code	Associated POH
P11	00101100	Z6

P10	00101001	Z5
P9	00100101	Z4
P8	00100000	Z3
P7	00011100	Z2
P6	00011001	Z1
P5	00010101	X
P4	00010000	B1
P3	00001101	G1
P2	00001000	X
P1	00000100	X
P0	00000001	C1

X - Receiver Ignores

3.4.1.7 Cell Payload Scrambler

For some DS3 physical links, cell scrambling can provide a solution to some transmission equipment's unexpected behavior sensitive to bit patterns in the ATM cell payload (e.g., "101010....", or "000000...." patterns). Another solution to this problem could be to disable alarm monitoring/reporting on transmission equipment. This, however, reduces alarm visibility and fault isolation capability.

(R) 3-53 Equipment supporting DS3 based B-ICI shall implement the cell payload scrambler as described in Section 3.5.3. This scrambler shall have the capability of being enabled or disabled.

(R) 3-54 As a default mode, the cell payload scrambler shall be disabled for the DS3 based B-ICI.

(O) 3-4 As a configurable option, a cell payload scrambler may be enabled for the DS3 based B-ICI.

Note: The use of scrambling/de-scrambling may increase the bit error rate through error multiplication.

3.4.1.8 Cell Delineation

(R) 3-55 The cells are in predetermined locations within the PLCP. Framing on the DS3 and then on the PLCP is sufficient and shall be used to delineate cells at the B-ICI. The PLCP framing requirements can be found in TR-TSV-000773[12].

(R) 3-56 The criteria in TR-TSY-000191[13] defining framing requirements for DS3 signals, shall be met at the B-ICI.

3.4.1.9 Powering Arrangements

(R) 3-57 Power shall not be provided across the B-ICI.

3.4.1.10 PMD Characteristics of the 44.736 Mbit/s B-ICI

(R) 3-58 The B-ICI for the DS3 shall meet the electrical PMD interface characteristics specified in ANSI T1.102.[14]

3.4.1.11 Jitter

(R) 3-59 The maximum output jitter that will appear at the 44.736 Mbit/s B-ICI shall meet the requirements given in TR-NWT-000499.[15]

3.4.1.12 Connector

The selection of a particular connector type for the 44.736 Mbit/s B-ICI is a matter for bilateral agreement.

3.4.2 HEC-Based ATM Mapping

The HEC-based (or, direct) ATM mapping will also be supported. The text to be provided in the next Version of this document.

3.5 HEC Functions and Cell Delineation

3.5.1 HEC-Generation

(R) 3-60 The following procedures[7]shall be performed to generate the HEC (Header Error Control) sequence by each cell originator.

Procedure: The following polynomials are used to specify the HEC value:

$G(x) = x^8 + x^2 + x + 1$

$C(x) = x^6 + x^4 + x^2 + 1$

Where:

G(x) is the generating polynomial, and

C(x) is the coset polynomial.

The HEC value corresponding to a given header shall be obtained by the following procedures:

— The 32 bits of octets 1, 2, 3 and 4 of the header are considered to be the coefficients of a polynomial M(x) of degree 31 (bit 8 of octet 1 of the header corresponds to the x^{31} term and bit 1 of octet 4 of the header corresponds to the x^0 term).

— M(x) shall be multiplied by x^8 and divided (modulo 2) by G(x). C(x) shall be added modulo 2 (exclusive OR) to the remainder of this division producing a polynomial R(x) of degree < 8.

— The coefficients of R(x) are considered to be an 8-bit sequence. This 8-bit sequence is the HEC. The 8 bits of the HEC shall be placed in the HEC field so that the coefficient of the x^7 term is bit 8 and the coefficient of the x^0 term is bit 1.

3.5.2 HEC-Check

The HEC function of the receiver on either side of the B-ICI has two states, Correction state and Detection state.

(R) 3-61 Network equipment supporting a B-ICI shall implement HEC error detection as defined in the CCITT Recommendation I.432[7] and ANSI T1.624[6].

(O) 3-5 Network equipment supporting a B-ICI may also implement single bit error correction in addition to error detection. In this case, the two modes of operation shall interact in accordance to the procedure defined in the CCITT Recommendation I.432[7] and ANSI T1.624[6].

(R) 3-62 In Detection state, all the cells with detected header errors shall be discarded.

The header error analysis process performed by the receiving physical layer equipment is illustrated in Figure 3.4. In Figure 3.4, the following Notes apply:

Note 1: Definition of "valid cell": A cell where the header is declared by the header error control process to be free of errors (CCITT Rec. I.113).

Note 2: An example of an impermissible header is a header whose VPI/VCI is neither allocated to a connection nor pre-assigned to a particular function (idle cell, OAM cell, etc.). In many instances, the ATM layer will decide if the cell header is permissible.

Note 3: A cell is discarded if its header is declared to be invalid; or if the header is declared to be valid and the resulting header is impermissible.

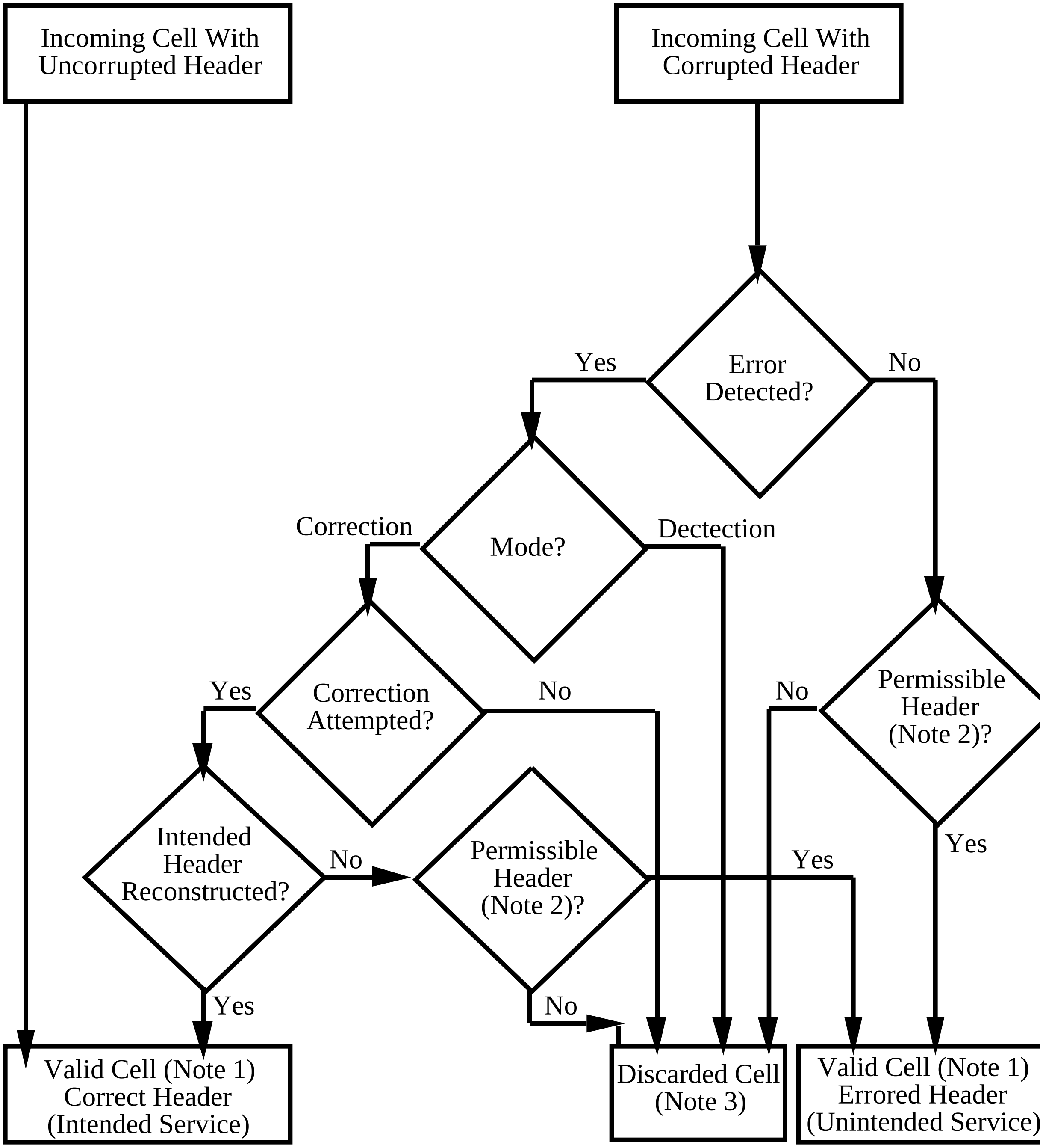


Figure 3.4 Cell Header Error Analysis

3.5.3 Cell Payload Scrambler

The following specifications apply to SONET and DS3 based B-ICIs:

(R) 3-63 A cell payload (self-synchronizing) scrambler, with polynomial $1 + X^{43}$ shall be used to scramble/de-scramble the 48 byte information field of ATM cells.

(R) 3-64 The scrambler shall operate continuously through the stream of ATM cells, bypassing ATM cell headers. Hence, ATM cell headers are not scrambled.

(R) 3-65 The scrambler state at the beginning of a cell payload shall be the state at the end of the previous cell payload.

(R) 3-66 Descrambling shall be disabled during the cell delineation hunt state (described later).

(R) 3-67 During the cell delineation presync and sync states (described later), the scrambler shall be enabled for a number of bits equal to the length of the information field and disabled for the following assumed header.

3.5.4 Cell Delineation

Cell delineation is performed using the HEC byte of the ATM cell header. For the DS3 based B-ICI, however, the ATM cells are explicitly delineated upon PLCP framing.

(R) 3-68 For the SONET-based B-ICIs, the location of cell boundaries within an octet stream shall be obtained by determining the location at which the HEC coding rule is obeyed. This cell delineation process is described by the state diagram shown in Figure 3.5. This process has three states of operation: Sync state, Hunt state, and Presync state. These are described below:

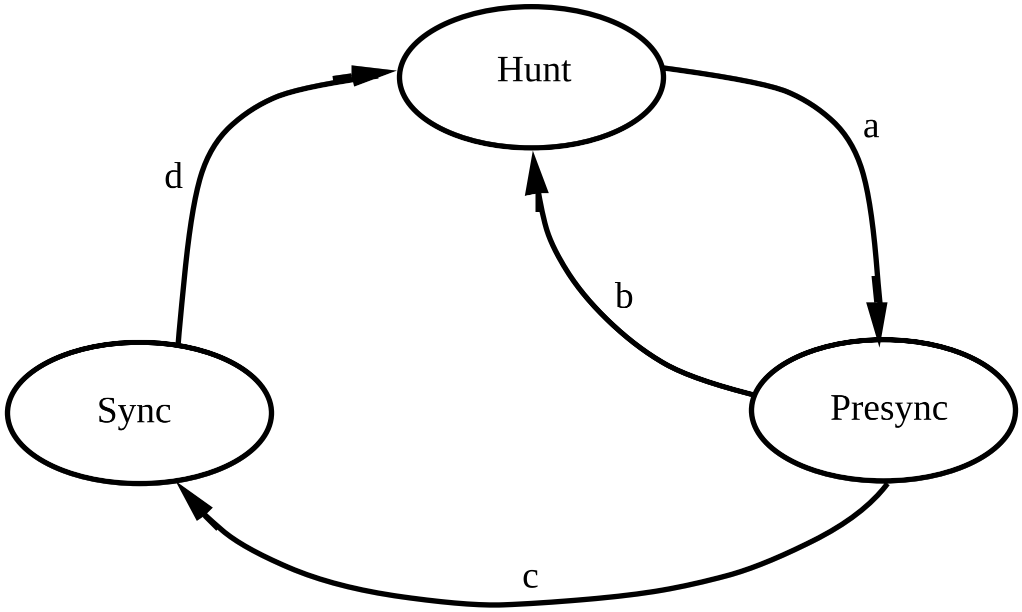
—*Sync State*: In this state, cell boundary is assumed to be correct. The process remains in this state until the HEC coding rule is determined to be incorrect Alpha consecutive times. When this occurs, the process moves to the Hunt state.

—*Hunt State:* In this state, the delineation process is performed by checking whether the HEC coding rule is obeyed for the assumed header field. The first time the HEC coding rule is obeyed, the process passes to the Presync state.

—*Presync State:* In this state, the HEC rule is applied at the next location that a cell header is expected. The process repeats until either:

- The HEC coding rule has been confirmed Delta consecutive times. The process then passes to the Sync state.
- One incorrect HEC is detected. The process then returns to the Hunt state.

Robustness against false misalignment due to bit errors depends on the value of Alpha. Robustness against false delineation in the synchronization process depends on the value of Delta. Suggested values for Alpha and Delta are 7 and 6, respectively.



State Transitions
(a) First Detection of cell boundary
(b) One incorrect HEC
(c) Delta (consecutive) correct HECs
(d) Alpha (consectutive) incorrect HECs

Figure 3.5 Cell Delineation Diagram

3.6 Physical Layer Characteristics of the 34.368 Mbit/s (E3) B-ICI

(R) 3-69 The specification for the 34.368 Mbit/s (E3) physical layer described in G.703 [57] shall comply with: ETSI ETS 300-337 [61] for the electrical characteristics of the physical layer, G.832 [58] for the transport frame format, and G.804 [59] for the mapping of ATM cells to the transport frame.

3.7 Physical Layer Characteristics of the 155.520 Mbit/s (SDH) STM-1 B-ICI

(R) 3-70 The specification for the 155.520 Mbit/s (SDH) STM-1 physical layer (including the mapping of the ATM cells into the STM-1 payload) shall comply with: G.707 [60] for the allowed bit rates, G.708 [1] for the transport frame format, and G.709 [2] for the multiplexing structure.

4. B-ICI ATM Layer Specification

This section provides CCITT/T1 defined ATM layer (including ATM cell header) functions. The U-plane is specified in this section, and the M-plane is specified in a later section .

4.1 ATM Layer Services

The ATM layer[16] provides for the transparent transfer of fixed sized ATM layer service data units (ATM-SDUs) between communicating upper layer entities (e.g., AAL-entities). This transfer occurs on a pre-established ATM connection with negotiated parameters such as cell-loss ratio, cell delay, cell delay variation, throughput and traffic parameters. Each connection is characterized by a traffic descriptor of one or more parameters. Traffic submitted to a connection on a B-ICI is expected to conform to these parameters, although some network induced cell delay variation may have accumulated on the connection before reaching the B-ICI.

Two levels of virtual connections can be supported at the B-ICI:

- A point-to-point Virtual Channel Connection (VCC) which consists of a single connection established between two ATM VCC end-points.
- A point-to-point Virtual Path Connection (VPC) which may consist of a bundle of VCCs carried transparently between two ATM VPC end-points.

Traffic monitoring and throughput enforcement may be performed on VCCs/VPCs at the B-ICI ingress to a carrier's network. For VPCs at the B-ICI, shaping, traffic monitoring and throughput enforcement (i.e., NPC) may be performed across all cells carried on the same VPI independently of the VCI values.

(R) 4-1 From a single source the relay of cells within a VPC and/or VCC shall preserve cell sequence integrity.

No retransmission of lost or corrupted information is performed by this layer. The ATM layer also provides its users with the capability to indicate the loss priority of the data carried in each cell. The information exchanged between the ATM layer and the upper layer (e.g., the AAL) across the ATM-SAP includes the primitives in Figure 4.1.

Primitive	Request	Indicate	Confirm	Respond
ATM-DATA	X	X		

Figure 4.1 ATM Service Access Point (SAP) Primitives

These primitives make use of the parameters in Figure 4.2.

Parameters	Associated Primitives	Meaning	Valid Values
ATM-SDU	ATM-DATA.request ATM-DATA.indicate	48 byte pattern for transport	Any 48 byte pattern
SDU-Type	ATM-DATA.request ATM-DATA.indicate	End-to-end cell type indication	0 or 1
Loss-Priority	ATM-DATA.request ATM-DATA.indicate	Cell Loss-Priority	High or Low Priority
Congestion-Experience	ATM-DATA.indicate	EFCN Indication	True or False

Figure 4.2 ATM-SAP Parameters

The primitives provide the following services:

- **ATM-DATA.request**: Initiates the transfer of an ATM-SDU and its associated SDU-Type to its peer entity over an existing connection. The loss priority parameter and the SDU-Type parameter are used to assign the proper CLP and PTI fields to the corresponding ATM-PDU generated at the ATM layer.
- **ATM-DATA.indicate:** Indicates the arrival of an ATM-SDU over an existing connection, along with a congestion indication and the received ATM-SDU. In the absence of errors, the ATM-SDU is the same as the ATM-SDU sent by the corresponding remote peer upper layer entity in an ATM-DATA.request.

The following parameters are passed within one or more of the previous primitives:

- **ATM-SDU:** This parameter contains 48 bytes of ATM layer user data to be transferred by the ATM layer between peer communicating upper layer entities.
- **SDU-Type:** This parameter is only used by the ATM layer user to differentiate two types of ATM-SDUs associated with an ATM connection.
- **Loss-Priority:** This parameter indicates the explicit loss priority (CLP = 0 or 1) for this ATM SDU relative to the other cells in the same VPC/VCC. It can take only two values, one for high priority and the other for low priority.
- **Congestion-Experience:** This parameter indicates that the received ATM-SDU has passed through one or more network nodes experiencing congestion.

4.2 Service Expected from the Physical Layer

The ATM layer expects the physical layer to provide for the transport of ATM cells between communicating ATM-entities. The information exchanged between the ATM layer and the physical layer across the PHY-SAP includes the primitives in Figure 4.3.

Primitive	Request	Indicate	Confirm	Respond
PHY-UNITDATA (1)	X	X		

(1): The ATM-entity passes one cell per PHY-UNITDATA.request and accepts one cell per PHY-UNITDATA.indicate.

Figure 4.3 PHY-SAP Services Required by the ATM Layer

4.3 ATM Cell Structure and Encoding at the B-ICI

(R) 4-2 Network equipment supporting a B-ICI shall encode and transmit cells according to the structure and field encoding convention defined for the NNI[3] (Figure 4.4 and 4.5).

The structure of the ATM cell is shown in Figure 4.4. It contains the following fields[17]:

(i) Virtual Path/Virtual Channel (VPI/VCI) Identifier: The actual number of routing bits in the VPI and VCI subfields used for routing is negotiated between the two carrier networks. This number is determined on the basis of the lower requirement of the networks.

(R) 4-3 The bits within the VPI and VCI fields used for routing shall be allocated using the following rules:

—The allocated bits of the VPI subfield shall be contiguous;

—The allocated bits of the VPI subfield shall be the least significant bits of the VPI subfield, beginning at bit 5 of octet 2;

—The allocated bits of the VCI subfield shall be contiguous;

—The allocated bits of the VCI subfield shall be the least significant bits of the VCI subfield, beginning at bit 5 of octet 4.

(R) 4-4 Any bits of the VPI subfield that are not allocated are set to 0. Any bits of the VCI subfield that are not allocated are set to 0.

(R) 4-5 Unallocated bits of the VPI for VP switching and VPI/VCI for VC switching shall be checked to be zero "0" at the receiver. Cells with invalid VPI/VCI shall be discarded.

At the B-ICI, there are two directions of transmission. When a routing field value (i.e., VPI plus VCI for a VC link or VPI for a VP link) is assigned at the B-ICI, the same value is assigned for both directions of transmission. The routing field value used in one direction is only to be used in the opposite direction to identify the VC/VP link involved in the same communication.

It should be noted that:

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

(2) The bandwidth in both directions may be different (asymmetric communication); or

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

(4) The bandwidth of the opposite direction may be large enough to carry only ATM layer management information (unidirectional communication with reverse management information)."

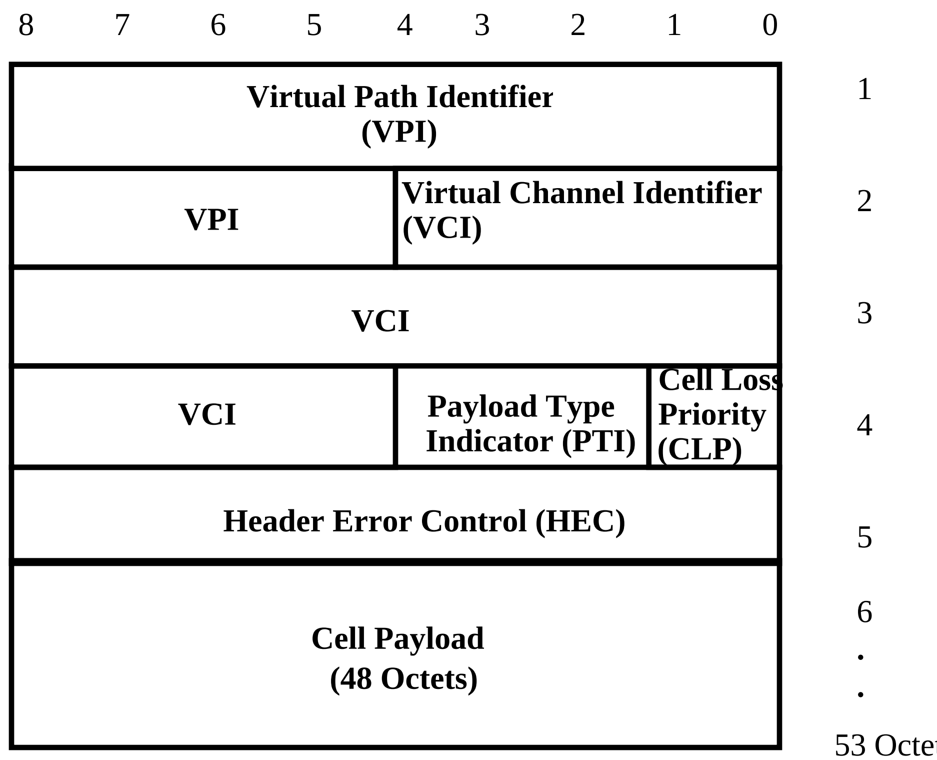


Figure 4.4 ATM Cell Structure at the B-ICI

(ii) Payload Type Indicator (PTI): This is a 3-bit field used to indicate whether the cell contains user information or Connection Associated Layer Management information (F5 flow). It is also used to indicate a network congestion state, or for network resource management. The detailed coding and use of the PTI field will be described in Section 4.4.4.

(iii) Cell Loss Priority (CLP): This is a 1-bit field which allows the user or a network to optionally indicate the explicit loss priority of the cell. More details on the use of the CLP bit are given in Section 4.4.5.

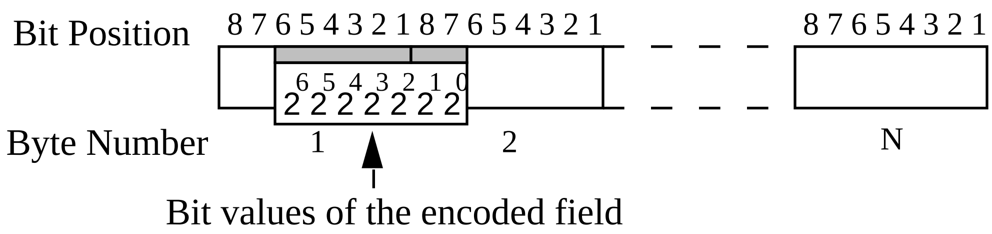


Figure 4.5 ATM Field Encoding Convention

(iv) Header Error Control (HEC): The HEC field is used by the physical layer for detection/correction of bit errors in the cell header. It may also be used for cell delineation.

4.4 ATM Layer Functions Involved at the B-ICI (U-plane)

This section describes ATM layer functions that need to be supported at the B-ICI (see Figure 4.6). It does not cover those ATM functions that are described in standards but have no impact on the B-ICI specification.

Functions	Parameters
Multiplexing among different ATM connections	VPI/VCI
Cell rate decoupling (unassigned cells)	Pre-assigned header field values
Cell discrimination based on pre-defined header field values	Pre-assigned header field values
Payload type discrimination	PTI field
Loss priority indication and selective cell discarding	CLP field, Network congestion state

Figure 4.6 Functions Supported at the B-ICI (U-plane)

4.4.1 Multiplexing Among Different ATM Connections

This function multiplexes ATM connections with different QOS requirements. ATM connections may have either a specified or an unspecified QOS. An ATM connection with a specified QOS is characterized by values of one or more of the following parameters: cell transfer delay, cell delay variation, and cell loss ratio. An ATM connection with unspecified QOS has no values for the above parameters. This document identifies the required set of specified QOS classes, and one unspecified QOS class.

The QOS is the same for all cells belonging to the same ATM connection, and remains constant for the duration of the connection.

(R) 4-6 Network equipment supporting a B-ICI shall support the required set of the specified QOS classes[18].

(O) 4-1 Network equipment supporting a B-ICI may support the unspecified QOS class[18].

4.4.2 Cell Rate Decoupling

The cell rate decoupling function at the sending entity adds unassigned cells to the assigned cell stream (cells with valid payload) to be transmitted, transforming a non-continuous stream of assigned cells into a continuous stream of assigned and unassigned cells. At the receiving entity the opposite operation is performed for both unassigned and invalid cells. The rate at which the unassigned cells are inserted/extracted depends on the bit rate (rate variation) of assigned cell and/or the physical layer transmission rate. The unassigned and invalid cells are recognized by specific header patterns[4] which are shown in Figure 4.7.

(R) 4-7 Network equipment supporting a B-ICI shall generate unassigned cells in the flow of cells passed to the physical layer in order to adjust to the cell rate required by the payload capacity of the physical layer.

(R) 4-8 Network equipment supporting a B-ICI shall encode the header fields of unassigned cells in accordance with the pre-assigned header field values defined in [3] and [17]. The information field of the unassigned cell shall be encoded in accordance with [3].

(R) 4-9 The receiving ATM entity shall extract and discard the unassigned and invalid cells from the flow of cells coming from the physical layer.

Note: The cell rate governing the flow between physical and ATM layer will be extracted from physical layer (e.g. SONET, DS3) timing information, if required.

4 The term "Cell Rate Decoupling" has a different meaning in CCITT, and it refers to a physical layer process involving physical layer cells (e.g., idle cells[7]). Further, the term "invalid' when applied to a cell or pattern refers to the illegal appearance of a physical layer cell at the ATM layer. It is possible, in some cases, that the generation of unassigned cells may not be required. Note that Idle Cells were originally defined for the ATM -based Physical Layer."

4.4.3 Cell Discrimination Based on Pre-defined Header Field Values

The pre-defined header field values[17] defined for the NNI apply at the B-ICI, and are given in Figure 4.7.

Sixteen VCI values (VCI = 0-15) are reserved by CCITT (I.361) for various applications:

1. VCI = 0 is only for Unassigned Cell indication (Figure 4.7).

2. VCI = 1-2 are only used for signaling function which may only be applicable in user-to-user and user-to-network VPs.

3. VCI = 3-4 are used for OAM functions (Figure 4.7).

4. VCI = 5 is used for point-to-point signaling (Figure 4.7).

5. VCI = 6-7 are reserved to provide the same functions for VPs as PTI values 110 and 111, respectively, will provide for VCs.

6. VCI = 8-15 are reserved for future standardization functions.

Function	Header Value			
	Byte 1	Byte 2	Byte 3	Byte 4
Unassigned Cell	00000000	00000000	00000000	0000XXX0
Invalid Pattern	00000000	00000000	00000000	0000XXX1
OAM Segment F4 Flow	AAAAAAAA	AAAA0000	00000000	0011AAAA
OAM End to End F4 Flow	AAAAAAAA	AAAA0000	00000000	0100AAAA
Point-to-Point Signaling (Note 1)	AAAAAAAA	AAAA0000	00000000	0101AAAA

Note 1 - This VCI subfield value is reserved for signaling.
A - Indicates that the bit is available for use by the appropriate ATM layer function.
X - Indicates bits that are unspecified at the transmitter and ignored at the receiver.

Figure 4.7 Pre-Defined Header Field Values

The Virtual Path Connection (VPC) operation flow (F4 flow) is carried via specially designated OAM cells. F4 flow OAM cells have the same VPI value as the user-data cell transported by the VPC but are identified by two unique pre-assigned virtual channels within this VPC. At the B-ICI, the virtual channel identified by a VCI value = 3 is used for VP level management functions between ATM nodes on both sides of the B-ICI (i.e., single VP link segment) while the virtual channel identified by a VCI value = 4 can be used for VP level end-to-end (User <-> User) management functions.

The detailed layer management procedures making use of the F4 flow OAM cells at the B-ICI, and the specific OAM cell format will be covered in a later section.

(R) 4-10 Network equipment supporting VP level management functions at the B-ICI shall encode the VCI field of the F4 flow OAM cells with the appropriate values as defined in [17] and shown in Figure 4.7.

(R) 4-11 Network equipment supporting VP level management functions at the B-ICI shall have the capability to identify F4 flow OAM cells within each VPC.

4.4.4 Cell Discrimination Based On Payload Type Indicator (PTI) Field Values

The main purpose of the PTI field is to discriminate between user cells (i.e., cell carrying user information) from non-user cells (see Figure 4.8). Code points 0 to 3 are used to indicate user cells. Within these code points, values 2 and 3 are used to indicate that congestion has been experienced in the network. Code points 4 and 5 are used for VCC level management functions. The PTI value of 4 is used for identifying OAM cells communicated within the bounds of a VCC segment (i.e., single link segment across the B-ICI) while the PTI value of 5 is used for identifying end-to-end OAM cells.

The detailed layer management procedures making use of the F5 flow of OAM cells at the B-ICI, and the specific OAM cell format is covered in a later section.

PTI Coding	Interpretation
000	User data cell, congestion not experienced, SDU_Type = 0
001	User data cell, congestion not experienced, SDU_Type = 1
010	User data cell, congestion experienced, SDU_Type = 0
011	User data cell, congestion experienced, SDU_Type = 1
100	Segment OAM F5 flow cell
101	End-to-End OAM F5 flow Cell
110	Reserved for future traffic control and res. manag. functions
111	Reserved for future functions

Figure 4.8 Payload Type Indicator Encoding

(R) 4-12 Network equipment supporting VC level management functions at the B-ICI shall encode the PTI field of the F5 flow OAM cells with the appropriate code points as defined in [17].

(R) 4-13 Network equipment supporting VC level management functions at the B-ICI shall have the capability to identify F5 flow OAM cells within each VC.

4.4.5 Loss Priority Indication and Selective Cell Discarding

The CLP field may be used for loss priority indication by the ATM end point and for selective cell discarding in network equipment. Users can set the CLP bit to indicate a lower priority cell. If the CLP is not set the cell has normal priority. Upon entering the network, a cell with CLP value = 1 may be subject to discard depending on network traffic conditions.

The treatment of cells with the CLP bit set to 1 (low priority cells) by the network traffic management functions is covered in later sections.

5. Common B-ICI Traffic Management and Network Performance

This section provides B-ICI traffic management functions and network performance considerations that are common to all services being supported across a B-ICI. The service-specific considerations for a B-ICI are discussed in later sections. The considerations developed in the ATM Forum's 1993 release of the UNI Specification[19] are used where applicable for a B-ICI.

To obtain numerical objectives on network performance parameters may be desirable after sufficient operating experience. Bilateral agreements between the carriers should address such numerical objectives on an interim basis. These objectives can be very dependent upon the actual service and configuration.

A traffic management function can generally be classified as being either a Traffic Control function or a Congestion Control function. ATM layer Traffic Control refers to the set of actions taken by the network to avoid congested conditions. ATM layer Congestion Control refers to the set of actions taken by the network to minimize the intensity, spread and duration of congestion. Congestion Control actions are triggered by congestion in one or more Network Elements.

In a BISDN, congestion is defined as a state of Network Elements (e.g., switches, concentrators, cross-connects and transmission links) in which the network is not able to meet the negotiated network performance objectives for the already established connections and/or for the new connection requests. In general, congestion can be caused either by unpredictable statistical fluctuation of traffic flows or by fault conditions within the network. Congestion is distinguished from the state where buffer overflow is causing cell losses, but the negotiated Quality of Service is still being met.

The primary role of Traffic Control and Congestion Control parameters and procedures is to protect the network and the user in order to achieve network performance objectives. An additional role is to optimize the use of network resources.

The uncertainties of broadband traffic patterns and the complexity of Traffic Control and Congestion Control suggest a step-wise approach for defining traffic parameters and network Traffic Control and Congestion Control mechanisms. This section defines a restricted initial set of Traffic Control and Congestion Control capabilities aiming at simple mechanisms and realistic network efficiency.

It may subsequently be appropriate to consider additional sets of such capabilities, for which additional Traffic Control mechanisms will be used to achieve increased network efficiency.

The objectives of ATM layer Traffic Control and Congestion Control for a BISDN are as follows:

- ATM layer Traffic Control and Congestion Control should support a set of ATM layer Quality Of Service (QOS) classes sufficient for all foreseeable BISDN services; and the specification of these QOS classes should be consistent with the 1993 release of the ATM Forum UNI Specification[19].

- ATM layer Traffic Control and Congestion Control should not rely on AAL protocols which are BISDN service specific, nor on higher layer protocols which are application specific. Protocol layers above the ATM layer may make use of information which may be provided by the ATM layer to improve the utility those protocols can derive from the network.

- The design of an optimum set of ATM layer Traffic Controls and Congestion Controls should minimize network and end-system complexity while maximizing network utilization.

To meet the above objectives, the following functions form a framework for managing and controlling traffic and congestion in ATM networks and may be used in appropriate combinations.

- Network Resource Management (NRM): Provisions may be used to allocate network resources in order to separate traffic flows according to service characteristics.

- Connection Admission Control (CAC): Defined as the set of actions taken by all involved carriers in order to determine whether a request to establish a new ATM connection will be accepted or rejected (or whether a request for re-allocation of an ATM connection's capacity can be accommodated). Routing is part of CAC actions.

- Feedback Controls: Defined as the set of actions taken by the network and by the users to regulate the traffic submitted on ATM connections according to the state of Network Elements.

- Network Parameter Control (NPC): Defined as the set of actions taken by a carrier to monitor and control traffic, in terms of traffic offered and validity of the ATM connection, at a B-ICI. Its main purpose is to protect network resources and the QOS of other already established ATM connections during occurrences of network equipment malfunction or misoperation by detecting violations of negotiated parameters and taking appropriate actions.

- Priority Control: The end user may generate different priority cell streams on an ATM connection by using the Cell Loss Priority (CLP) bit. A Network Element may selectively discard cells with low priority if necessary to protect as far as possible the network performance experienced by cells with high priority.

- Other control functions are for further study.

All of these functions can make use of information that passes across the B-ICI. As a general requirement, it is desirable that a high level of consistency be achieved between the above Traffic Control and Congestion Control functions.

For this Version of the B-ICI Specification, those ATM layer Traffic Control and Congestion Control functions for a B-ICI that are common to all services will use the following simplifying assumptions:

- Other than supporting the exchange of information across a B-ICI, no feedback control actions are to be required of Network Elements.

- Bilateral agreement on availability may be needed, but is not quantified here.

- When it is present, Network Parameter Control is only required to enforce peak cell rate on a VPC.

- No Traffic Shaping function for traffic going into a B-ICI link is required of Network Elements.

The following sections address common B-ICI aspects of network performance, the traffic contract, and the traffic management functions.

5.1 Network Performance Considerations

The ATM layer performance parameters defined in the 1993 release of the ATM Forum UNI Specification[19] are adopted without modification for use in those B-ICI network performance considerations that are common to all services.

Further network performance considerations addressed in this Specification are the definition of reference traffic loads for use when measuring the performance of a B-ICI link, and the establishment of network performance allocation principles based on appropriate reference configurations.

5.1.1 Reference Traffic Loads

Measurement of certain traffic-sensitive network performance parameters to verify agreement with specified values of those parameters has meaning in the presence of a known or reference traffic load. In particular, it is necessary to identify the traffic loads under which a specific B-ICI link is to operate when complying with the ATM layer performance objectives that can be allocated to this link.

These reference traffic loads can be characterized in terms of the utilization factor for the relevant type of physical link that is carrying the VPC or VCC whose performance is being specified. Table 5.1 provides three types of reference traffic loads. Reference Traffic Load Type 1 is intended to represent CBR traffic, and Reference Traffic Loads Type 2 and Type 3 are intended to provide initial representations of VBR traffic.

Three types of physical link are considered here. These are a DS3 using the PLCP cell mapping defined for BISDN, a SONET STS-3c, and a SONET STS-12c.

- Reference Traffic Load Type 1 is generated as follows. Apply the number of active traffic sources shown in Table 5.1, each of which provides DS1 circuit emulation, to each link under test. Each such traffic source shall produce cells at the rate of 4,106 cells/second. The initial phasing of these sources with respect to each other shall be random, and shall have a uniform distribution over a 244 micro-second interval.

  This source traffic rate is compatible with a Type 1 AAL since $\frac{1.544 \text{ Mbit/s}}{47 \times 8 \text{ bits/cell}} = 4106$ cells/second.

  The interval for the initial phasing distribution is determined as the time between two adjacent cells from the same source, which is $\frac{1}{4106 \text{ cells/second}} = 244$ micro-seconds.

- Reference Traffic Load Type 2 is generated as follows. Each cell time slot on a link under test shall contain a cell with probability equal to the specified link utilization factor, and shall not contain a cell with probability equal to one minus the specified link utilization factor. The probability of one cell time slot containing a cell shall be independent of whether or not other cell slot times contain cells.
  This type of traffic load is often referred to as a Bernoulli traffic load.

Table 5.1 Reference Traffic Loads for PVC Performance Specification

Reference Traffic Load Type	Link's Capacity	Number of Active Traffic Sources to Provide Link Utilization Factor	Link Utilization Factor
1	DS3 PLCP	20	0.86
1	STS-3c	73	0.85
1	STS-12c	292	0.85
2	DS3 PLCP	Not Applicable	0.85
2	STS-3c	Not Applicable	0.85
2	STS-12c	Not Applicable	0.85
3	DS3 PLCP	66	0.70
3	STS-3c	242	0.70
3	STS-12c	969	0.70

Note:

1. Reference Traffic Load Type 1 is based on DS1 circuit emulation.
2. Reference Traffic Load Type 2 is based on Bernoulli traffic.
3. Reference Traffic Load Type 3 is based on methodology given in[19], and the model shown in Figure 5.1.

- Reference Traffic Load Type 3 is generated as follows. Apply a number of traffic sources shown in Table 5.1, each of which provides emulation of a VBR source with Peak Cell Rate (PCR) at the DS1 rate and a Sustainable Cell Rate (SCR) of 384 kbit/s with a Maximum Burst Size (MBS) corresponding to 25 cells.

  More details on this type of traffic source are provided in[19]. Figure 5.1 shows a model for this type of traffic source.

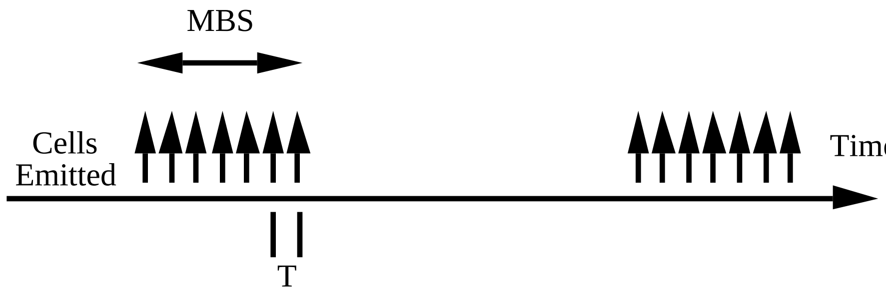


Figure 5.1 Traffic Source Model Used to Provide Reference Traffic Load Type 3

$$SCR = \frac{1}{Ts}; \quad PCR = \frac{1}{T}$$

$$MBS = \left\lfloor 1 + \frac{\tau s}{Ts - T} \right\rfloor$$

τs = burst tolerance; $\lfloor x \rfloor$ = greatest integer less than or equal to x.

(R) 5-1 The mixture of Type 1, Type 2 and Type 3 or other Reference Traffic Loads, and associated parameters applicable to a particular B-ICI link shall be established by bilateral agreement between the carriers for determining compliance with ATM layer performance objectives.

5.1.2 Allocation Principles for Network Performance

The 1993 release of the ATM Forum UNI Specification[19] defines ATM network performance parameters and their relationships with fundamental references such as ITU/CCITT's Recommendation I.356. The five primary ATM network performance parameters so defined are listed in Table 5.2. This section considers the principles to be used when allocating to individual network portions the objective maximum amounts of the network impairments characterized by these network performance parameters. These principles indicate the manner in which the performance impairment characterized by each such parameter builds up through a representative chain of Network Elements.

Table 5.2 Buildup of Performance Impairments for Traffic-Sensitive ATM Network Performance Parameters

ATM Network Performance Parameters	Reference Traffic Load Required	Build-up of Impairment on ATM Switches	Build-up of Impairment on BISDN Links
Cell Transfer Delay	No, to first order	Fixed delay per ATM switch; additive between ATM switches	Proportional to link length; additive between links
Cell Delay Variation	Yes	Generally convolution-based build-up between ATM switches	Independent of link length, consider with ATM switch
Cell Error Ratio	No	Fixed (small) per ATM switch; negligible w.r.t. links	Proportional to link length
Cell Loss Ratio	Yes	Additive between ATM switches	No impact
Cell Misinsertion Rate	No	For further study	No impact

A representative chain of Network Elements that is established to support the allocation of network performance objectives is called a "reference configuration". Such a reference configuration must identify the number and type of performance-affecting Network Elements in each of the various network portions involved with a performance allocation, as well as the relationships among these network portions. Each network portion in a reference configuration is demarcated by two jurisdictional boundaries which can be either a T_B reference point on a UNI link or a Portion Boundary (PB) on a B-ICI link.

A reference configuration is intended to provide this information for a particular class of network or carrier-to-carrier configurations. For example, one class of network configurations is two carrier networks jointly providing an end-to-end connection. Figure 5.2 shows an example of a reference configuration.

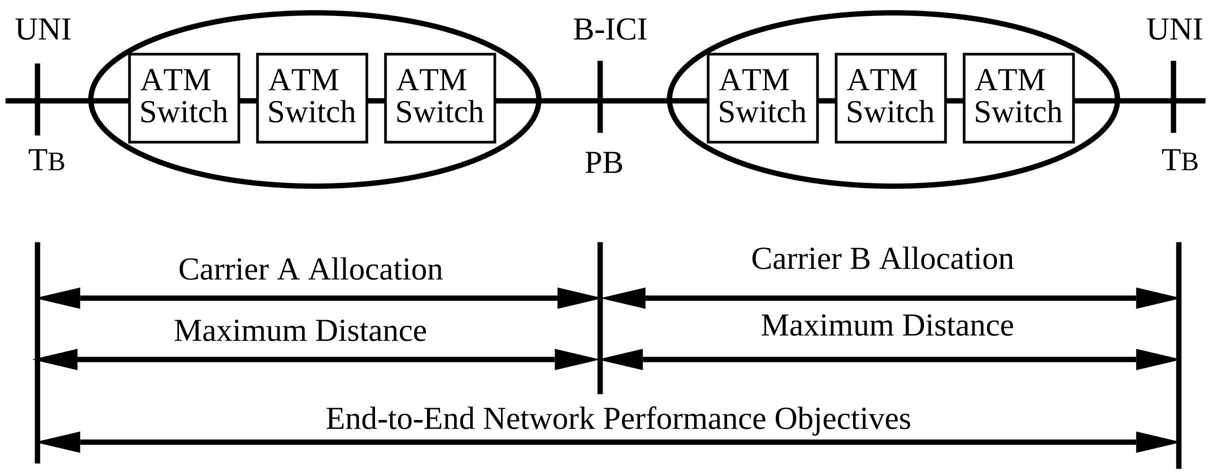


Figure 5.2 An Example of a Reference Configuration and its Role in Network Performance Allocation

For each of the primary ATM network performance parameters, Table 5.2 identifies whether or not a reference traffic load is relevant to its measurement, the manner in which the associated performance impairment builds up through ATM switches, and the manner in which the associated performance impairment builds up through BISDN transmission links. Reference traffic loads are relevant for characterizing values of Cell Delay Variation (CDV) and Cell Loss Ratio. The following considerations apply to characterizing the build-up of CDV.

In principle, the build-up of CDV through a chain of ATM switches could be precisely determined by a detailed consideration of the correlations between all of the traffic streams passing through each of the ATM switches, together with the impacts of cell spacing (traffic shaping) functions that may optionally be present. As a practical matter, however, three simplifying assumptions can be used:

1. First, assuming independence of cell spacing between each of the traffic streams and the absence of a cell spacing function allows the distribution of the CDV that is built up on a VCC or VPC through several ATM switches to be estimated as a convolution of the CDV distributions that each of the ATM switches would add to a "pure" (zero CDV) input stream.

2. Second, there is a way to roughly estimate an extreme value, such as a 10^{-x} quantile, of the convolved CDV that is built up through a chain of ATM switches that starts at a "pure" stream on an input to the first ATM switch. This quantity is roughly approximated by multiplying the extreme value (say the 10^{-x} quantile) of the CDV that any one ATM switch typically adds to a "pure" input stream by the square root of the number ATM switches in that chain.

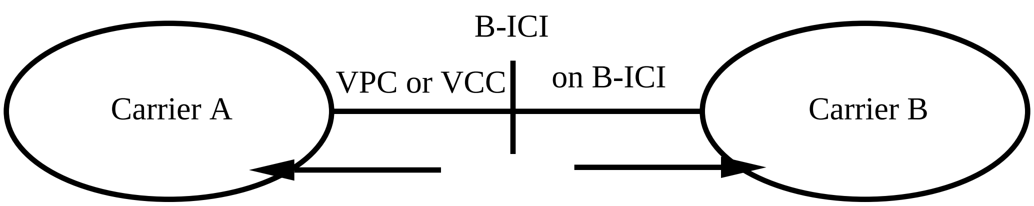
3. Third, the extreme value of CDV on a VCC or VPC at a point where it has just exited from a cell spacing function is some value to be specified by the carrier which operates that function.

Availability, which is a derived network performance parameter expressible in terms of the primary parameters, may be considered in future releases of this document.

5.2 Traffic Contract

The 1993 release of the ATM Forum UNI Specification[19] defines the user-network traffic contract for an ATM connection at a UNI as well as definitions for traffic parameters, a Connection Traffic Descriptor and a Generic Cell Rate Algorithm (GCRA). The UNI Specification's GCRA is adopted without modification for use in B-ICI traffic contract considerations. With the modifications noted herein, these traffic parameter and Connection Traffic Descriptor definitions also applies to a B-ICI.

A carrier-to-carrier traffic contract specifies the negotiated characteristics for each direction of transmission over an ATM connection, i.e., a VPC or a VCC, at a B-ICI. In general, these characteristics may be different for each direction of transmission, as illustrated in Figure 5.3.



B to A Direction:
Connection Traffic Descriptor
Requested QOS Class
Definition of Compliant ATM Connection

A to B Direction:
Connection Traffic Descriptor
Requested QOS Class
Definition of Compliant ATM Connection

Figure 5.3 Direction-Dependent Aspects of a Carrier-to-Carrier Traffic Contract for a B-ICI

(R) 5-2 For each direction of transmission over a B-ICI, the carrier-to-carrier traffic contract shall consist of the Connection Traffic Descriptor, the requested QOS class, and the definition of a compliant ATM connection.

The QOS class defined in[19] applies without modification at a B-ICI. The definitions of the Connection Traffic Descriptor and a Compliant ATM Connection are modified for a B-ICI as described below.

5.2.1 Connection Traffic Descriptor

Separate consideration is provided here for the Connection Traffic Descriptors used for a VCC and for a VPC at a B-ICI.

For a VCC at a B-ICI, connecting carriers may agree to apply either the simplified Connection Traffic Descriptor defined below for a VPC, or else adapt a more complete Connection Traffic Descriptor[19]. Adaptation to a B-ICI of the Connection Traffic Descriptor from the 1993 ATM Forum UNI Specification would include consideration of a possibly increased CDV Tolerance at a B-ICI.

For a VPC at a B-ICI, some simplification is made to the Connection Traffic Descriptor.

The Connection Traffic Descriptor for a cell stream on a VPC at a B-ICI consists of all parameters and the Conformance Definition used to unambiguously specify the conforming cells of the VPC. These are:

- Source Traffic Descriptor including only the Peak Cell Rate (additional parameters such as Sustainable Cell Rate and Burst Tolerance are optional).

- CDV Tolerance.

- Conformance Definition based on one application of the Generic Cell Rate Algorithm (GCRA).

The Cell Loss Priority (CLP) bit may be used to delineate two priority levels for cells within a VPC/VCC. If this CLP bit usage is supported for a particular VPC, then two applications of the Conformance Definition based on the GCRA would apply — one for the peak cell rate of the CLP = 0+1 cell stream, and second for the peak cell rate of the CLP = 0 cell stream. (The notation CLP = 0+1 means that the CLP bit may take the value of either 0 or 1).

The definition of CDV tolerance provided in[19] will also apply at a B-ICI, though its value at a B-ICI may differ from its value at a UNI.

5.2.2 Compliant ATM Connection

The Conformance Definition based on the GCRA[19] is used to unambiguously specify the conforming cells of a VPC at a B-ICI.

The Conformance Definition should not be interpreted as the NPC algorithm. Although traffic conformance at the B-ICI is defined by the Conformance Definition based on the GCRA, each network provider may use any NPC as long as the operation of the NPC does not violate the QOS objectives of a compliant connection.

(R) 5-3 The definition of a compliant ATM connection at a B-ICI shall be established by agreement between the connecting carriers.

For example, such an agreement may allow up to a certain percentage of the User Information cells on a particular VPC to violate the Conformance Definition based on the GCRA. Also, the carrier on each side of a B-ICI may wish to apply the GCRA-based Conformance Definition, and both carriers may wish to agree that a particular VPC is compliant only if both applications of the Conformance Definition (i.e., on each side of the B-ICI) indicate it to be compliant.

(R) 5-4 For compliant ATM connections, the network performance objectives (established by agreement between the connecting carriers) allocated to each network portion, demarcated by the B-ICI, shall be supported.

5.3 Traffic Management Functions

The traffic management functions that are common to all services at a B-ICI were introduced earlier. The 1993 release of the ATM Forum UNI Specification[19] provides information on these functions as they apply to a UNI. Traffic management functions at a B-ICI can be provided with some significant simplifications at a B-ICI. The objective is to be consistent with the 1993 ATM Forum UNI traffic management functions and principles which are used where applicable. An attempt is made to use the least complex functionality for achieving a satisfactory network performance across a B-ICI and reasonable levels of B-ICI link utilization.

The B-ICI link provides the physical transport of cells between two ATM networks. The B-ICI link is the Transmission Path which is terminated on the ATM Network Element (NE) or Inter-Working Function (IWF) on either side of the B-ICI. It enables the connection related functions on the contained VPCs and VCCs."

5.3.1 Connection Admission Control

Connection Admission Control (CAC) is defined as the set of actions taken by all involved carriers in order to determine whether a request to establish a new ATM connection will be accepted or rejected (or whether a request for re-allocation of an ATM connection's capacity can be accommodated). This issue of the B-ICI Specification considers only PVC capabilities, for which new ATM connections are established on an administrative basis together with appropriate OAM procedures.

A new ATM connection is to be established on a B-ICI link only when sufficient resources are available to: (1) support that connection through all involved network portions at its required QOS, and (2) maintain the agreed QOS of existing ATM connections. It is possible that a requested new ATM connection can be so supported on a particular B-ICI link but not on other Network Elements within a given network portion, and in such a circumstance this requested new ATM connection cannot be established on that particular B-ICI link. Routing considerations help to identify when all Network Elements intended to support a requested new connection are capable of doing so.

(R) 5-5 A carrier requesting that a new ATM connection be established across a B-ICI shall provide at least the following information:

- Source Traffic Descriptor[19] including only the Peak Cell Rate;
- Required QOS class[19];
- CDV Tolerance[19] at the B-ICI, as adjusted for build-up through the Network Elements between the originating UNI(s) and the B-ICI;
- Conformance Definition[19].

(R) 5-6 The CAC function of the carrier receiving a request that a new ATM connection be established across a B-ICI shall determine:

- Traffic parameters needed by this carrier's NPC function;
- Routing and allocation of network resources within this carrier's network.

• Whether or not this new ATM connection will be accepted by this carrier's network at its required QOS class.

The following steps will allow a "least common denominator" approach for resource allocation on a B-ICI link. It focuses on the aggregated cell stream in each direction of an ATM connection.

1. In order to ensure network performance and to protect the network, both the CLP = 0+1 and the CLP = 0 cell streams in each direction of transmission over an ATM connection can be allocated resources on a B-ICI link whenever usage of the CLP bit is supported on that B-ICI.

2. When the carriers on either side of a B-ICI support different modes of CLP bit usage (e.g., tagging NPC versus non-tagging NPC), it is necessary to allocate resources to the CLP = 0+1, or aggregated, cell stream in each direction of transmission over an ATM connection on a B-ICI link.

3. As determined by the bilateral agreement, allocation of resources to only the CLP = 0+1 flow may be performed even when the carriers on either side of a B-ICI support the same modes of CLP usage.

Information such as the measured B-ICI link load may be used when performing this CAC function, and this information may allow a carrier to achieve increased utilization of network equipment while still meeting network performance objectives.

Each carrier may select its own CAC function. A new ATM connection would be established only if CAC functions of all carriers being requested to participate in its support determine to accept it.

Routing considerations are beyond the scope of the current release of this document. Here, only a portion of the overall CAC process pertaining to the support of PVC ATM connections on a particular B-ICI link itself is considered.

Use of Virtual Path Connections

VPCs are an important component of Network Resource Management[19] [20] which is applicable to B-ICI links. A Virtual Path Connection (VPC) is a concatenation of Virtual Path Links (VPLs), and a Virtual Channel Connection (VCC) is a concatenation of Virtual Channel Links (VCLs). VPLs or VCLs can be used on a B-ICI link to:

- Simplify that portion of the CAC function pertaining to the B-ICI link. It should be noted that ATM NEs (or IWF) on either side of the B-ICI may use different CAC algorithms. Consequently, for any given VPL, a mutual agreement will be necessary for consistent bandwidth allocation to any given connection.

- Aggregate VCCs carrying like services so that the optional NPC function can be applied to an aggregated traffic flow. It should be noted that this can only be done for VPCs that do not terminate at the B-ICI. For VPCs terminating at the B-ICI, individual VCCs need to be enforced by the NPC function, if supported.
- Implement a form of priority control by segregating traffic types requiring different QOS;

- Efficiently distribute messages for the operation of traffic control schemes (for example to indicate congestion in a network portion by distributing a single OAM or Resource Management message for all VCCs within a VPC).

By reserving capacity on a VPC over a B-ICI link for like types of services, the CAC processing needed to establish individual VCCs is reduced. For this purpose, a VCC's service type could be determined from the source traffic descriptors and QOS class provided during the CAC process. The CAC decision as to whether a newly requested VCC can be supported on this link is thereby reduced to a simple, threshold-oriented decision.

An example of this use of VPCs for the CAC function is illustrated in Figure 5.4. It is applied to a specific B-ICI link in two stages. In the first or engineering stage, capacity is allocated to a VPC for like service types (e.g., similar source traffic descriptors and same QOS class), and the maximum number of simultaneously active VCCs (or threshold) permitted on each VPC is determined. This engineering stage would incorporate where appropriate a priori and/or measurement-based estimates of the statistical multiplexing efficiencies achievable with particular service types. In the second or admission stage, a new VCC is accepted only if there is room in the VPC corresponding to its service type, i.e., until the threshold determined in the engineering stage is met.

Strategies for the reservation of capacity on VPCs will be determined by the tradeoff between increased capacity costs and reduced control costs. These strategies are left to each carrier's decision.

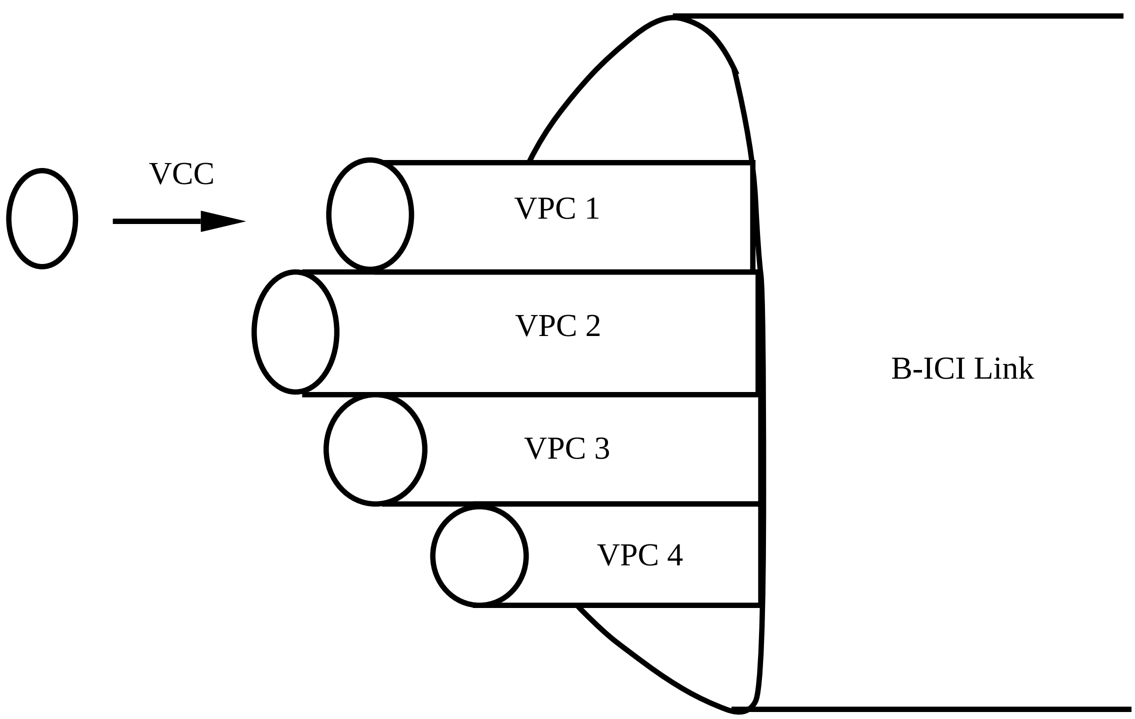


Figure 5.4 An Example of a VPC-based CAC for B-ICI Links

5.3.2 Network Parameter Control

The Network Parameter Control (NPC) function is defined as the set of actions taken by a carrier to monitor and control traffic, in terms of traffic offered and validity of the ATM connection, at a B-ICI. Its main purpose is to protect network resources and the QOS of other already established

ATM connections during occurrences of network equipment malfunction or misoperation by detecting violations of negotiated parameters and taking appropriate actions. Each carrier determines whether or not to implement the NPC function on the ingress direction to its network portion.

Each carrier may use any implementation of the NPC function so long as it does not violate the QOS objectives of a valid and compliant ATM connection. The traffic parameters that are subject to an NPC are those which are included in the source traffic descriptor. The information on an ATM connection's source traffic descriptors and Conformance Definition[19] that is provided during the CAC process can in principle support the NPC enforcement of a number of traffic parameters.

To a significant extent, the purpose of the NPC function can be achieved with a reduced set of traffic enforcement functions that only enforce peak cell rate on the VPCs of a B-ICI link.

> **(R) 5-7** When the NPC function is present, it shall provide at least the following actions:
> - Verification of the validity of each VPI (i.e., whether the VPI value is associated with active VCCs);
> - Enforcement of the peak cell rate for each VPC.

When a VPC contains an aggregation of VCCs carrying like types of services as described in the previous section, the above **(R)** facilitates a simplified implementation of the NPC function.

At the cell level, actions of the NPC function may include:

- Cell passing — mandatory for conforming cells;
- Cell re-scheduling (when traffic shaping and network parameter control are combined);
- Cell tagging (carrier option) — cell tagging operates on CLP = 0 cells only by overwriting the CLP bit to 1;
- Cell discarding.

At a carrier's option, two applications of the NPC function may be established for a VPC — one for the peak cell rate of the CLP = 0+1 cell stream, and second for the peak cell rate of the CLP = 0 cell stream.

Since cell sequence integrity must be maintained on any ATM connection, the NPC function, including its optional tagging action, should meet the following requirement:

> **(R) 5-8** An NPC function shall maintain cell sequence integrity on every ATM connection it acts upon.

At the connection level, actions of the NPC function may include:

- Releasing the ATM connection.

5.3.3 Priority Control

The end user may generate different priority cell streams on an ATM connection by using the Cell Loss Priority (CLP) bit. A Network Element may selectively discard cells with low priority (CLP = 1) if necessary to protect as far as possible the network performance experienced by cells with high priority (CLP = 0). The relation between values of the CLP bit and QOS classes is established[19].

If the tagging option is used by a carrier in its NPC function, those CLP = 0 cells identified as nonconforming by this NPC function (when acting on the CLP = 0 cell stream) are converted to CLP = 1 cells, and merged with the CLP = 1 cell stream on that same ATM connection[19].

The following is a minimum requirement on the relation between the priority control and NPC functions.

> **(R) 5-9** Any cell, regardless of its CLP bit value, that is identified as nonconforming by the NPC function when acting on the aggregate CLP = 0+1 cell stream of an ATM connection shall be discarded.

5.3.4 Explicit Forward Congestion Indication

The Explicit Forward Congestion Indication (EFCI) is an ATM level congestion notification mechanism that uses certain code points in the Payload Type Identifier (PTI) field of the cell header. Its purpose is to notify end user equipment that a cell has passed through a congested network resource, e.g., a congested ATM switch. Such a notification may be optionally used by end user equipment in establishing feedback controls to reduce the impact of network congestion on that end user equipment. A carrier should not rely on this mechanism to control network congestion.

After a cell has been transferred across a B-ICI, it is desirable to prevent the clearing of a cell's previously set EFCI value that indicates "congestion experienced". If such information were cleared, it would be lost to the end user equipment.

> **(R) 5-10** A network portion shall not modify the value of the EFCI code points (to preserve the EFCI integrity) in any User Information cell received across a B-ICI, except to set such code points to indicate the "congestion encountered" state when that network portion determines this would be appropriate.

6. Common B-ICI Operations and Maintenance

This section provides B-ICI Operations and Maintenance functions applicable to Carrier-to-Carrier connections of public ATM-based networks. The operations functions common to all services are discussed in this section, and service specific operations functions are discussed in later sections.

6.1 Physical Layer Operations

This section provides specifications of operations and maintenance for the Physical Layer, which includes the Physical Medium Dependent (PMD) sublayer and the Transmission Convergence (TC) sublayer. DS3, STS-3c, and STS-12c rate B-ICIs are considered.

6.1.1 Physical Layer Operations for the 44.736 Mbit/s DS3 B-ICI

Operations and maintenance functions and framing formats required for DS3 transmission are described in ANSI T1.107[21], ANSI T1.107a[11], and TR-TSV-000773[12]. For ATM, the Physical Layer Convergence Procedure (PLCP) path layer operations are a subset of those specified in the IEEE 802.6 standard [22] and TR-TSV-000773[12] . Specifically, the PLCP path User Channel (F1), the Control Information bytes (M2 - M1) and the Link Status Signal of the Path Status byte (G1) are not supported at the B-ICI. Additional information on the parameters specified in this section can be found in ANSI T1.624[6] .

6.1.1.1 DS3 Layer Operations and Maintenance

(R) 6-1 The DS3 transmission system shall meet the operations and maintenance requirements specified in ANSI T1.107[21] and ANSI T1.107a[11]. This includes provisions for performance monitoring, failure detection, alarms and maintenance.

These requirements are also described in ANSI T1.624[6] and TR-TSV-000773[12] .

6.1.1.2 DS3 PLCP Operations and Maintenance

This section specifies Physical Layer Convergence Procedure (PLCP) level operations functions of PLCP error monitoring, PLCP Far End Block Error (FEBE) encoding, and PLCP Remote Alarm Indication (RAI)[5] for the 44.736 Mbit/s B-ICI. These functions are summarized in Table 6.1.

Figure 6.1 illustrates the PLCP path status (G1) byte subfields: a 4-bit FEBE, a 1-bit RAI (Yellow), and 3 X bits (X bits are ignored).

Table 6.1 DS3 PLCP Layer Maintenance

[5] The RAI is sometimes also referred to as a "Yellow Alarm".

Function	Overhead Byte	Coding
PLCP Error Monitoring	B1 of PLCP	BIP-8
PLCP FEBE	G1 (bits 1-4) of PLCP	B1 Error Count
PLCP RAI (Yellow)	G1 (bit 5) of PLCP	0 or 1

Far End Block Error (FEBE)	RAI (Yellow)	X-X-X
4 Bits	1 Bit	3 Bits

Figure 6.1 PLCP Path Status (G1) Byte

6.1.1.2.1 DS3 PLCP Performance Monitoring

The Bit Interleaved Parity - 8 (BIP-8) for the PLCP is an 8 bit code in which the n-th bit of the BIP-8 code calculates the even parity over the n-th bit of each byte covered by the BIP-8. Thus, the BIP-8 provides for 8 separate even parity calculations.

(R) 6-2 The PLCP performance parameters shall be monitored at the PLCP layer, as described in ANSI T1.624[6] . Monitored parameters include Coding Violations (CV), Errored Seconds (ES), Severely Errored Seconds (SES), Severely Errored Framing Seconds (SEFS), and Unavailable Seconds (UAS).

A CV occurs when a received BIP-8 code (in the B1 byte of the PLCP) is not identical to the corresponding locally-calculated code. One received B1 byte can contain from 0 to 8 CVs. An ES is a second with at least one CV. An SES is any second with 5 or more CVs. An SEFS is a count of one-second intervals in which one or more PLCP Out of Frame (OOF) events occur (PLCP OOFs are discussed below). A UAS is a second in which service becomes unavailable at the declaration of a transmission failure condition.

(R) 6-3 The operations of the PLCP Far End Block Error (FEBE) shall conform to ANSI T1.624[6]. The FEBE field shall provide a count of 0 to 8 BIP-8 errors received in the previous PLCP frame, i.e., G1(FEBE) = 0000 through G1(FEBE) = 1000. Any other value of G1 would be caused by other errors and shall be interpreted as 0 errors.

6.1.1.2.2 DS3 PLCP Loss of Frame (LOF)

The PLCP LOF state is defined in the IEEE 802.6 standard[22] as the persistence of a PLCP Out of Frame (OOF) for 1 milli-second. The PLCP OOF is declared when an error in both the A1 and A2 PLCP framing bytes occurs, or two consecutive invalid (i.e., non-sequential)[6] Path Overhead Identified (POI) bytes occur.

(R) 6-4 The PLCP LOF state shall be declared when a PLCP OOF, as defined in IEEE 802.6[22], persists for 1 milli-second.

This is also specified in TR-TSV-000773[12] .

6.1.1.2.3 DS3 PLCP Path RAI (Yellow)

The RAI (Yellow) shall follow the procedures specified in Section 6.2.2 of ANSI T1.624[6] , which are summarized below.

(R) 6-5 The RAI (Yellow) field shall alert the transmitting PLCP that a received failure indication has been declared along the path.

(R) 6-6 When an incoming failure condition is detected that persists for a "soaking period" (typically 2 - 10 seconds), an RAI (Yellow) shall be sent to the upstream end by setting G1(RAI)=1. The RAI (Yellow) shall be detected (by the upstream end) when G1(RAI)=1 for 10 consecutive PLCP frames.

The indication is cleared at the downstream end by setting G1(RAI)=0 when the incoming failure has ceased for 15 ± 5 seconds. At the upstream end, removal of the RAI (Yellow) signal is recognized by detecting G1(RAI)=0 for 10 consecutive PLCP frames.

Note: A PLCP path level Far End Receive Failure (FERF) is not supported at present. The specification of a PLCP Path RDI (Remote Defect Indicator) in addition to or in replacement of PLCP Path RAI is for further study.

6.1.2 Physical Layer Operations for the 155.520 Mbit/s STS-3c B-ICI

Maintenance signals that traverse the SONET B-ICI terminate at three layers: the SONET Section, Line and Path layers. Capabilities associated with the three layers include performance monitoring, alarm surveillance and facility testing. These capabilities are made possible by the Section Overhead (SOH), Line Overhead (LOH), and Path Overhead (POH) fields of the SONET framing structure.

T1E1.2/93-020R1[23] specifies the operation of transmission performance monitoring, failure states, and fault management signals. TR-NWT-001112[24] and TR-NWT-000253[5] also address these issues.

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6 For example, the POI sequence of 11, 10, 9, 4, 7 would not cause a PLCP OOF, while the sequence 11, 10, 9, 4, 5 would.

6.1.2.1 Transmission Performance Monitoring

Transmission performance monitoring is accomplished using a combination of the B1, B2, and B3 bytes. These bytes are encoded into the transmitted signal as specified in T1E1.2/93-020R1[23]. The following **(R)** may or may not apply depending on the B-ICI configurations (B-ICI, B-ICI', B-ICI") summarized in Table 3.1.

(R) 6-7 Section BIP-8 shall be calculated over all bits of the previous STS-Nc frame after scrambling by the frame synchronous scrambler. The computed BIP-8 shall be placed in the first B1 byte location of the subsequent STS frame before scrambling.

(R) 6-8 Line BIP-8N shall be calculated over all bits of the LOH and STS Envelope capacity of the previous STS frame before scrambling by the frame synchronous scrambler. The computed BIP-8N shall be placed in each B2 byte of the STS frame before scrambling.

(R) 6-9 Path BIP-8 shall be calculated over all bits ($N \times 783$ bytes for STS-Nc, regardless of pointer justification) of the previous STS SPE before scrambling by the SONET frame synchronous scrambler, and placed in the B3 byte of the current STS SPE before scrambling.

The parity errors detected by the line BIP-8N are accumulated into a single error count for the STS-N (or STS-Nc) Line.

At the termination point, the B1, B2, and B3 bytes of the incoming signal are monitored for errors.

(R) 6-10 Monitoring of the incoming signal shall be accomplished by calculating the values of the Section BIP-8, the Line BIP-8N, and Path BIP-8 and comparing them to the incoming B1, B2, and B3 bytes.

(R) 6-11 SONET path performance parameters shall be monitored as described in ANSI T1.624[6]. Monitored parameters include STS Path Coding Violations (CVs), STS Path Errored Seconds (ESs), STS Path Severely Errored Seconds (SESs), and STS Path Unavailable Seconds (UAS).

(R) 6-12 A count of the difference in the calculated Path BIP-8 and the received B3 byte shall be placed in bits 1 through 4 of the G1 byte.

Errors are reported to the layer management entity.

6.1.2.2 Failure States

ATM equipment on both sides of the SONET B-ICI detect failure states relevant to the layer of functionality the equipment provides (i.e., SONET Section, Line and Path Layers). The following failure states can be declared within the functional equipment on the receiving side of the interface. The following requirements are based on Section 13 of T1E1.2/93-020R1[23] .

6.1.2.2.1 Loss of Signal (LOS)

(R) 6-13 The network equipment supporting a B-ICI shall enter an LOS state on the incoming signal within 100 micro-seconds of the onset of an all-zeros pattern lasting 2.3 micro-seconds or longer. An "all-zeros pattern" corresponds to no light pulses for OC-N optical interfaces and no voltage transitions for STS-N electrical interfaces[7].

(R) 6-14 The network equipment supporting a B-ICI shall exit the LOS state when two consecutive valid frame alignment patterns have been detected and, during the intervening time, no "all-zeros pattern" considered as LOS was detected in the incoming signal.

6.1.2.2.2 Loss of Frame (LOF)

(R) 6-15 The network equipment supporting a B-ICI shall enter an LOF state when an Out-of-Frame (OOF) on the incoming signal persists for 3 milli-seconds. An OOF is declared when four or more consecutive errored framing patterns have been received.

(R) 6-16 The network equipment supporting a B-ICI shall exit the LOF state within 3 milli-seconds of a continuous in-frame signal in the incoming signal.

6.1.2.2.3 Loss of Pointer (LOP)

(R) 6-17 The network equipment supporting a B-ICI shall enter an LOP state when a valid STS pointer cannot be obtained using the pointer interpretation rules described in ANSI T1.105[4]. The network equipment supporting a B-ICI also enters an LOP state if a valid pointer is not found in 8, 9, or 10 consecutive frames, or if 8, 9, or 10 consecutive New Data Flags (NDFs) are detected.

Bits 1 through 4 of the pointer word (comprised of H1 and H2 bytes) carry the NDF. More information on the NDF can be found in TR-NWT-000253[5].

(R) 6-18 The network equipment supporting a B-ICI shall exit the LOP state when a valid STS pointer with normal NDF, or a concatenation indicator, is detected in three consecutive frames in the incoming signal.

6.1.2.2.4 Loss of Cell (LOC) Delineation

The network equipment supporting a B-ICI may enter the LOC state when the HEC coding rule is determined to be incorrect seven consecutive times for the incoming signal (i.e., Alpha = 7). A precise definition of LOC state is under study in standards.

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[7] T1M1.3 is proposing a slight change to the LOS definition, but this change will not be approved until later. The current proposed definition [T1M1.3/92-005 (R3), October 1992, Layer 1 Performance Monitoring] is, "An LOS defect is the occurrence of no transitions on the incoming signal (before descrambling) for time T, where $2.3 \leq T \leq 100$ micro-seconds."

The network equipment supporting a B-ICI may exit the LOC state when the HEC coding rule has been confirmed seven consecutive times for the incoming signal (i.e. Delta = 6, Hunt = 1, Delta + Hunt = 7).

See Section 3.5 of this document for further information concerning HEC, Alpha, Delta, and Hunt. LOC is also discussed in Section 10 of T1E1.2/93-020R1[23] and Section 4.5 of I.432[7].

6.1.2.2.5 Path Signal Label Mismatch

(R) 6-19 The network equipment supporting a B-ICI shall follow the Path Signal Label Mismatch states defined in TR-NWT-000253[5].

6.1.2.3 Fault Management Signals

The following Fault Management signals are generated and transmitted/received across the interface to report failure states that persist for a defined period of time. These signals are consistent with those defined in ANSI T1.624[6] and TR-NWT-000253[5].

(R) 6-20 The network equipment on either side of a B-ICI shall meet the requirements associated with generation, detection, activation, and deactivation of Line AIS, Path AIS, Line RDI, and Path FEBE as specified in TR-NWT-000253[5].

Note: Line RDI is called Line FERF in TR-NWT-000253.

- **Path RDI:**

  Path RDI alerts the upstream STS Path Terminating Equipment (PTE) that a downstream failure has been detected along the STS Path.

  (R) 6-21 Path RDI shall be generated within 250 micro-seconds by an STS PTE upon entering LOS, LOF, LOP, or LOC state, or upon detecting Line AIS or Path AIS, by setting bit 5 in the Path Status byte (G1) to '1'. This bit retains this value for the duration of the RDI condition. Transmission of the RDI signal shall cease within 250 micro-seconds when the STS PTE no longer detects the above failure states or Line AIS or Path AIS.

- **Line FEBE:**

  The Line FEBE signal is used to convey the count of the interleaved bit blocks that have been detected to be in error by the Line BIP-8N (B2) bytes. The count has (8N+1) legal values, namely, 0 to 8N errors. The remaining possible values (255 - 8N), represented by the 8 bits of Z2 shall be interpreted as zero errors. N equals 3 for the STS-3c based 155.520 Mbit/s B-ICI.

  The following Line FEBE specification was adopted in SONET standards (ANSI T1X1.5).

  (R) 6-22 A count of the differences in the calculated BIP-8N and the received B2 bytes shall be placed in the 3rd Z2 byte of the STS-3c frame.

6.1.2.4 State Tables for Precedence of Fault Management Signals

To specify the transitions in case of multiple fault conditions, it is necessary to identify the priority of the various fault conditions. Equipment at each side of the B-ICI informs the other of fault conditions in a manner that can be depicted in detail by state tables. Two state tables are defined, one at each side of the B-ICI. Information on these fault conditions are exchanged between the two sides in the form of the fault management signals specified earlier.

(R) 6-23 Equipment at each side of the B-ICI shall transition to failure states on the basis of bilateral agreements.

Transitions are specified by the state tables of I.432[7], T1E1.2/93-020R1[23], and TR-NWT-001112[24].

6.1.3 Physical Layer Operations for the 622.080 Mbit/s STS-12c B-ICI

(R) 6-24 The operations and maintenance functionality defined for the STS-3c (155.520 Mbit/s) B-ICI shall also apply to the STS-12c (622.080 Mbit/s) B-ICI.

6.1.4 Physical Layer Operations for the 155.520 Mbit/s (SDH) STM-1 B-ICI

(R) 6-25 The operations and maintenance functionality for the 155.520 Mbit/s (SDH) STM-1 B-ICI shall be based on ETSI TM-01015[62].

6.2 ATM Layer Operations

This section focuses on the use of OAM cells, identifies the ATM Layer Management functions and procedures at the B-ICI. Management functions at the B-ICI require some level of cooperation between network equipment of the two carriers. The ATM Layer Management functions supported at the B-ICI are grouped into the categories of Fault Management and Performance Management (see Figure 6.2). All functions use OAM cells. Performance management cells could play a larger role in the B-ICI as compared to the UNI.

- Fault Management includes Alarm Surveillance and Connectivity Verification functions. OAM cells are used for exchanging related operations information.

- Performance Management is activated only for selected connections. When active, Performance Management includes the counting of lost or misinserted cells, and the monitoring of bit errors in the payloads of the connection's cells. Cell delay may also be measured, which can be used to estimate the cell delay variation experienced on a connection.

Support of continuity check fault management function and configuration management function (e.g., VP/VC status) are for further study.

In this Version of the document, ATM layer OAM functions apply for point-to-point connections. ATM layer OAM functions for multipoint connections will be provided in future Versions of this document.

Fault Management
- Alarm surveillance (VP, VC optional)
- Connectivity verification (VP, VC)

Performance Management (selected VPs, VCs)
- Lost/misinserted cell counts
- Cell delay variation
- Bit error monitoring

Figure 6.2 ATM Layer Management Functions at the B-ICI

6.2.1 ATM Layer Management Information Flows

Figure 6.3 shows the OAM flows defined for the exchange of operations information between nodes. At the ATM layer, the F4-F5 flows will be carried via OAM cells[8]. The F4 flow is used for segment[9] or end-to-end (VP termination) management at the VP level using VCI values 3 and 4. The F5 flow is used for segment[10] or end-to-end (VC termination) management at the VC level using Payload Type Indicator (PTI) code points 4 and 5. A detailed explanation of the OAM cell flow mechanism is given in CCITT Recommendation I.610[25] and T1S1.5/94-004[26].

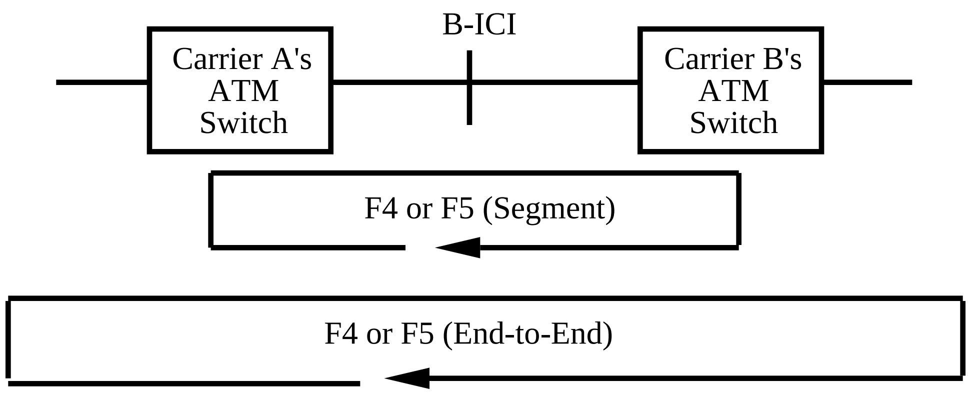

Figure 6.3 ATM Layer OAM Flows at the B-ICI

Virtual Paths and Virtual Channels are always visible at the B-ICI, so the F4 and F5 flows are always supported.

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8 The F1-F5 flows are defined in CCITT Recommendation I.610. F1-F3 are defined for the physical layer, and F4 and F5 are defined for the ATM Layer.

9 For the B-ICI specification, this always includes the case where the segment is the link between the nodes on either side of the B-ICI.

10 For the B-ICI specification, this always includes the case where the segment is the link between the nodes on either side of the B-ICI.

(R) 6-26 Network equipment at a B-ICI shall support the F4 and F5 Management flows as defined in CCITT Recommendation I.610[25] and T1S1.5/94-004[26] for the OAM functions defined in Section 6.2.3.

More detail on OAM flows may be found in Section 4 of CCITT Recommendation I.610[25], Section 3 of T1S1.5/94-004[26], and Section 4 of TA-NWT-001248[27].

6.2.2 ATM OAM Cell Formats

The Virtual Path (VP) operations information is carried via the F4 flow OAM cells. These cells have the same VPI value as the user-data cells but are identified by pre-assigned VCI values. Two unique VCI values are used for every VPC as shown in Figure 6.4. The VCI value = 3 is used to identify a connection between ATM layer management entities (LMEs) on both sides of the B-ICI (e.g., single link segment), and VCI value = 4 is used to identify a connection between end-to-end ATM LMEs.

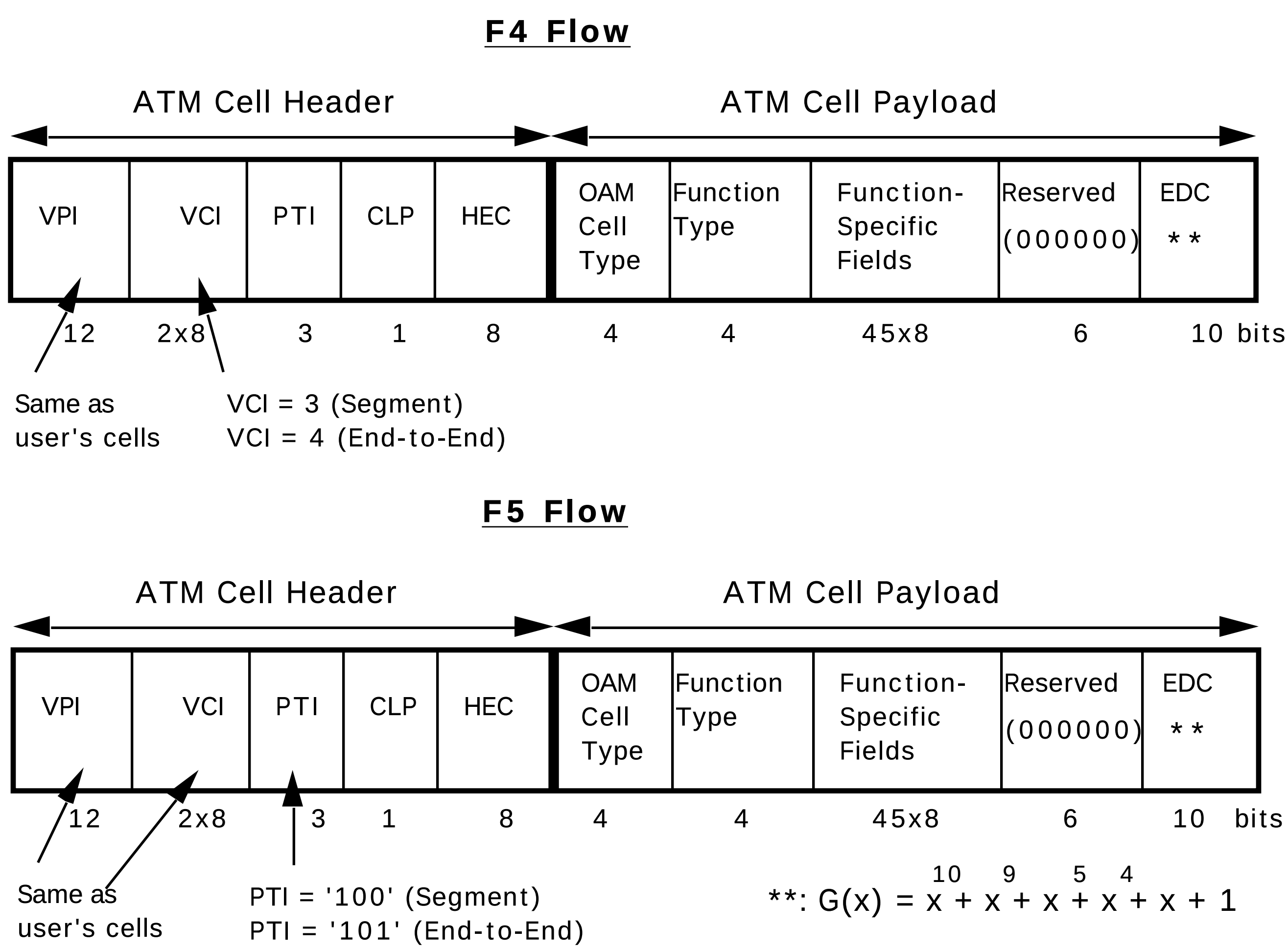


Figure 6.4 Format of the Common Part of the OAM Cell

The Virtual Channel (VC) operations information is carried via the F5 flow OAM cells. These cells have the same VPI/VCI values as the user-data cells but are identified by pre-assigned code points of the PTI field. Two unique PTI values are used for every VCC as shown in Figure 6.4. The PTI value = '100' (i.e., 4) is used to identify the connection between ATM LMEs on both sides of the B-ICI (e.g., single link segment) while the PTI value = '101' (i.e., 5) is used to identify connections between end-to-end ATM LMEs.

End-to-end OAM cells must be passed unmodified by all intermediate nodes. The contents of these cells may be monitored by any node in the path. These cells are only to be removed by the end point of the VPC (F4 flow) or VCC (F5 flow). Segment OAM cells shall be removed at the end of a segment. The format of the common part of the OAM cell is shown in Figure 6.4.

The Error Detection Code (EDC) field of all OAM cells carries a CRC-10 error detection code computed over the OAM cell Information Field excluding the EDC field. It shall be the remainder of the division (modulo 2) by the generator polynomial of the product of x^{10} and the content of the OAM cell information field (i.e., OAM Cell Type, Function Type, Function Specific Fields, Reserved Field, excluding the EDC Field (374 bits). Each bit of the concatenated fields mentioned above is considered as coefficient (modulo 2) of a polynomial of degree 373 using the first bit as coefficient of the highest order term. The CRC-10 generating polynomial is: $G(x) = 1+x+x^4+x^5+x^9+x^{10}$. The result of the CRC calculation is placed with the least significant bit right justified in the CRC field.

One example test cell, with its corresponding calculated CRC-10 value, is shown below to provide some measure of assurance of a correctly implemented EDC generation function.

Example: CRC-10 for an RDI cell. The OAM Cell Type is "0001", the OAM Function Type is '0001', and the next 45 octets are all coded 6A hexadecimal. The Reserved Field consists of six "0" bits. The calculated CRC-10 is AF hexadecimal (i.e., "00 1010 1111"). The 48 octet Information Field is transmitted as:

1 1	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A
6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A
6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A
6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	6 A	0 0	A F

Appendix A of I.610 contains an additional example.

The OAM Cell Type field and the Function Type fields, as specified in ITU-T Recommendation I.610[25] are shown in Table 6.2.

The format of the function-specific fields of the Fault Management OAM cell, as defined in I.610[25], is shown in Figure 6.5.

The format of the function-specific fields of the Performance Management OAM cell, as defined in ITU-T Recommendation I.610[25], is shown in Figure 6.6.

The format of the function-specific fields of the Activation/Deactivation cell, as defined in ITU-T Recommendation I.610[25], is shown in Figure 6.7.

Table 6.2 OAM Type/Function Type Identifiers

OAM Cell Type	Value	OAM Function Type	Value
Fault Management	0001	AIS	0000
		RDI	0001
		Continuity Check	0100
		Loopback	1000
Performance Management	0010	Forward Monitoring	0000
		Backward Reporting	0001
Activation/Deactivation	1000	Performance Monitoring	0000
		Continuity Check	0001
System Management	1111	Not Standardized	

(R) 6-27 Network equipment at a B-ICI shall encode/interpret the OAM cells according to the format and encoding rules defined in ITU-T Recommendation I.610[25] for the OAM functions defined in Section 6.2.3.

Further discussion on each of these cell types may be found in ITU-T Recommendation I.610[25] and GR-1248-CORE[27].

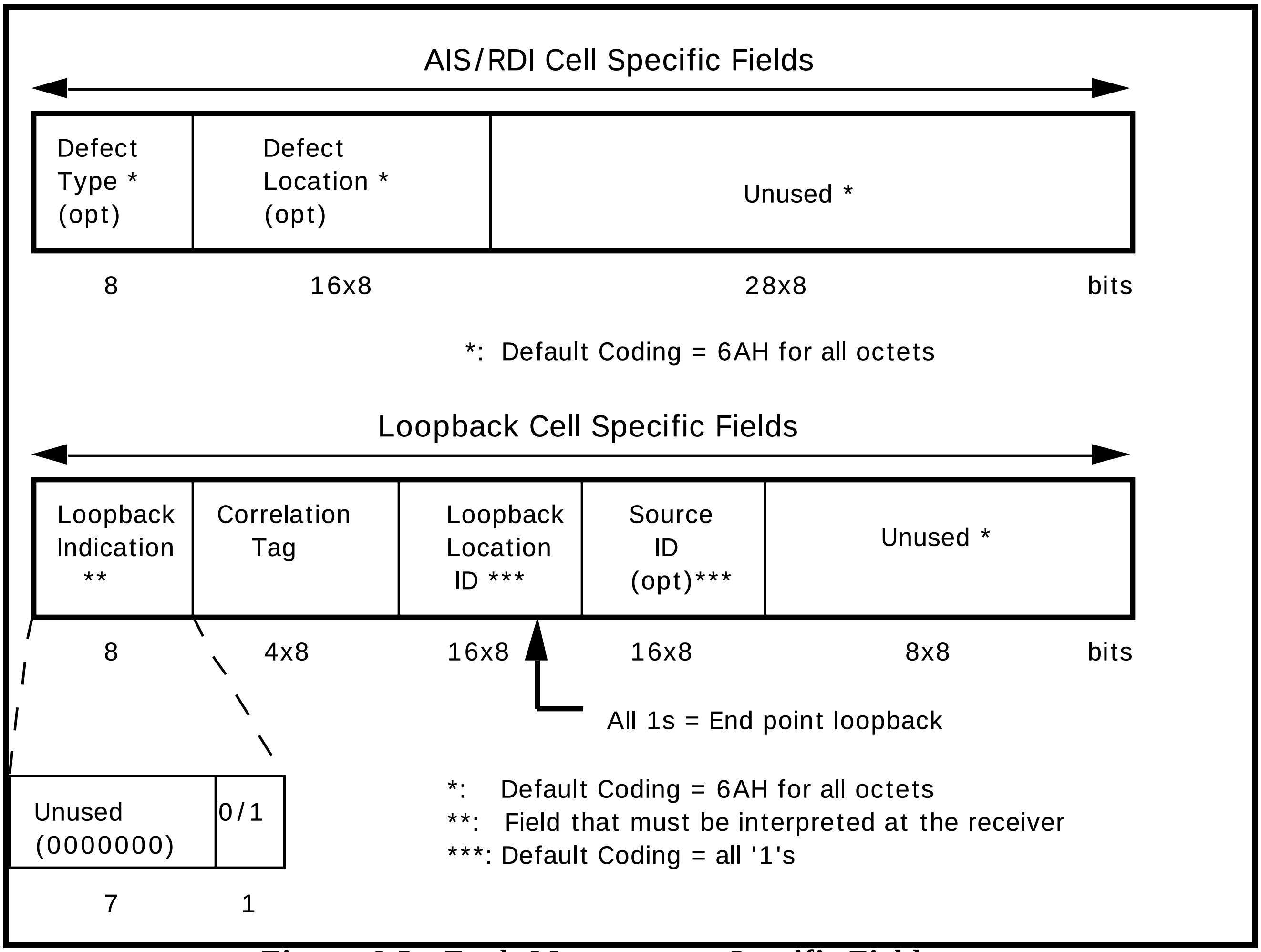
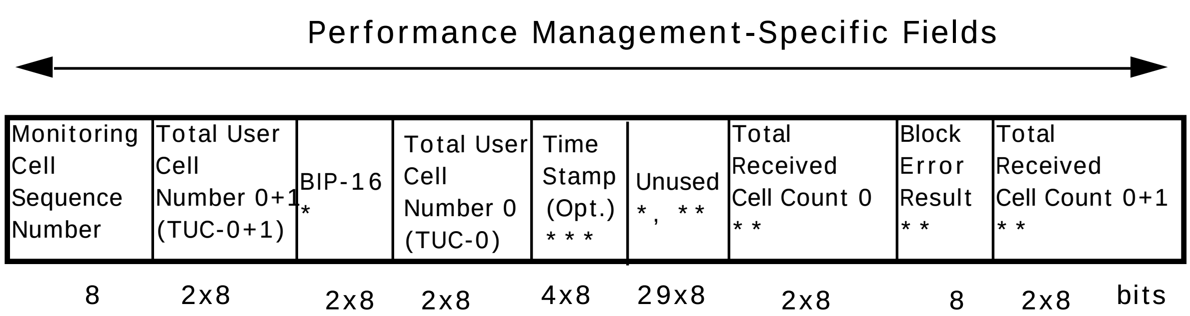


Figure 6.5 Fault Management-Specific Fields



*:Default Coding = 6AH for all octets in backward reporting PM cells
**:Default Coding = 6AH for all octets in forward monitoring PM cells
***:Coding = All 1s when Time Stamp not used

Figure 6.6 Performance Management-Specific Fields

Activation/Deactivation-Specific Fields

Message ID	Directions of Action	Correlation Tag	PM Block Size A-B**	PM Block Size B-A**	Unused Octets*	
6	2	8	4	4	42x8	bits

*:Default Coding = 6AH for all octets
**:Default Coding = 0000

Figure 6.7 Activation/Deactivation Management-Specific Fields

6.2.3 OAM Functions

This section discusses the Fault Management and Performance Management OAM functions to be supported over the B-ICI.

6.2.3.1 ATM Fault Management Functions at the B-ICI

The Fault Management functions at the B-ICI are grouped into three categories: Alarm Surveillance, Connectivity Verification, and Continuity Check.

6.2.3.1.1 Alarm Surveillance

Alarm surveillance at the B-ICI involves detection, generation, and propagation of VPC/VCC failures (failure indications). In analogy with the SONET physical layer, the failure indication signals are of two types: Alarm Indication Signal (AIS) and Remote Defect Indicator (RDI). These signals are carried via OAM cells as defined in Section 6.2.2. The VP/VC AIS (VP-AIS and VC-AIS) is generated by a VPC/VCC node at a connecting point to alert the downstream VPC/VCC nodes that a failure has been detected upstream. The VP-AIS/VC-AIS can be caused by the detection of a VPC/VCC failure or by the notification of a physical layer failure. Upon receiving a VP-AIS/VC-AIS, a VPC/VCC end point at the B-ICI will return a VP-RDI/VC-RDI to alert the upstream nodes that a failure has been detected downstream.

Network equipment at a B-ICI may terminate a connection, or act as an intermediate (i.e., connecting) node. This is shown in Figure 6.8.

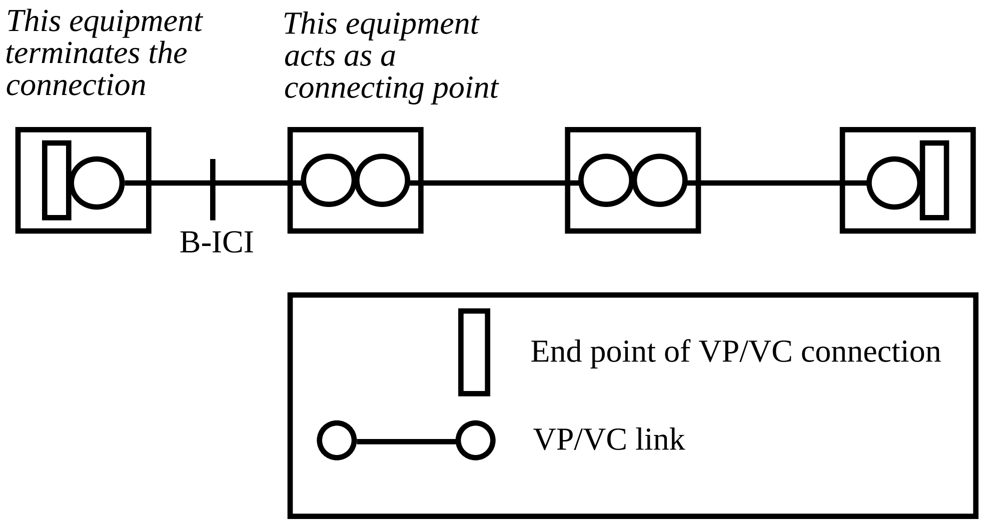


Figure 6.8 Terminating and Intermediate Equipment at a B-ICI

The following requirements apply to network equipment at the B-ICI that terminates a connection.

(R) 6-28 Network equipment terminating a VPC at the B-ICI shall detect incoming VP-AISs and shall generate VP-RDIs in the upstream direction (toward the other carrier's network) to alert the ATM nodes about the failure.

(R) 6-29 Network equipment terminating a VCC at the B-ICI that detects an incoming VC-AIS shall generate a VC-RDI in the upstream direction (toward the other carrier's network).

The following requirements apply to equipment at the B-ICI that acts as an intermediate connection.

(R) 6-30 Network equipment at a B-ICI, acting as an intermediate VP node, shall generate a VP-AIS upon detection of a VPC failure or upon receiving a physical layer failure notification.

(R) 6-31 Network equipment at a B-ICI, acting as an intermediate VC node, shall generate a VC-AIS upon detection of a VCC failure or upon receiving a physical layer failure notification.

The following requirement applies to both intermediate and terminating nodes.

(R) 6-32 Network equipment at a B-ICI inserting Alarm Surveillance cells shall do so at a nominal rate of 1 cell per second per VPC or VCC, as specified in Section 6 of ITU-T Recommendation I.610[25]. The release conditions shall be as specified in ITU-T Recommendation I.610.

More detail on alarm surveillance may be found in ITU-T Recommendation I.610[25] and GR-1248-CORE[27].

6.2.3.1.2 Connectivity Verification

Connectivity verification is supported by the use of the OAM loopback capability for both VP and VC connections. More complete details on this loopback function can be found in I.610 [25]. The VCC or VPC being checked can remain in service while this loopback function is being performed. The OAM Cell Loopback function supported at the B-ICI includes the following four fields:

- Loopback Indication - This eight-bit field identifies, for the end point receiving the OAM cell, whether the incoming cell is to be looped back. A value of '00000001' indicates that the cell should be looped back. All other values indicate that the cell is to be discarded. Before the cell is looped back, the end point shall encode the Loopback Indication field as '00000000'.

- Correlation Tag - At any given time, multiple OAM Fault Management Loopback cells may be inserted in the same virtual connection. As a result, the OAM cell loopback mechanism requires a means of correlating transmitted OAM cells with received OAM cells. The node inserting the OAM cell may put any value in this 32-bit field, and the end point looping back the cell shall not modify it.

- Loopback Location ID (Optional) - This 16 octet field identifies the point(s) along a virtual connection where the loopback is to occur. The default value of all ones is used by the transmitter to indicate the end point.

- Source ID (Optional) - This 16 octet field can be used to identify the originator of the Loopback cell so the originator can identify the looped back cell when it returns. This may be encoded any way that enables the originating point to be certain that it has received the cell it transmitted. The default value is all ones.

  (R) 6-33 Network equipment terminating a connection at a B-ICI that receives OAM cells with a Loopback Indication value other than '00000001', OAM Cell Type = '0001', and Function Type = '1000' shall discard the cell.

  (R) 6-34 Network equipment terminating a connection at a B-ICI that receives OAM cells with a Loopback Indication value of '00000001', OAM Cell Type = '0001', and Function Type = '1000', shall encode the Loopback Indication value as '00000000' and then loopback the cell within one second.

Network equipment inserting loopback cells will do so at a rate low enough to ensure that loopback cells amount to less than one percent of the capacity of any link in the connection.

6.2.3.1.2.1 Segment Loopback

An ATM-level loopback can be performed across the B-ICI using segment loopback cells which are looped back by the end point of a VPC or VCC segment. The segment can be defined as the link between the ATM nodes on either side of the B-ICI. Segment end points must either remove these cells or loop them back depending on the value in the Loopback Indication field. That is, these cells must not travel beyond the segment in which they are generated. Segment loopback cells are indicated by a PTI value of '100' for VCCs and a VCI value of 3 for VPCs. An example of how the segment loopback cell is used is shown in Figure 6.9.

6.2.3.1.2.2 End-to-End Loopback

End-to-end loopback cells (i.e., those with a Loopback Location ID of all 1s) are only looped back by the end point of a VPC or VCC. These cells may be inserted by any node in the connection (intermediate or end point) and may be monitored by any node. However, only end points may remove these cells. End-to-end loopback cells are indicated by a Payload Type Indicator (PTI) value of '101' for VCCs and a VCI value of 4 for VPCs. An example of how the end-to-end loopback cell is used is shown in Figure 6.9.

The switch supporting the B-ICI shall support the insertion of end-to-end loopback cells. It shall also support the copying of received loopback cells to check for the return of loopback cells it initiated.

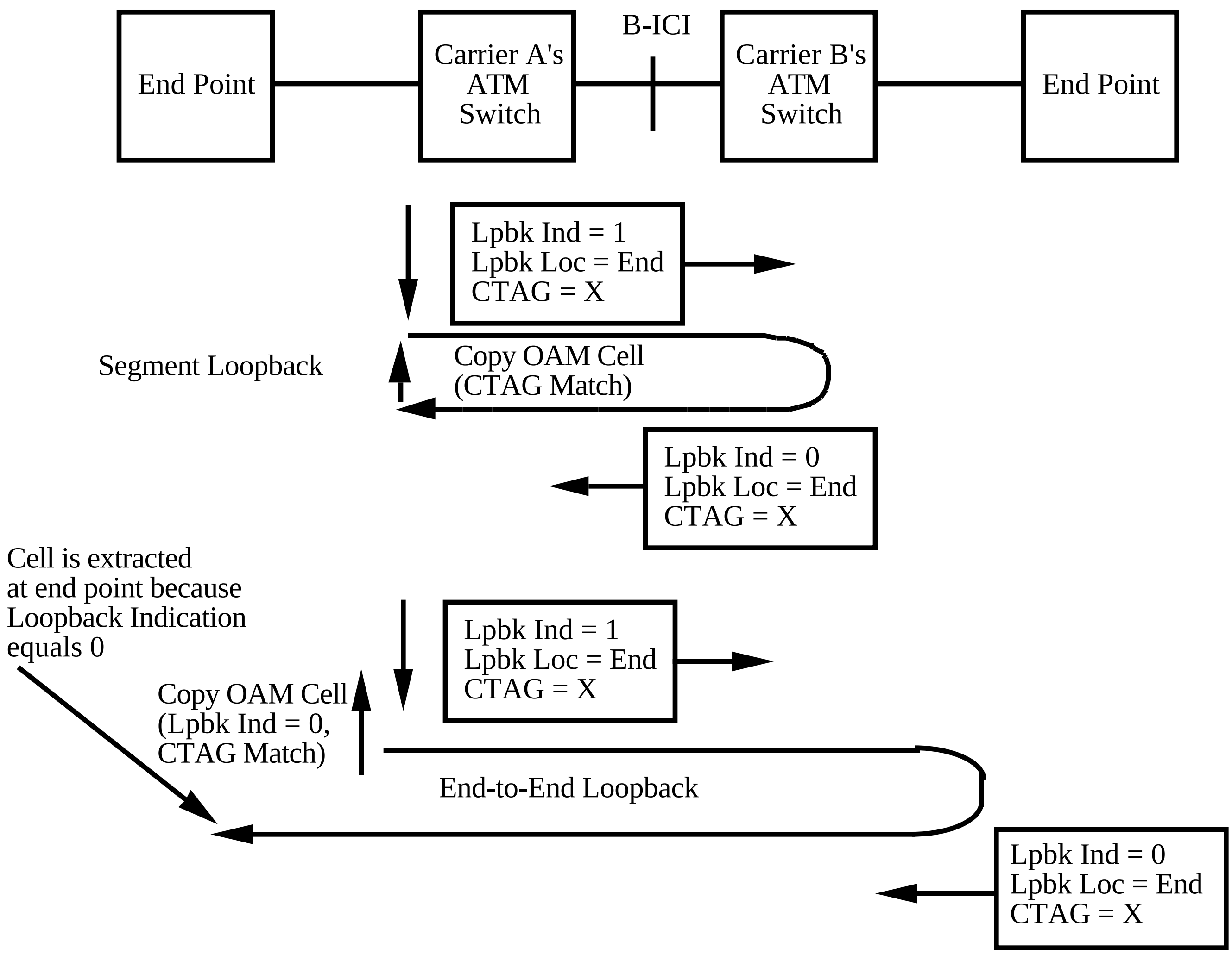


Figure 6.9 The Loopback Function

6.2.3.1.3 Continuity Check

The need for Continuity Check is for further study. If used for a connection that crosses a B-ICI, it could be activated/deactivated using the activation/deactivation "handshaking" procedures of ITU-T Recommendation I.610[25] or through TMN, using management system commands at each side of the B-ICI. More detail on the Continuity Check procedure, and its activation/deactivation, may be found in I.610.

6.2.3.2 Performance Management Functions at the B-ICI

Performance Management functions at the B-ICI consist of monitoring selected connections for lost or misinserted cells, bit errors, and (optionally) cell delays. A node needs to only support performance monitoring for a limited number of connections or segments that it terminates. When used across a B-ICI, it must first be activated, either by using Activation/Deactivation OAM cells, as specified below in Section 6.2.3.3, or through TMN procedures.

6.2.3.2.1 Performance Management Cell Payload Structure

The Performance Management cell payload structure is specified in ITU Recommendation I.610[25], and its function-specific fields are shown in Figure 6.6. The fields of the Performance Management cell are described below.

- OAM Cell Type: The OAM Type is "Performance Management," encoded as 0010.
- Function Type: The Function Type field specifies whether the cell is to be used for Forward Monitoring (0000) or Backward Reporting (0001). Figure 6.6 shows which fields are used only for the forward monitoring function, and which are used only for the backward reporting function.
- Monitoring Cell Sequence Number (MCSN): This field carries the sequence number of the Performance Management cell, modulo 256. This field allows for the detection of a lost or misinserted Performance Management OAM cell.
- Total User Cell Number related to the CLP=0+1 user cell flow ($TUC\text{-}_{0+1}$): This field indicates the current value of a running counter related to the total number (modulo 65536) of transmitted user cells[11] (i.e., CLP=0+1), when the Forward Monitoring PM cell is inserted. In case of a Backward Reporting PM cell, this field contains the $TUC\text{-}_{0+1}$ value copied from the paired Forward Monitoring PM cell.
- Total User Cell Number related to the CLP=0 user cell flow ($TUC\text{-}_{0}$): The use of this field is similar to the use of the $TUC\text{-}_{0+1}$ field. It is related to the transmitted user cells with a CLP value equal to '0'.
- Block Error Detection Code (BEDC): This field contains the even parity BIP-16 error detection code computed over the information fields of the block of user-data cells transmitted after the last monitoring cell. In the Backward Reporting PM cell, this field is unused, and all octets are encoded as "6A" hexadecimal.

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11 For the purposes of OAM cell flows, "user cells" have been precisely defined in I.610. All OAM-related text in this document adopts the I.610 definition.

- Time Stamp: This field is optional and may be used to represent the time at which the OAM cell was inserted. T1S1.5/94-004[26] specifies that the time is encoded in units of .01 micro-seconds. However, the node does not need to be accurate to .01 micro-seconds. (A precision[12] of at least one micro-second seems sufficient.) If the field is not used, this field is set to all 1s. In the backward reporting cell, procedures for use of the time stamp field have not been defined, and so the field should be set to all 1s.

- Unused: Octets in this field are encoded as "6A" hexadecimal ('01101010').

- Total Received Cell Count related to the CLP=0 user cell flow (TRCC-$_{0}$): This field is used for Backward Reporting OAM cells only. The use of this field is similar to the use of the TRCC-$_{0+1}$ field. It is related to the total number of received user cells with a CLP value equal to '0'.

- Block Error Result (BLER$_{0+1}$): This field is used for Backward Reporting OAM cells only. It carries the number of errored parity bits detected by the BIP-16 code of the paired Forward Monitoring cell. This number is only inserted in the corresponding Backward Reporting Cell if the following two conditions are met:
  (i) The number of user data cells (i.e., CLP=0+1) between the last two Forward Monitoring OAM cells equals the difference between the TUC of the last two Forward Monitoring OAM cells
  (ii) The MCSN of the last two PM OAM cells used for forward monitoring are sequential.
  Otherwise the field shall be encoded as all 1s. In the case of Forward Monitoring OAM cells, this field is unused and coded as 6AH.

- Total Received Cell Count related to the CLP=0+1 user cell flow (TRCC-$_{0+1}$): This field is used for Backward Reporting OAM cells only. All user cells are considered (i.e., CLP=0+1). This field carries the current value of a running counter related to the total number (modulo 65536) of received user cells (CLP=0+1), read when a Forward Monitoring PM cell is received.

6.2.3.2.2 Mechanism for VP/VC PM Cell Generation

This section describes the procedure of generating Performance Management OAM cells at a B-ICI. A Performance Management cell contains information about a block of user-information cells of one connection; Performance Management and other OAM cells such as Fault Management cells are not part of the block. Figure 6.10 illustrates the concept of a block. The allowable nominal block sizes are 128, 256, 512, and 1024 cells.

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[12] Here "precision" refers to the smallest counting unit, and not the drift of the clock. Thus a node with a precision of 1 microsecond would increment the Time Stamp field in multiples of 100.

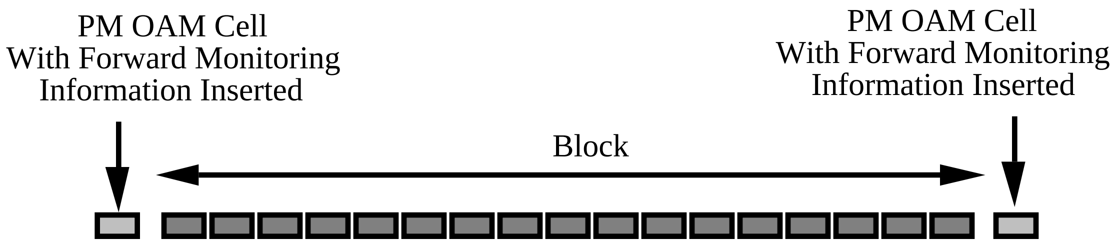

Figure 6.10 A Performance Monitoring Block

A Performance Management cell may be a forward monitoring PM cell, or a Backward Reporting cell.

6.2.3.2.2.1 Segment VP/VC Monitoring

The steps for generating PM cells when performing segment VP/VC performance monitoring are listed below.

1. The originating VP/VC segment end point will generate a BIP-16 error detection code over the payloads of the user information cells in the block. Then the end point will place the following information in the payload of a Performance Management OAM cell: the Monitoring Cell Sequence Number of the PM cell (modulo 256), the TUC_{0+1}, the TUC_0 (modulo 65536), the BIP-16, and an optional Time Stamp. This OAM cell will be transmitted before the next user-information cell of the VPC/VCC. Although the block size for a segment has a nominal value, the actual size of any given block may vary from that nominal value. This variation allows PM cells to be inserted without delaying the flow of user cells.

2. The far-end VP/VC segment end point will compare the number of the cells received in the block with the difference between the received Total User Cell 0+1 (TUC_{0+1}) count and the TUC_{0+1} count at the end of the last received block. A mis-match in this comparison indicates lost or misinserted cells. If no cells have been lost or misinserted and the MCSN of the PM cell is consecutive, the end point will compare the BIP-16 in the forward monitoring cell with the result of an identical BIP-16 calculation it has performed over the same number of user-information cells. A mis-match in this comparison indicates bit errors in the block. The number of errored parity bits in the BIP-16 code, the running count of received 0+1 cells, the running count of received 0 cells, as well as the TUC_{0+1} and TUC_0 of the corresponding transmitted cell, are stored until the backward reporting cell is sent. If the BLER cannot be calculated, the Block Error Result in the backward report is coded as all 1s.

3. The far-end VP/VC segment end-point will report the results back to the originating (i.e., near-end) VPC/VCC end point, using a Performance Management OAM cell to send a backward report. This report may be used by monitor points along the VPC/VCC to monitor end-to-end performance.

More detailed discussion about this procedure may be found in GR-1248-CORE[27].

(R) 6-35 Network equipment at a B-ICI that terminates a segment on which performance monitoring is active in the outgoing direction, shall generate PM cells containing forward monitoring information. These cells shall be generated according to the procedures specified in ITU-T Recommendation I.610[25], and described in this section.

(R) 6-36 Network equipment at a B-ICI that terminates a segment on which performance monitoring is active in the incoming direction, shall generate PM cells containing backward reporting information. These backward reports shall be generated according to the procedures specified in ITU-T Recommendation I.610[25], and described in this section.

(R) 6-37 Network equipment at a B-ICI that sends backward reports shall send those reports within one second after receiving the PM cell with the forward monitoring information. The end point shall send backward reports in the same sequence in which the corresponding forward monitoring OAM cells were received.

This procedure is performed symmetrically for both directions of VPC/VCC transmission if bidirectional PM has been activated. Figure 6.11 shows a connection segment in which PM is active in both directions. This provides each VPC/VCC node in the segment the capability to monitor the bidirectional VPC/VCC. In Figure 6.11, the left-most point collects history data for both the left-to-right and right-to-left directions of user data flow. In configurations in which there are intermediate points, the intermediate point can collect history data for both directions as well.

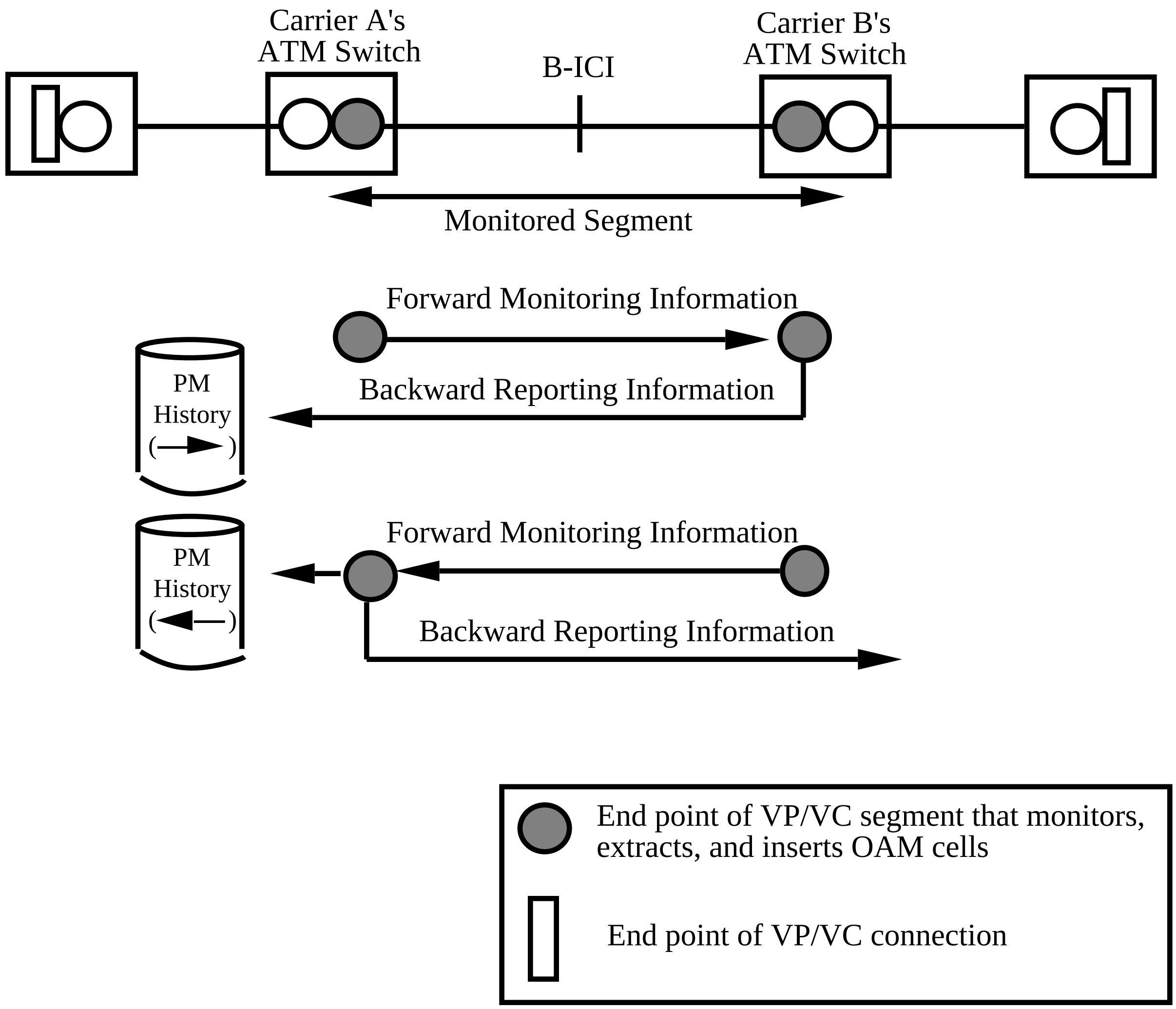

Figure 6.11 Segment Performance Monitoring Across a B-ICI

A user may wish to have only uni-directional performance monitoring. In this case, there is still a bi-directional flow of PM OAM cells, because the reporting flow is needed across a B-ICI. There is one pair of PM cell flows for each direction of user data flow that is being monitored.

Network equipment at a B-ICI that is an intermediate point of a connection/segment over which PM cells are being generated should be capable of monitoring (i.e., copying) the PM cells to read the backward report. This allows a carrier to monitor the performance of connection/segment from one switch, when desired.

(R) 6-38 Network equipment at a B-ICI shall be capable of generating PM cells on a minimum number of simultaneous connections/segments. This minimum number depends on the rate of the interface.

6.2.3.2.2.2 End-to-End VP/VC Monitoring

In some cases, equipment at one end of a B-ICI may be at the end point of a connection on which end-to-end performance monitoring is desired. Thus equipment that terminates a B-ICI should support performance monitoring of end-to-end VP/VC connections. Figure 6.12 shows an end-to-end connection that terminates at a B-ICI at one end point. (For example, the network equipment supporting the B-ICI might provide SMDS service.) In this example, only one direction of user information cells is being monitored, and history data is collected only at the intermediate point.

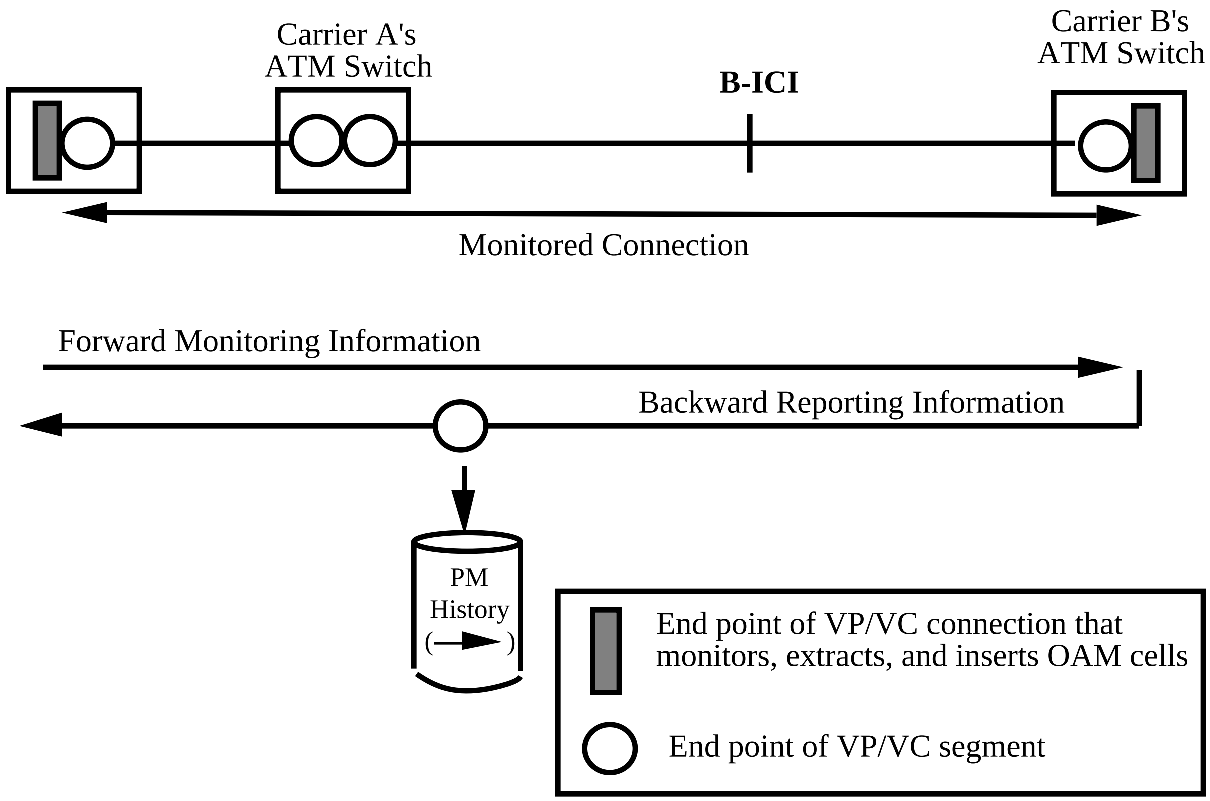

Figure 6.12 End-to-End Performance Monitoring Across a B-ICI

The procedures for end-to-end VP/VC performance monitoring are essentially the same as the end-to-end procedure described earlier. One difference is that Performance Management OAM cells are inserted and extracted at the end points of the connection, instead of at end points of a segment. The second difference, as specified in ITU-T Recommendation I.610[25], is that PM cells are "forced" into the connection when necessary to ensure that a fixed average block size is maintained. However, the actual size of any given block may vary ± 50% from that nominal value. This variation allows PM cells to be inserted without delaying the flow of user cells in most cases.

(R) 6-39 Network equipment at a B-ICI shall support end-to-end performance monitoring for specified VPC/VCC connections. This entails following the same requirements as for segment performance monitoring, except that the generation of Performance Management cells occurs at connection end points, and an average block size is enforced.

6.2.3.3 OAM Activation/Deactivation Functions at the B-ICI

This section presents the procedure for activating and deactivating the VP/VC level performance monitoring function across a B-ICI. The procedures presented here apply to equipment at a B-ICI activating the monitoring function for either end-to-end VP/VC connections or VP/VC segments, *as long as at least one connection/segment end point is at a B-ICI*. The term "connection/segment" is used to refer to either the entire end-to-end VP/VC connection or a segment of it. One or both end points of the connection/segment may be at a B-ICI, as shown in Figure 6.13.

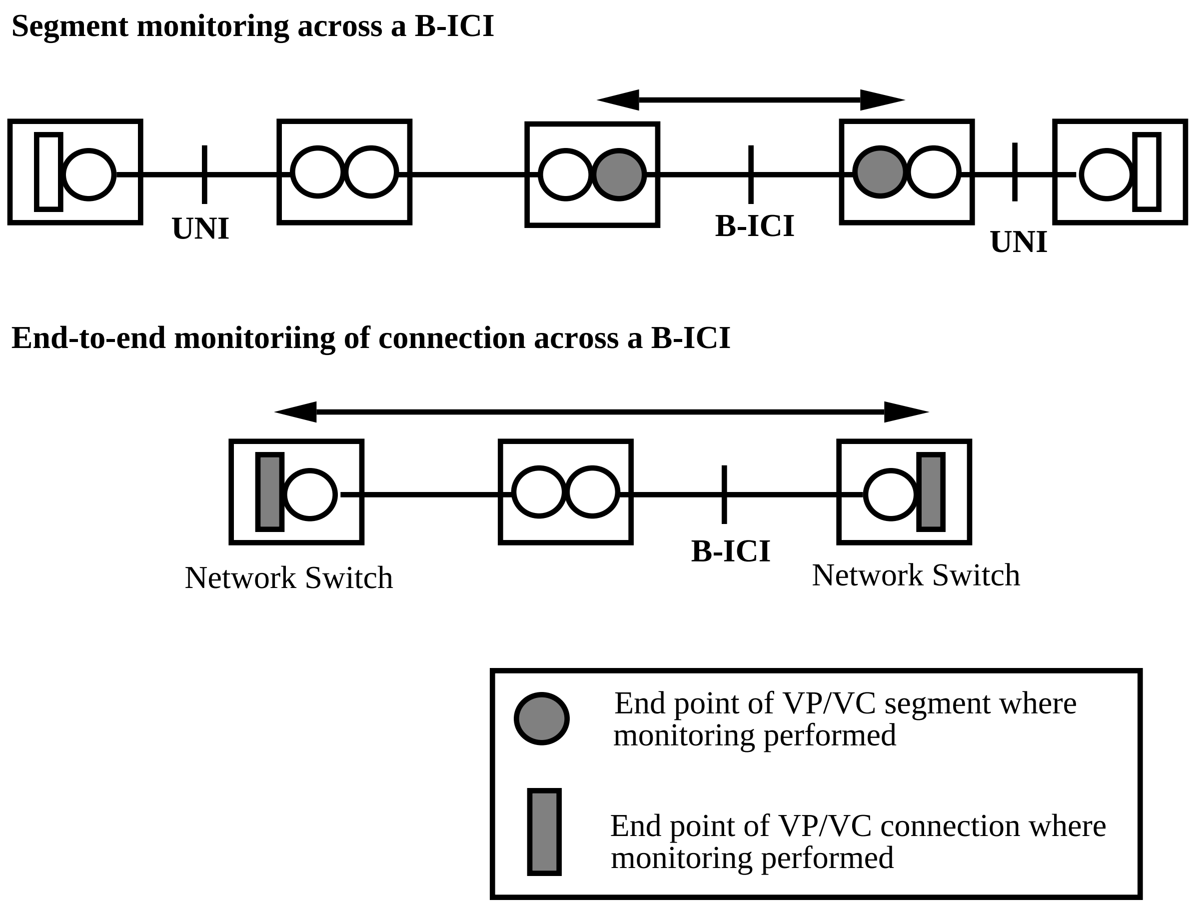

Figure 6.13 Examples of Performance Monitoring of Connections and Segments

The activation/deactivation of VP/VC performance monitoring at a B-ICI is a system management function, initiated by the appropriate Management System through the Telecommunications Management Network (TMN). Initiation may be done entirely via TMN (in which case the different administrations must coordinate - see I.610 for more information), or by using Activation/Deactivation OAM cells. Within an administration, TMN may be adequate, but OAM cell use is attractive across carrier boundaries.

6.2.3.3.1 Activation/Deactivation Cell Payload Structure

The activation/deactivation cell format, as defined in ITU-T Recommendation I.610[25], is shown in Figure 6.7, and each field is briefly described below.

Table 6.3 Message ID Field Values in the Activation/Deactivation Cell

Message	Value
Activate	000001
Activation Confirmed	000010
Activation Request Denied	000011
Deactivate	000101
Deactivation Confirmed	000110
Deactivation Request Denied	000111

- Message ID (6 bits): This field indicates the message ID for activating or deactivating VP/VC functions. Code values for this field are shown in Table 6.3.
- Directions of Action (2 bits): This field identifies the direction(s) of transmission to activate or deactivate the OAM function. The A-B and B-A notation is used to differentiate between the direction of user data transmission away from or towards the activator/deactivator, respectively. This field value is used as a parameter for the "Activate" and "Deactivate" messages. This field shall be encoded as '01' for B-A, '10' for A-B, '11' for two-way action, and '00' (default value) when not applicable.
- Correlation Tag (8 bits): A correlation tag is generated for each message so nodes can correlate commands with responses.
- PM Block Size A-B (4 bits): This field specifies the A-to-B PM block size required by the activator for Performance Monitoring. Currently defined values are shown in Table 6.4. This field value is used as a parameter for the "Activate" and "Activation Confirmed" messages. The default value for this field shall be '0000' for all other messages and when activating/deactivating Continuity Check.
- PM Block Size B-A (4 bits): This field specifies the B-A block size required by the activator for the Performance Monitoring function. It is encoded and used in the same manner as the PM Block Size A-B field.

Table 6.4 PM Block Size Encodings

Message Type	PM Block Size	Coding

Other	unused	0000
Activate and Activate Confirmed for performance monitoring	1024	0001
	512	0010
	256	0100
	128	1000

6.2.3.3.2 PM Activation and Deactivation Procedures

The performance monitoring activation and deactivation handshaking procedures are illustrated in Figure 6.14. In the figure, the vertical flows represent messages or stimuli provided by an external source, such as a Management System via the TMN, to activate performance monitoring over a particular VP/VC connection or segment. The horizontal flows represent operations messages internal to the VP/VC itself via OAM cells. For the purposes of this specification, at least one, and possibly both, of the end points are at a B-ICI. The message flows for activating and deactivating performance monitoring (PM) are specified in ITU-T Recommendation I.610[25].

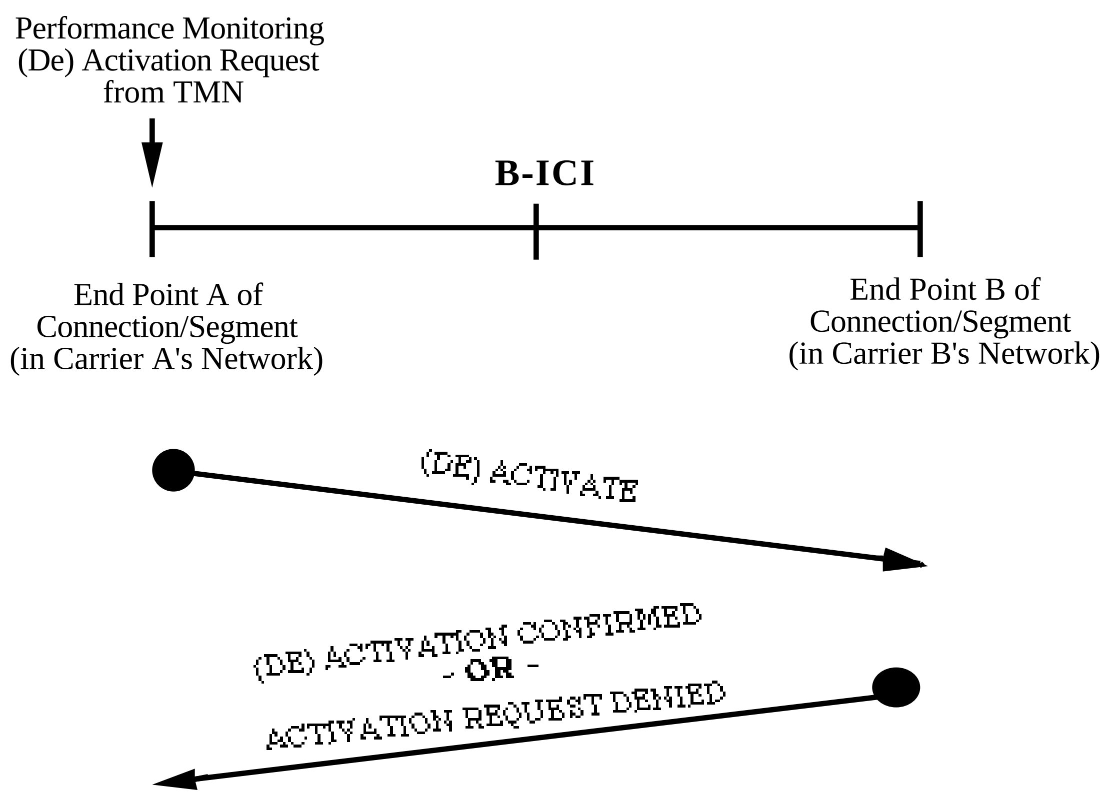

Figure 6.14 Handshaking Procedure for PM Activation and Deactivation

The following two sections provide a verbal description of the figure, to clarify the actions implied by the "handshaking" figure.

6.2.3.3.2.1 PM Activation Procedure

Below is a verbal description of the activation "handshaking" procedure.

- Request for PM Activation: An end user or Management System initiates a request at one end of the connection/segment. By definition, this end point is "A", and the other end point is "B". The initiation includes a specification of the direction(s) of PM to activate, and the requested block size in the A-B direction (if appropriate) and the B-A direction (if appropriate). If end point A can accept the request, then end point A starts a >= 5 second timer. If end point A can support the PM request, it sends an "Activate" message, including the block size value and directions of action, to end point B.

- Send "Activation Confirmed" message or "Activation Request Denied" message: End point B determines whether it can support the requested block size. If it can, it sends an "Activation Confirmed" message to end point A. End point B begins the following processes: (1) it generates PM cells, if PM was activated in the B-A direction[13], and (2) it waits to receive PM cells, if PM was requested in the A-B direction[14].

  If end point B cannot support the PM activation request, it sends an "Activation Request Denied" message back to end point A. End point A informs the PM activation requester of the denial.

- Beginning of PM at End Point A: When end point A receives the confirmation, it begins the same activities that end point B did, where appropriate, and notifies its Management System that performance monitoring activities have begun.

6.2.3.3.2.2 PM Deactivation Procedure

The performance monitoring deactivation handshaking procedure is described below.

- Request for PM Deactivation: An end user or Management System initiates a request at one end of the connection/segment. By definition, this end point is "A", and the other end point is "B". The initiation includes a specification of the direction(s) of PM to deactivate. The two PM Block Sizes fields are not used, and hence are coded as '0000'. End point A first determines whether PM cells are being generated in the requested direction. If not, the request is denied, and the PM deactivation requester is informed. If end point A can accept the request, then end point A starts a >= 5 second timer. If end point A has no reason to deny the deactivation request, it relays a "Deactivate" message to end point B.

- Send "Deactivation Confirmed" message: End point B sends a "Deactivation Confirmed" message to end point A. End point B makes sure that PM cells are not being generated for the appropriate directions, if the deactivation request included the B-A direction.

- Deactivation of PM at End Point A: When end point A receives the confirmation or when the timer expires, it ends the same activities that end point B did, where appropriate, and notifies the appropriate Management System that performance monitoring activities have ended.

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[13] I.e., if the "Direction of Action" field = '01' or '11'.

[14] I.e., if the "Direction of Action" field = '10' or '11'.

More details on the PM activation/deactivation procedures are specified in I.610[25].

6.2.3.3.2.3 Responses and Actions Resulting from a Deactivation Request

The following matrix indicates the response that should be returned and the actions that should be taken when a deactivation request is received.

The matrix indicates the four possible PM states (across the top of the matrix) that the receiving switch can be in when it receives the Deactivation request. These four states are:

1. PM is not active,
2. PM is active in the user data flow A-B,
3. PM is active in both user data flows A-B and B-A, and
4. PM is active in the user data flow B-A.

There are three possible deactivation requests that can be received at B. They are:

1. Deactivate PM flow A-B,
2. Deactivate PM flow in both directions A-B and B-A, and
3. Deactivate PM flow B-A.

The matrix shown in Figure 6.15 shows all combinations of possible activation states and received deactivation messages. There are two items described in each location of the matrix: 1) the response to the deactivation request by B, and 2) the action taken by B.

6.2.3.3.3 Performance Monitoring Activation/Deactivation Requirements

(R) 6-40 In support of on-demand VP/VC Performance Monitoring for connections and/or segments terminated at a B-ICI, network equipment at a B-ICI shall provide the capability of activating and deactivating the VP/VC Performance Monitoring function according to the procedures specified in I.610[25], and described in Section 6.2.3.3.2.

In order to provide for early interoperability, initially only one-way activation is required.

Current PM State / Deactivation Request	No Active PM Process	Data Flow (→) Report (←)	Data Flow (→) Report (←) (and) Data Flow (←) Report (→)	Data Flow (←) Report (→)
A Data Flow → B Report ← (Dir. of Action = '10')	Response: Ack request Action: No action taken	Response: Acknowledge request Action: Stop sending PM report for flow A-B	Response: Acknowledge request Action: Stop sending PM report for flow A-B; continue sending PM for B-A	Response: Acknowledge request Action: No action taken
A Data Flow → B Report ← (and) A Data Flow ← B Report → (Dir. of Action = '11')	Response: Acknowledge request Action: No action taken	Response: Acknowledge request Action: Stop sending PM report for flow A-B; ignore other part of request	Response; Acknowldege request Action: Stop sending PM report for flow A-B; stop sending PM flow B-A	Response: Acknowledge request Action: Stop sending PM flow B-A; ignore other part of request
A Data Flow ← B Report → (Dir. of Action = '01')	Response: Acknowledge request Action: No action taken	Response: Acknowledge request Action: No action taken	Response: Acknowledge request Action: Stop sending PM flow B-A; continue sending PM report for flow A-B	Response: Acknowledge request Action: Stop sending PM flow B-A

Figure 6.15 Responses to PM Deactivation Requests

(R) 6-41 Network equipment at a B-ICI that receives an "Activate" message for Performance Monitoring shall support requests for PM in the direction of A-B (i.e., when the "Directions of Action" field = '10'). It may also support activation requests for the direction B-A or for bi-directional activation (both A-B and B-A).

(R) 6-42 When network equipment at a B-ICI receives an "Activate" or "Deactivate" message for Performance Monitoring, it shall send the appropriate return message within 1 second.

(R) 6-43 Network equipment at a B-ICI shall disable Performance Monitoring even if no response is received from a deactivation request before the timer expires. For interoperability, the network equipment at a B-ICI shall send the deactivation request before disabling Performance Monitoring.

Network equipment at a B-ICI may choose to collect data on any VP/VC it terminates or accesses, on which Performance Monitoring is active (i.e., when PM cells flow over the connection/segment). Data collection is performed when requested by the appropriate Management System; activation/ deactivation of data collection is separate from the activation/ deactivation procedure for PM cells.

6.3 Additional Operations Considerations

Agreement will be needed on aspects of some service management processes to allow carriers to negotiate and manage ATM connections that cross the B-ICI. Figure 6.16 shows exchange of management information between carriers. Agreement is also needed on which management data should be exchanged. This will satisfy a short-term need to support manual methods, and provide a basis for establishing automated interfaces (where appropriate) in the future. It is acknowledged that some management information exchange may be unique between a given pair of carriers; such exchanges may be defined via bilateral agreements.

In this release of the B-ICI Specification, some guiding principles and a framework for further work is provided.

The following guidelines are proposed:

- Management information for inter-carrier CRS, FRS, and SMDS should be exchanged between carriers using existing methods where appropriate. For example, it is desirable that the ATM-specific aspects of procedures for FRS and SMDS, be consistent with the procedures of the Frame Relay Forum's (FRF's) Inter-Carrier Committee (see [29]) and the SMDS Interest Group's (SIG's) Inter-Carrier Working Group (see [30] and [31] where applicable.

- Management information to be exchanged between carriers should be identified by examining service management processes. (These processes are defined below.)

- This section should document agreements on ATM network-specific information to be exchanged, or changes in existing procedures.

6.3.1 Service Management Processes

The need for management information exchange between carriers will be identified by analyzing the service management processes (i.e., work processes) required by carriers to offer service. The activities that may require the exchange of management information between carriers may be categorized as:

- Service Activation and Deactivation: "Service Activation" refers to the set of activities required to establish new service (e.g., a new CRS connection) for a customer. The term "Ordering and Provisioning" is sometimes used. "Service Deactivation" refers to the activities required to terminate a service for a customer.

Procedures exist for one carrier to order non-ATM-based services from another carrier, so procedures and systems are in place that can be modified or supplemented to support ATM. In addition, procedures are being defined for FRS and SMDS for ordering and provisioning these two services.

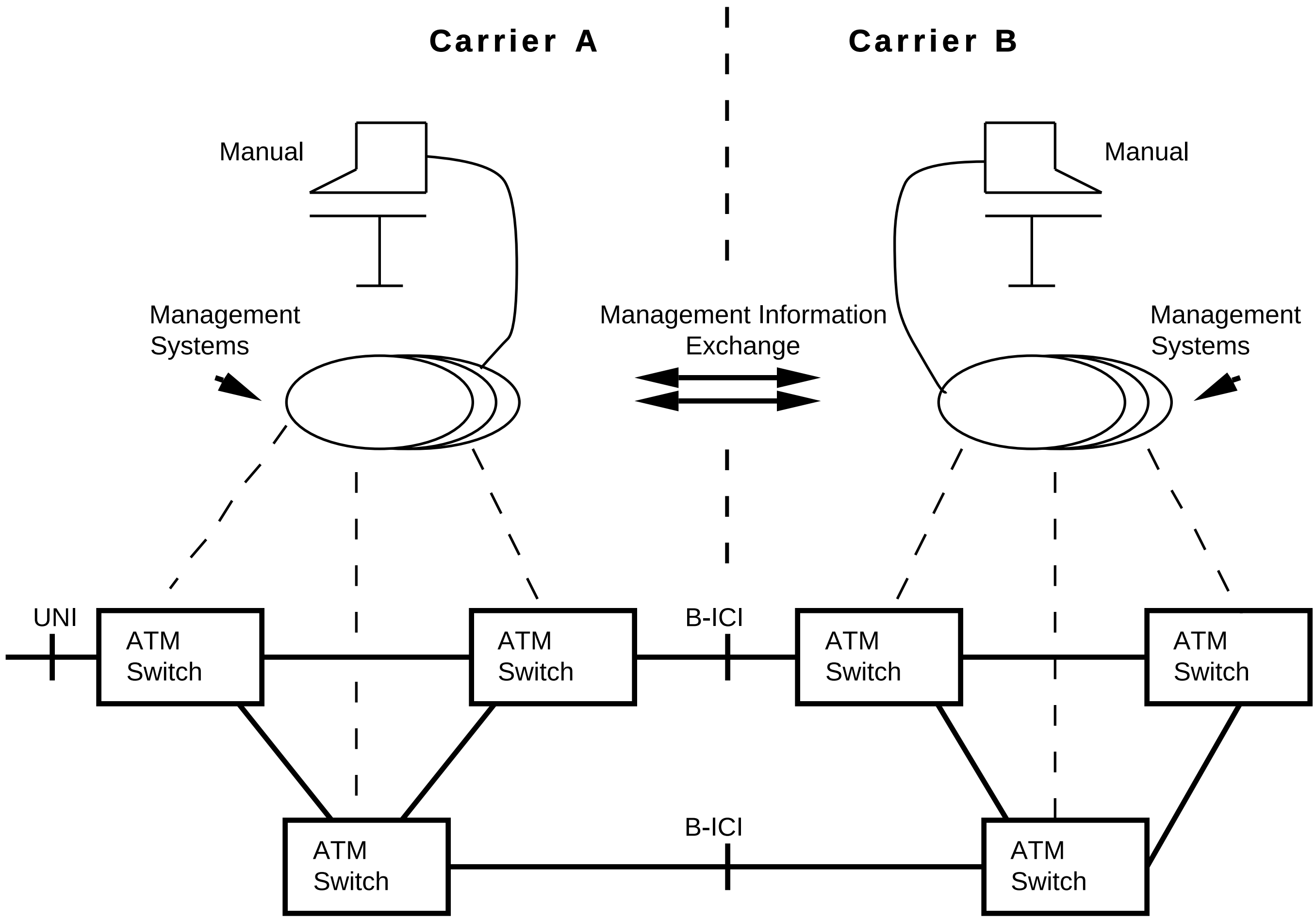

Figure 6.16 Exchange of Management Information Between Carriers

- Service Assurance: "Service Assurance" refers to the set of activities required to maintain the services provided to customers. It may be reactive (responding to troubles reported by a customer) or pro-active (e.g., continuous monitoring of the network to detect alarms). This includes activities such as Trouble Administration and Performance Monitoring.

  Trouble administration includes: one carrier detecting a trouble and reporting it to another carrier, one carrier requesting trouble status information from another, and a carrier asking the carrier with the trouble for its estimate of the required repair time. Other activities are possible. Procedures to support a B-ICI should be consistent with existing procedures, with modifications or supplements to satisfy ATM-specific needs.

Carriers may exchange management information about traffic and performance of B-ICI links and connections within those links. This can include information about both the ATM layer and the service layer.

- Usage Metering: "Usage Metering" refers to the activities required to gather the information needed to support accounting management for services. Procedures to exchange accounting information between carriers have been specified for non-ATM-based services, so those procedures and systems can be modified or supplemented to support ATM. It is desirable that the procedures for usage metering for CRS, and the ATM-specific aspects of usage metering for CES, FRS or SMDS on a B-ICI, be consistent with similar procedures defined elsewhere. (For example, see [29] and [31].)

6.3.2 Management Information to Be Exchanged Between Carriers

Below are various types of information that may be exchanged between carriers. The list below is an initial framework for future efforts to make a more detailed specification. In the discussion of each type, examples are given.

a. General System and B-ICI Information: This includes general system and B-ICI information, such as the system's name, location, the contact person, interface description (e.g., DS3, STS-3c), and administrative status (e.g., In-Service, Out-of-Service).

b. Ordering and Provisioning Information: This is information needed for one carrier to order service from another, except for configuration information, which is listed separately. The procedure followed will vary depending on factors such as whether physical facilities already exist, or whether the service already exists on the B-ICI (e.g., an order may be the first request for CRS on an established B-ICI that currently carries only FRS). The procedures used for the physical layer should be very similar to today's procedures. It will include information such as the service being ordered, the required bandwidth, a requested VPI/VCI, and the date for which service is requested.

c. Physical Layer and ATM Layer Specific Configuration Information: This information type includes physical and ATM-layer configuration information about a B-ICI. This allows carriers to confirm that they share the same view of the B-ICI at the physical and ATM layers. This type of information would be used by multiple service management processes. Configuration information for B-ICIs should include physical-level and ATM-level items such as:

— Physical: Switch ID, B-ICI physical link ID, transmission type, and media type.

— ATM Layer: Maximum number of VPCs, number of configured VPCs; maximum number of VCCs, and number of configured VCCs.

— VP Layer: VPI, and the following, if applicable: shaping descriptor, policing traffic descriptor, and QOS Category.

— VC Layer: VCI, and the following, if applicable: shaping descriptor, policing traffic descriptor, and QOS Category.

In order to satisfy customers desiring high-reliability service across a B-ICI, it is desirable for carriers on each side of a B-ICI to have the information required to quickly reroute or quickly reconfigure traffic to an alternate route in the event of a failure. An example of this would be to pre-provision a VPC/VCC that will serve as an alternate route when a fault is detected in the primary route.

d. Service-Specific Configuration Information: Service-specific configuration information will also be needed. Principles for specifying FRS and SMDS specific information will be established in the FRF's Inter-Carrier Working Group and SIG's Inter-Carrier Working Group. (See references [29], [30], and [31].) This section should point to service-specific configuration information in those documents, where applicable. (More detailed information is also available in [32] for SMDS and [33] for FRS.)

e. Accounting Information: Accounting information gathered by a switch may be used to support accounting management arrangements between carriers and between a carrier and its customers. Carriers will have to agree, for a B-ICI or connections on a given B-ICI, what method is used to exchange accounting information. In addition, carriers will also need to reach agreement about inter-company billing arrangements and/or cost separations, but these issues are beyond the scope of this document. Issues should be similar to those for existing services.

f. Trouble Administration Information: This includes information such as description of trouble (e.g., "failed physical facility"), trouble status information (e.g., "under investigation"), and estimated repair time. Much of this information should be similar to that used for existing (non-ATM) services, but some information should be specific to ATM.

g. Performance Information: This includes physical-layer performance information, information about cell traffic at the ATM layer, and information about service traffic at the service layer. Examples of performance information at the ATM layer include: cells transmitted at a B-ICI, cells received at a B-ICI, and cells dropped at a B-ICI.

7. B-ICI Signaling

This section provides network signaling specification for the multi-service B-ICI supporting switched services between the two carriers networks.

To achieve timely implementations and availability of equipment, a phased approach has been adopted in developing the B-ICI specification in the ATM Forum. The objective is to align the B-ICI signaling specification with other ATM Forum signaling specifications and base it on available standards. In particular, this version (Version 2) of the B-ICI specification provides the functionality of the ATM Forum's UNI 3.1 while being aligned with relevant ITU-T and ANSI-T1 BISUP standards.

As currently specified in this document, procedures for the ATM Forum ATM End System Addresses (AESAs) based on the Data Country Code (DCC) and International Code Designator (ICD) formats are not fully supported. The reason for this is to maintain compliance with ITU-T and ANSI BISUP standards. It is the intention of the B-ICI Working Group to address increased support for DCC and ICD formats as soon as ANSI or ITU-T standards are formed.

Certain services may require that optional elements of this B-ICI specification are implemented. For example, end-to-end carriage of Calling Party Number (CgPN) is required by the P-NNI and LAN Emulation specifications.

7.1 B-ICI Requirements and Selection of B-ISUP

7.1.1 B-ICI Signaling Requirements

The following network signaling requirements for a B-ICI supporting Switched Virtual Connection (SVC) inter-carrier services have been generated. These requirements have guided the selection of a suitable signaling protocol for the B-ICI.

(a)Service and Call Control Aspects

B-ICI signaling is required to provide the capability for establishing, maintaining, and releasing ATM connections for information transfer. B-ICI signaling supports SVC Cell Relay Service as described by the ATM Forum UNI Version 3.1 Specification.

The following capabilities are included in Version 2.0:

- Support of point-to-point connections and unidirectional point-to-multipoint network connections.
- Support of symmetric and asymmetric connections.
- Support of variable bit rate connections.
- Support of ATM end system addresses.
- Support of call rejection due to unavailable ATM resources.
- Support of a minimum set of peer-to-peer signaling network OAM functions, e.g., blocking, testing, and reset.
- Support of an efficient mechanism for fast identification of control plane associations

(assignment of signaling messages to their call/connection) between two nodes by means of signaling identifiers.

- Support of the evolution of services, protocol reusability, and version compatibility.

(b)Signaling Message Transfer Aspects

The following requirements apply to the transfer of signaling messages:

(R) 7-1 The carriage of B-ICI SVC signaling messages across the interface shall meet or exceed these existing network signaling reliability and availability requirements:

(1) a message loss rate of less than 1 message in 10^7,
(2) message mis-sequencing less than 1 in 10^8,
(3) unavailability of signaling message transfer capabilities between two signaling entities is less than 10 minutes a year.

(R) 7-2 B-ICI signaling shall provide procedures to handle signaling message overload. Procedures to handle this could include:

(1) back pressure to reduce signaling traffic,
(2) rerouting signaling messages over alternative signaling paths,
(3) call rejection,
(4) signaling traffic load sharing.

(R) 7-3 Failure of any B-ICI signaling message transfer capability shall not affect existing calls that are in the active state.

(R) 7-4 Recovery of B-ICI signaling message transfer capability shall not affect existing calls that are in the active state.

7.1.2 B-ICI Signaling Protocol Selection

Considering the network signaling requirements established above for the multi-service B-ICI, the ITU-T defined BISUP/BISDN NNI signaling system has been selected as the basis of future work in the ATM FORUM B-ICI SWG. The B-ICI signaling requirements that follow will be generated on the basis of available and ongoing standards work on BISDN NNI signaling.

7.2 Likely B-ICI Signaling Evolution

For ATM-based signaling networks, the need for access to remote nodes such as a Service Control Point (SCP) is likely to become a higher priority due to the desire to offer more sophisticated services. This implies in the longer term either an associated network with direct links between BSSs and SCPs, or development of a quasi-associated network capability through ATM/Broadband compatible Signaling Transfer Point (STP) nodes or adjuncts.

Transaction Capabilities Application Part (TCAP) and Signaling Connection Control Part (SCCP) will be added to the protocol stack for ATM-based high speed links, to support transactions between BSS and SCP, or between remote BSSs. No change is required to these protocols from the existing ITU-T specifications, except that the existing SCCP cannot take advantages of the longer message lengths supported by the SAAL. Modifications to the SCCP to support longer message lengths are now under study in ITU-T.

The BISUP call control protocol is expected to evolve to support additional functions such as leaf-initiated actions and third party control capabilities, beyond the initial step of Capability Set (CS)-2. Separation of call and connection control has been adopted by ITU-T for the support of the multi-connection capability in Capability Set 2, Step 1 (CS-2.1) Recommendations. These enhancements are defined by ITU-T as additional Application Service Elements (ASEs) for BISUP using TCAP.

ABR and parameterized QOS are ATM Forum UNI 4.0 capabilities that future B-ICI versions will consider.

7.3 Relationship of the ATM Forum's B-ICI Signaling Requirements and the ITU-T Work

As shown in the Table 7.1, most of the B-ICI signaling requirements generated by the ATM Forum are consistent with the ITU-T's initial (Release 1) BISUP Recommendations, while others are consistent with CS-2 extensions. In particular, CS-2.1 extensions support point-to-multipoint connections and VBR services. Support of ATM Forum UNI 3.1 QOS classes may require additional coding in ITU. ANSI BISUP has reserved four code points to support the ATM Forum UNI 3.1 QOS classes.

7.3.1 Interoperability Between ATMF B-ICI Spec 2.0 and ITU Versions of the BISUP and MTP Level 3

The selection of signaling capabilities from ITU BISUP/MTP Level 3 standards for the B-ICI Spec 2.0 implementation agreement are such that interoperability is assured between a device conforming to the ATMF B-ICI Spec 2.0 and a device conforming to the ITU BISUP Recommendations Q.2761-Q.2764, Q.2722.1 (point-to-multipoint), Q.2723.1 (Additional traffic parameters), Q.2726.1 (ATM End System Address) and Q.2210 (Broadband MTP Level 3) for all functionality that is common to both signaling protocols. The differences in functionality between this ATMF B-ICI Spec 2.0 implementation agreement and ITU BISUP/MTP Level 3 standards are indicated below.

Interoperability is required for connecting:

- An originating or intermediate BSS with a ATMF B-ICI Spec 2.0 interface to an BSS with the interface of an incoming international or intermediate international BSS, as specified in ITU's BISUP standards.

- An BSS with the interface of an outgoing international or intermediate international BSS, as specified in ITU's BISUP, to an intermediate or destination BSS with a ATMF B-ICI Spec 2.0 interface.

If any ambiguities or inconsistencies are present in the ATMF B-ICI Spec 2.0 text due to rephrasing of functionality in ITU's BISUP standards, the original ITU text takes precedence. If the ATMF B-ICI Spec 2.0 text resolves any ambiguities in the original ITU BISUP text, the ATMF B-ICI Spec 2.0 text takes precedence.

7.3.2 Differences Between ATMF B-ICI Spec 2.0 and ITU BISUP/MTP Level 3 Standards

ATMF B-ICI Spec 2.0's BISUP requirements and ITU's BISUP/MTP Level 3 Recommendations have the same functionality for a large part. However, some differences are present, which are indicated below from a high level view.

7.3.2.1 Signaling Functionality in ITU BISUP/MTP Level 3 Omitted in ATMF B-ICI Spec 2.0

ATMF B-ICI Spec 2.0 deliberately leaves out the following BISUP/MTP Level 3 functionality contained in ITU standards:

- Difference between national and international BSSs
- Interworking with N-ISDN (including overlap operation, A-law/µ-law conversion, early through-connect to prevent speech clipping, tones and announcements, and network-initiated Suspend and Resume
- Propagation delay determination
- User part availability procedure
- Segmentation of messages for use of narrowband signaling links
- MTP Level 3 quasi-associated signaling
- MTP Level 3 Restart procedure (optional in B-ICI)
- MTP Level 3 user part availability control[15]

The omitted MTP features are not part of the MTP subset that has been specified in this document. This subset will be discussed in Section 7.7.

7.3.2.2 Additional Functionality of ATMF B-ICI Spec 2.0 Signaling, Relative to ITU BISUP Standards

ATMF B-ICI Spec 2.0 contains additional functionality relative to ITU BISUP standards, which originates from the ANSI T1S1 BISUP standards. These enhancements are marked as carrier options throughout this document and only apply to networks using ANSI BISUP procedures:

- Use of an additional BISUP message:
  - Exit message
- Use of additional BISUP parameters:
  - Carrier Identification Code
  - Charge Number
  - Carrier Selection Information
  - Outgoing Facility Identifier, and
  - Originating Line Information
- Additional procedures for use of the Transit Network Selection parameter

A few capabilities are unique to ATMF B-ICI Spec 2.0:

- Support of QOS classes
- Some administrative requirements related to assignment of VPCs and configuration of message content

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[15] User part availability control is the ITU-T term; this procedure is called MTP user flow control in the ANSI MTP standard.

- Procedures for usage measurement
- Transport of non-E.164 AESAs

Table 7.1 ATM Forum's B-ICI Signaling Capabilities, and the ITU-T Work

ATM Forum B-ICI Signaling Capabilities	Corresponding State of ITU-T BISUP Work
Service and Call Control Aspects	
1. B-ICI shall support SVC Cell Relay Service (ATM Forum UNI Spec 3.1)	CBR Cell Relay supported by BISUP CS-1 specifications (ITU-T Recommendations Q.2761-4). VBR and QOS supported by BISUP CS-2.1.
2. B-ICI shall provide the capability for establishing, maintaining and releasing ATM connections.	Supported as indicated for Item 1.
3. Support of VBR connections	Supported by BISUP CS-2.1 (Q.2723.1)
4. Support of AESAs	Supported by BISUP CS-2.1 for E.164 AESAs (Q.2726.1)
5. B-ICI shall support point-to-point and point-to-multipoint network connections.	Point-to-point connections supported BISUP CS-1, point-to-multipoint supported by BISUP CS-2.1.
6. B-ICI shall support symmetric and asymmetric connections.	Supported by BISUP CS-1.
7. B-ICI shall support call rejection due to unavailable ATM resources.	Supported by BISUP CS-1.
8. A minimum set of peer-to-peer signaling network OAM functions, e.g., blocking, testing and reset, shall be supported.	Supported by BISUP CS-1.
9. B-ICI shall allow for evolution of services, protocol reusability, and version compatibility.	Supported by BISUP CS-1.
10. An efficient mechanism for fast identification of control plane associations between two nodes shall be required.	Supported by BISUP CS-1.
Signaling Message Transfer Aspects	
11. The carriage of signaling messages across the interface shall meet or exceed existing network signaling reliability and availability requirements.	Should be satisfied by SAAL and MTP Level 3 protocols used to support BISUP.
12. B-ICI shall provide procedures to handle message overload, such as backpressure, message rerouting, call rejection, and signaling traffic load sharing.	Should be satisfied by SAAL and MTP Level 3, plus BISUP procedures such as Automatic Congestion Control and BISUP Signaling Congestion Control.
13. Failure of any B-ICI signaling message transfer shall not affect existing calls that are in the active state.	Supported by BISUP CS-1.
14. Recovery of B-ICI signaling message transfer capability shall not affect existing calls that are in the active state.	Supported by BISUP CS-1.

Note: In general, the BISUP capabilities in this Table are applicable to the interface between any two BISUP nodes, including both gateways between carriers and BSSs within one carrier.

7.4 Signaling Network Topology

This section describes example topologies for B-ICI signaling. In the first case, shown in Figure 7.1, supported by the Version 2.0, ATM virtual channel connections are used to transport BISUP signaling messages directly between BSSs. This type of signaling architecture is called associated mode signaling. The BISUP protocol is used for call control between BSSs. Although associated signaling links are used, it is assumed that the MTP Level 3 protocol is still used for network layer functions above the SAAL layer. It routes the BISUP messages to the appropriate outgoing link and supports management functions such as changeover of signaling traffic from a failed signaling link to a backup signaling link. The link speed is determined by parameter settings for the ATM connection. The SAAL protocol is designed to operate over a range of link speeds from 64 Kb/s to at least 4 Mb/s.

Access to centralized databases (e.g., SCPs), requiring SCCP and TCAP, is beyond the scope of Version 2.0. Figure 7.1 shows a BSS accessing SCPs via a conventional SS7 link that is independent of the B-ICI. Alternatively, if a BSS implements only associated mode signaling over SAAL/ATM links at the MTP Level, but implements the necessary SCCP and TCAP functions, it can access an SCP if a SAAL/ATM link is directly connected to the SCP or to an SCCP relay point that can forward messages to the SCP.

In the second case, shown in Figure 7.2, signaling between BSSs is routed via signaling transfer points. This configuration is not supported by Version 2.0 of the B-ICI specification, but it may be used by bilateral agreement between the carriers. In this architecture, BISUP is still used as the call control protocol between BSSs. If needed, this architecture can also support access to centralized databases in addition to call setup and release. This type of signaling architecture is called quasi-associated signaling.

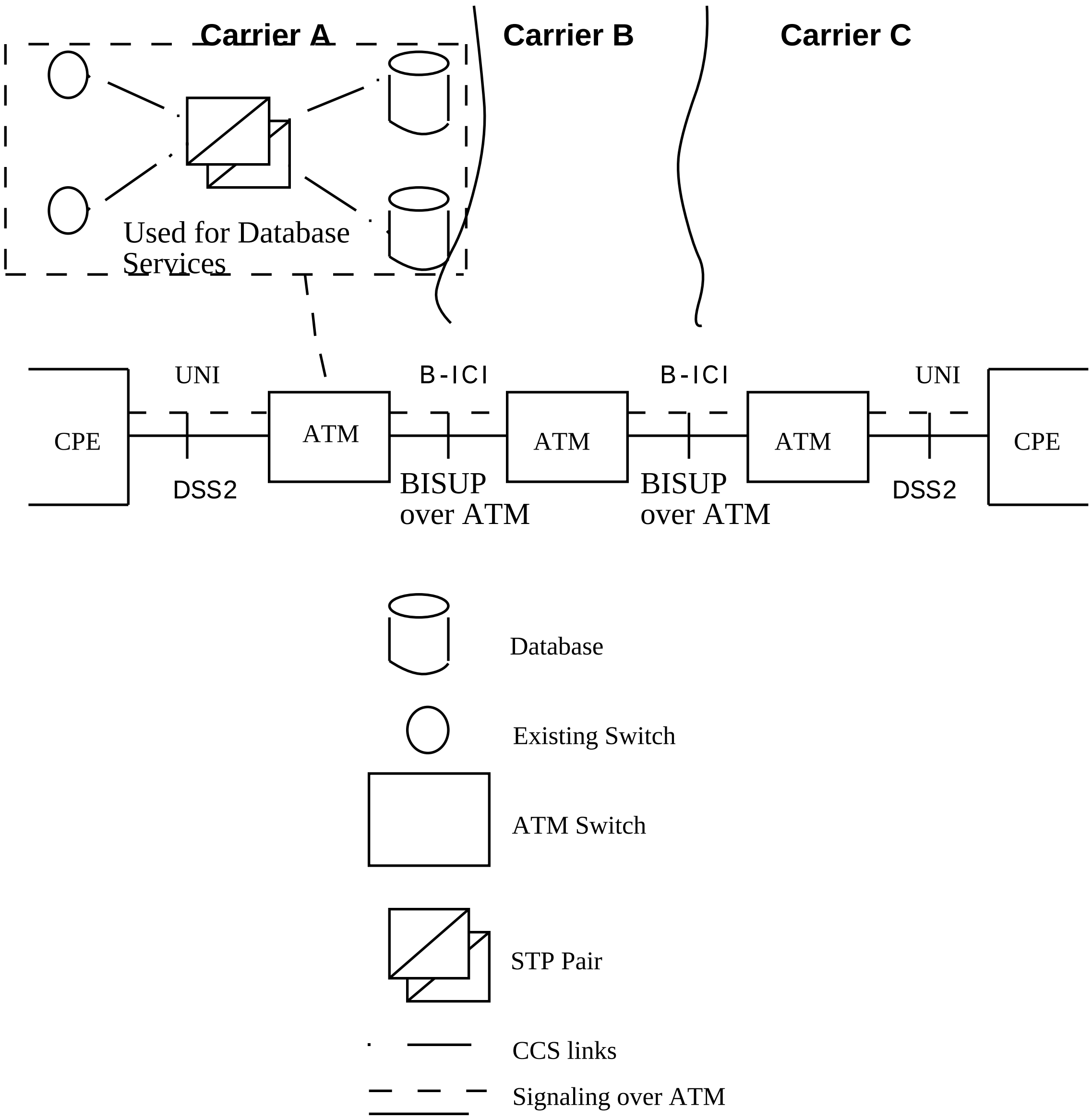


Figure 7.1 An Example B-ICI Signaling Architecture - BISUP over ATM in the Associated Mode

Note: B-ICI is the subject of this specification. Other interfaces are shown only to illustrate their relationship to the B-ICI.

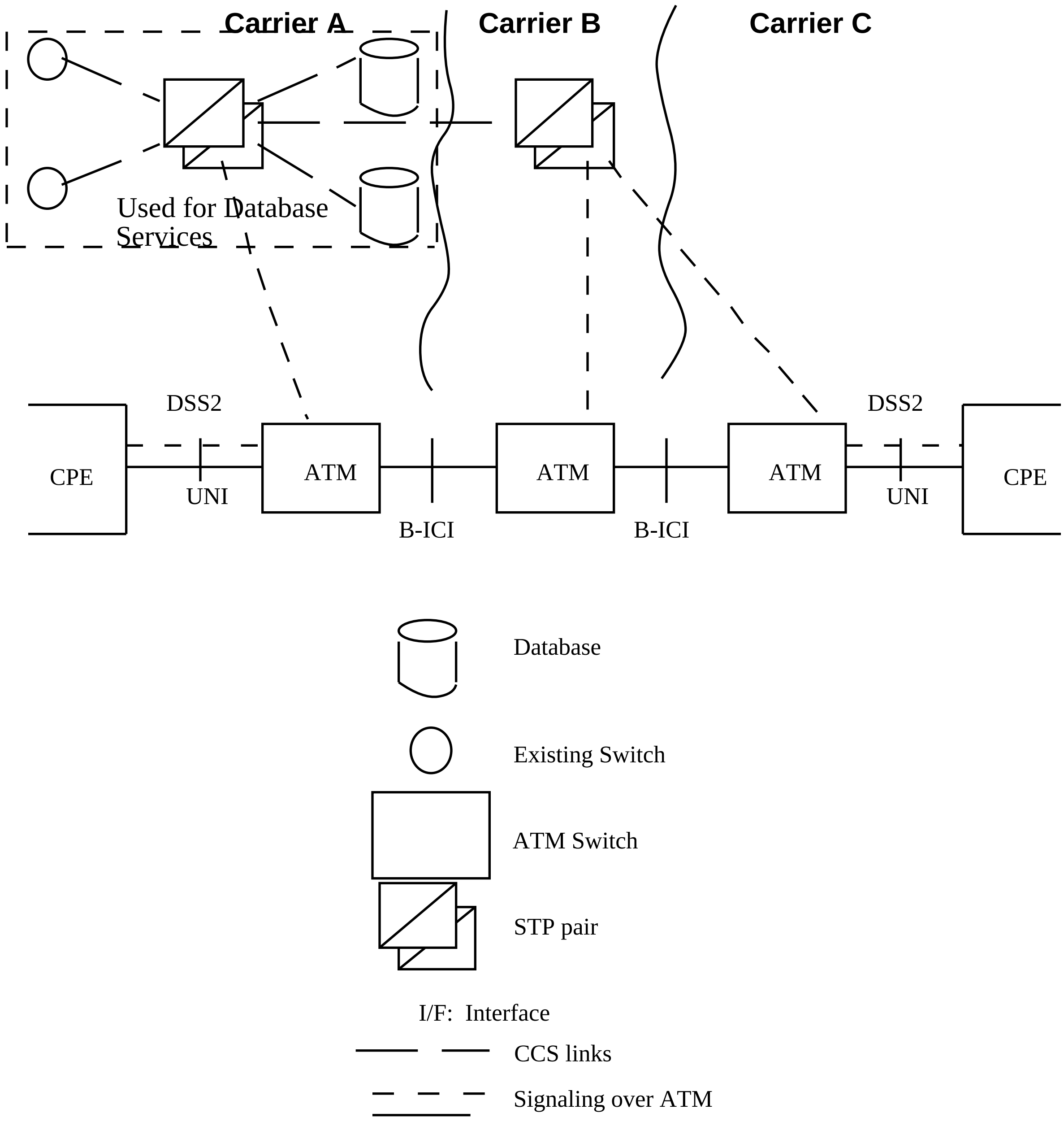
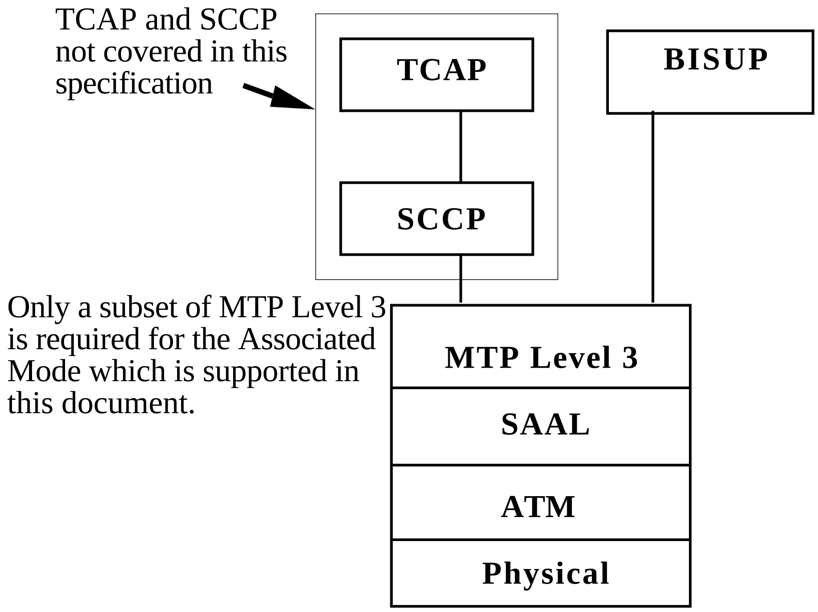


Figure 7.2 An Example B-ICI Signaling Architecture - BISUP in the Quasi-Associated Mode

Note 1: B-ICI is the subject of this specification.
Note 2: CCS links may or may not be over ATM.

7.5 Signaling Network Configuration

(R) 7-5 For the B-ICI Specification, Version 2.0, connection related signaling shall be associated mode using the "BISUP/MTP Level 3/SAAL/ATM/Physical" protocol stack shown in Figure 7.3.



MTP = Message Transfer Part, SCCP = Signaling Connection Control Part, TCAP = Transaction Capabilities Application Part

Figure 7.3 Network Signaling Protocol Stack for Transport of Signaling Messages at the B-ICI

Signaling messages among the Broadband Switching Systems[16] (BSS) can be transported using a virtual channel connection and the Signaling ATM Adaptation Layer (SAAL) defined for the Network Node Interface (NNI). The SAAL for the NNI has the same structure as the SAAL for the UNI. It comprises the Type 5 Common Part protocol, the Service Specific Connection Oriented Protocol (SSCOP), a Service Specific Coordination Function (SSCF), which in this case enhances the services provided by SSCOP to provide the layer service expected by MTP Level 3, and a layer management entity.

(R) 7-6 The BSS shall support the SAAL as defined in the ITU Recommendations I.363 (Common Part), Q.2110 (SSCOP), Q.2140 (SSCF), and Q.2144 (Layer Management).

MTP Level 3 provides a connectionless network service and includes extensive network management procedures to route around failures of network components while minimizing

[16] A BSS includes, but is not limited to, call/connection control functions and the ATM switching fabric. A BSS may contain multiple physical entities.

message loss and missequencing. MTP Level 3 protocol and procedures for use with SAAL links are specified in ITU-T Recommendation Q.2210, which relies heavily on Recommendations Q.704 and Q.707. Depending on the interconnecting carriers and their networks, the appropriate national specification (e.g., ANSI T1.111-1996) may be used, rather than Recommendation Q.2210. This B-ICI specification does not repeat specification of the MTP Level 3 protocols and procedures themselves. Section 7.7 does specify, however, which of the MTP Level 3 procedures must be implemented to meet the B-ICI Version 2.0 requirements for associated mode signaling.

7.6 Network Signaling Protocol Architecture

The protocol stack shown in Figure 7.3 is based on SS7 which is a family of protocol parts for different service and signaling network functions. Various protocol parts and combinations are suitable for B-ICI signaling.

SS7 is designed for complex signaling networking involving many nodes and multiple networks. The overall objective of the lower levels of the protocol stack shown in Figure 7.3 (physical, ATM, SAAL, and MTP Level 3) is to provide a reliable means of information transfer, in correct sequence and without loss or duplication. MTP Level 3 provides the signaling message handling functions and the signaling network management functions. The former are the functions that direct a signaling message to the proper signaling link or higher level functions. The latter functions control message routing and configuration of the signaling network facilities.

The B-ICI signaling protocol architecture takes advantage of the routing and network management capabilities offered by MTP Level 3 [68], along with the robustness of BISUP as the call and connection control signaling protocol. BISUP is designed for efficient virtual ATM call and connection control and management. The flexibility of the ATM switching fabric using cell relay as transport makes the use of ATM-based B-ICI signaling attractive for ATM SVC services support on a common (ATM-based) platform. The SAAL is used to package the signaling information into the cells which the ATM layer transfers across the network and to extract the information from the cells and from signaling information frames for use by the signaling application.

7.7 MTP Level 3 Subset for Associated Mode Signaling

Associated Mode signaling allows for the deployment of an MTP Level 3 subset. This section provides a simplified version (i.e., subset) of the "Full MTP Level 3" (used for the Quasi-Associated Mode) when MTP Level 3 is used above the SAAL in an ATM network (this is called Associated Mode Signaling). This simplified version of MTP Level 3 is possible because associated mode signaling does not require any Signaling Transfer Point (STP) functions between the signaling nodes.

MTP Level 3 procedures can be separated into four categories:

1. Signaling Message Handling
2. Signaling Link Management
3. Signaling Route Management
4. Signaling Traffic Management

The following subsections examine the MTP Level 3 procedures and specify an MTP Level 3 subset for associated signaling.

7.7.1 Signaling Message Handling

Signaling Message Handling procedures consist of message discrimination, distribution, and routing. All of these procedures will still be needed. The Signaling Link Selection (SLS) code will still be needed to ensure message sequencing for multi-link signaling link sets. Because multi-link link sets could be desirable for reliability reasons (with links of the same link set on diverse physical facilities), it is recommended that both the SLS code and load sharing capability be retained in the associated signaling mode.

Each signaling link is configured with exactly one Signaling Link Code (SLC). If a signaling link set contains multiple links, a set of SLCs is associated with the signaling link set, and there shall be load sharing among the signaling links of the signaling link set.

A BSS is capable of being configured so that at least one Signaling Point Code (SPC) is assigned to it. The signaling links of a signaling link set shall be configured to indicate the two associated SPCs.

7.7.2 Signaling Link Management

Signaling Link Management procedures consist of the following:

- Activation / Restoration / Deactivation
- Signaling Link Test
- Automatic Allocation of Signaling Terminals and Signaling Data Links
- False Link Congestion Detection (an ANSI network enhancement which detects false link congestion)
- Link Oscillation Filter (an ANSI network enhancement which controls the maximum link oscillation rate)

Link Activation, Restoration, and Deactivation procedures are needed independent of the network configuration. Only basic link management procedures have been specified for SAAL links in ITU-T Recommendation Q.2210; so procedures for Automatic Allocation of Signaling Terminals or Signaling Data Links are not needed.

It is recommended to retain both the Signaling Link Test and False Link Congestion Detection (for North American networks) for network reliability in associated signaling. The Signaling Link Test can detect link irregularities such as looped links and crossed links.

Because the Link Oscillation Filter procedure is designed primarily to prevent STP overload caused by multi-link oscillations, it is not needed for associated signaling, although it is possible that the procedure can be useful for a very large associated signaling network.

7.7.3 Signaling Route Management

The Signaling Route Management procedures are STP related procedures and are not needed for associated signaling.

7.7.4 Signaling Traffic Management

Signaling Traffic Management procedures consist of the following:

- Changeover / Changeback
- Management Inhibit
- Forced / Controlled Rerouting
- MTP Restart
- Signaling Traffic Flow Control

While Changeover / Changeback and Management Inhibit procedures are not needed for single-link link sets, they are useful procedures for networks with multi-link link sets (which could be desirable for reliability reasons). It is recommended to retain these procedures for associated signaling. Management Inhibit can be initiated through Management System commands.

Forced / Controlled Rerouting are STP related procedures, and are not needed for associated signaling.

MTP Restart is designed to protect the restarting node by giving the restarting node time to BSS routing data (regarding remote signaling points) with the adjacent available signaling points and to activate sufficient links. In an associated signaling network, there is no need for the restarting node to BSS routing data regarding remote signaling points with the adjacent available signaling points. While MTP Restart can still be desirable for a large associated signaling network by allowing a restarting signaling point sufficient time to activate its links, it may not be needed for initial specification. It is recommended to have MTP Restart as an optional procedure.

Signaling Traffic Flow Control notifies an MTP user (e.g., BISUP) of the availability, unavailability, and congestion of signaling route sets so that the user can control traffic for the affected destinations appropriately. It also notifies the user of the unavailability of a remote peer (of the user) through user part availability control[17] procedures. The capability to notify the user of the availability, unavailability, and congestion of signaling route sets is needed in any network configuration and is required in Version 2.0. The usefulness of the MTP user part availability control procedure, however, depends largely on whether MTP users can fail independently. This is not required for Version 2.0.

7.7.5 Requirements for MTP Level 3 for Associated Mode

(R) 7-7 In support of MTP Level 3 in associated mode, the BSS shall:

- Support the signaling message handling procedures of message discrimination, distribution, and routing.
- Support the signaling link management procedures of link Activation, Restoration, and Deactivation; and of Signaling Link Test.
- Support Changeover / Changeback and Management Inhibit (for multi-link link sets only)
- Support Signaling Traffic Flow Control procedures except for user part availability control.

[17] Called MTP user flow control in the ANSI MTP standard.

(R) 7-8 As a carrier option (see Section 7.3.2.2), in support of MTP Level 3 in associated mode, the BSS shall support the signaling link management feature of False Link Congestion Detection.

(O) 7-1 In support of MTP Level 3 in associated mode, the BSS should support MTP Restart.

7.8 Call and Connection Control Functions

7.8.1 Call and Connection Control Messages

For the set up and release of basic point-to-point calls, the following BISUP call connection control messages are used: Initial Address Message (IAM), Address Complete Message (ACM), IAM Acknowledgment Message (IAA), IAM Reject Message (IAR), Exit Message (EXM), Release Message (REL), Release Complete Message (RLC), Answer Message (ANM), and Call Progress Message (CPG). Subsequent address and forward transfer messages are defined in the ITU-T BISUP recommendations, but are not used in this implementation agreement. First, the assignment procedures for Virtual Path Connection Identifier/ Virtual Channel Identifier (VPCI/VCI) and bandwidth and the assignment procedures for signaling identifiers are described because they are applicable to all types of BSSs - originating, intermediate and destination BSSs. Then, actions specific to each type of BSS are described. The call and connection control functions and procedures are based on, and are consistent with, the ITU-T BISUP Recommendations[69-88].

> **(R) 7-9** BISUP timers and timer values defined in ITU-T Rec. Q.2764 shall be applicable.

7.8.2 Assignment Procedure of VPCI/VCI and Bandwidth

On an interface, a given VPI that provides VC service is designated to provide one of the following possible functions:

(a) Only PVC VC connections are allowed,
(b) Only SVC VC connections are allowed, or
(c) Both PVC and SVC VC connections are allowed.

Support of Case (c) is not required, however, neither is it precluded. In cases (b) and (c), the VPC is assigned a VPCI, and in Case (c), it must be clearly specified which VCI range is under the control of BISUP (i.e., to support SVCs). Furthermore, for Case (c), SVC procedures (e.g., Reset) must only affect the SVC range of VCIs within the VPCI.

The one side selection method of VCI values for a given VPCI, which allows one BSS to be the assigning BSS for both outgoing and incoming calls for a specific VPCI, is adopted to completely prevent dual seizure. This method is described below.

> **(R) 7-10** For proper operation of BISUP, the one side selection method shall apply for all VPCs (that support SVCs) between two BSSs whether the two BSSs are in the same or different networks.

Each BSS allocates its own bandwidth to a given VPCI/VCI as a result of a CAC calculation on the traffic descriptors in the IAM.

7.8.2.1 Management of VPCI/VCI Values and Bandwidth of Each VPC

> **(R) 7-11** Before a route between two BSSs can be put into service, the following is necessary:

- The VPCI to be used shall be assigned unambiguously and identically at both ends of each VPC between the two BSSs.

- The VPCI shall be associated with the two appropriate SPCs at the BSSs.

- For every VPCI, it shall be defined which BSS controls this VPCI, i.e., which BSS is responsible for assigning bandwidth and the VCIs for this VPCI.

(R) 7-12 The following default mechanism for determining assigning/ non-assigning designation shall be supported by every BSS:

Each BSS shall be the assigning BSS for one half of the VPCI values between two BSSs. The BSS with the higher signaling point code shall be the assigning BSS for all even numbered VPCI values, and the other BSS shall be the assigning BSS for all odd numbered VPCI values.

(R) 7-13 For an outgoing call/connection (including an automatic repeat attempt), a BSS shall first use a VPCI which it controls; i.e., an IAM including the Connection Element Identifier parameter containing the selected VPCI/VCI values shall be sent. Only if there is not sufficient bandwidth of acceptable QOS, or VCIs related to the VPCIs which the BSS controls and which can fulfill the bandwidth requirement of the call, the BSS shall send an IAM without the Connection Element Identifier parameter. In this case, the far end BSS will be expected to assign a VPCI/VCI from the set of VPCIs it controls.

7.8.2.2 Procedures for the Assigning BSS and Non-Assigning BSS

The assigning BSS assigns both VPCI/VCI and bandwidth (according to its CAC procedures) for outgoing and incoming calls. The non-assigning BSS does not assign but requests the assigning BSS to assign both VPCI/VCI and bandwidth.

(a) <u>Outgoing Calls from the Assigning BSS to the Non-Assigning BSS</u>

(R) 7-14 The assigning BSS shall perform the following actions:

- Selection of a VPC (identified by a VPCI) from the available VPCs it controls which can allocate the bandwidth according to the requested ATM Cell Rate and acceptable QOS.

- Assignment of bandwidth and a VCI value to the call/ connection. VCI values 0 to 15 shall not be used.

- Updating the bandwidth and VCI value per VPCI and sending an IAM including the selected VPCI/VCI values (in the Connection Element Identifier (CEI) parameter) towards the non-assigning BSS. The VPCI subfield (octets 1 and 2) of the CEI shall contain the code expressing in pure binary representation the identifier of the virtual path connection. Bit 8 of octet 1 is the most significant and bit 1 of octet 2 is the least significant. The VCI subfield (octets 3 and 4) shall contain the code expressing in pure binary representation the identifier of the virtual channel. Bit 8 of octet 3 is the most significant and bit 1 of octet 4 is the least significant. The value of this field shall be the same as the value used in the VCI field of the corresponding ATM cell header.

(R) 7-15 The non-assigning BSS shall allocate the VPCI/VCI values and bandwidth (according to its CAC procedures) for the call and return an IAA to the assigning BSS. If this is not successful, an IAR is returned.

(b) Outgoing Calls from the Non-Assigning BSS to the Assigning BSS

(R) 7-16 The non-assigning BSS shall perform the following actions:

- Sending the IAM without the CEI.
- Allocating the VPCI/VCI values contained in the CEI for the call on receipt of IAA from the assigning BSS.

(R) 7-17 The assigning BSS shall perform the following actions:

- Selection of a VPC (identified by a VPCI) it controls that has enough bandwidth of acceptable QOS and a VCI value available on receipt of the IAM. VCI values 0 to 15 shall not be used.

- Updating the bandwidth and VCI value per VPCI and sending an IAA with the selected VPCI/VCI values (in the CEI) towards the non-assigning BSS. The coding of the CEI shall be as described in (a) above.

(c) Simultaneous Call Request from the Assigning BSS and the Non-Assigning BSS

As the assigning BSS assigns bandwidth and the VPCI/VCI value at the time of call acceptance at the assigning BSS, a dual seizure of bandwidth or VPCI/VCI value cannot occur. If enough bandwidth is not available at the receipt of the call request, the call will be released with the cause value 51 ("Cell Rate not available").

7.8.2.3 Abnormal Conditions

(R) 7-18 For abnormal conditions of the one-side selection method, the following procedures shall apply:

- If an IAM with VPCI/VCI is received at the assigning BSS for that virtual path, an IAR shall be returned with the cause value 36 ("VPCI/VCI assignment failure"). The BSS receiving the IAM shall initiate the blocking procedure for the concerned VPCI.

- If an IAM without VPCI/VCI is received at a BSS which is non-assigning for all virtual paths between the sending and receiving BSSs, an IAR shall be returned with the cause value 36 ("VPCI/VCI assignment failure").

- If an IAA with VPCI/VCI is received at the assigning BSS for that virtual path, the event shall be reported to maintenance. The BSS receiving the IAA shall initiate the blocking procedure for the concerned VPCI, and shall release the call using the cause value 36 ("VPCI/VCI assignment failure").

- If an IAA without VPCI/VCI is received at a BSS which sent an IAM without the CEI, the event shall be reported to maintenance, and the call shall be released using cause value 36 ("VPCI/VCI assignment failure").

7.8.2.4 Monitoring of Assigning End Disagreements

To monitor for disagreements between signaling entities regarding which end is the assigning end, the following is required:

(R) 7-19 For each VPCI, the BSS shall count and threshold a count of the number of disagreements regarding which BSS is the assigning node for a VPCI, and which BSS is not. This count shall include the following:

- *IAM* messages received with VPCI/VCI values specified for a VPCI for which the BSS is the assigning node.
- *IAA* messages received with VPCI/VCI values specified for a VPCI for which the BSS is the assigning node.
- *IAM* messages received without VPCI/VCI values at a BSS which is the non-assigning BSS for *all* VPCIs associated with that SPC pair (i.e., signaling link set).
- *IAA* messages received without VPCI/VCI values at a BSS which is the non-assigning BSS for *all* VPCIs associated with that SPC pair (i.e., signaling link set).

7.8.3 Signaling Identifiers

A Broadband Switching System (BSS) manages Signaling Identifiers (SIDs). These identifiers identify a signaling association and remain constant for the life of the signaling association. The SIDs need to be established for each bearer or maintenance control association between two BSSs. The two BSSs may be in the same or different networks. The SIDs are independently assigned by each of two BSSs concerned, A and B, enabling each switch to uniquely identify the signaling association (i.e., bearer control association or maintenance control association) and associate the signaling information with this particular signaling association. Figure 7.4 illustrates how SIDs are assigned and released for a successful call set up and release. Figure 7.5 illustrates how SIDs are assigned and released for an unsuccessful call set up.

For the example shown in these Figures, SID value Ai is assigned by BSS A when it sends the first message of a signaling association to BSS B; it is used to identify the signaling association at BSS A. SID value Bi is assigned by BSS B when it receives that first message of the signaling association from BSS A; it is used to identify the signaling association at BSS B.

Origination Signaling Identifier (OSID) parameter and Destination Signaling Identifier (DSID) parameter are used in BISUP messages to establish and identify signaling associations between a pair of BSSs. These parameters are used to carry the SIDs.

(R) 7-20 A BSS shall have the capability of assigning a SID for each signaling association (bearer and maintenance control association) between itself and a connected BSS.

(R) 7-21 The following requirements apply for bearer (connection) control associations when BSS A sets up a connection to BSS B. For proper operation of BISUP, these requirements shall be met whether the two BSSs are in the same or different networks.

- The Initial Address message sent by BSS A to BSS B shall contain Ai (the SID value assigned by BSS A) in the OSID.
- The IAM Acknowledgment message sent by BSS B to BSS A shall contain Bi (the SID value assigned by BSS B) in the OSID and Ai in the DSID in order to allow mapping between the sending and receiving directions.
- The IAM Reject message sent by BSS B to BSS A shall contain Ai in the DSID but no OSID.
- All subsequent call/bearer control messages (e.g., ACM) from BSS B to BSS A shall contain Ai in the DSID.
- All subsequent call/bearer control messages (e.g., REL) from BSS A to BSS B shall contain Bi in the DSID.

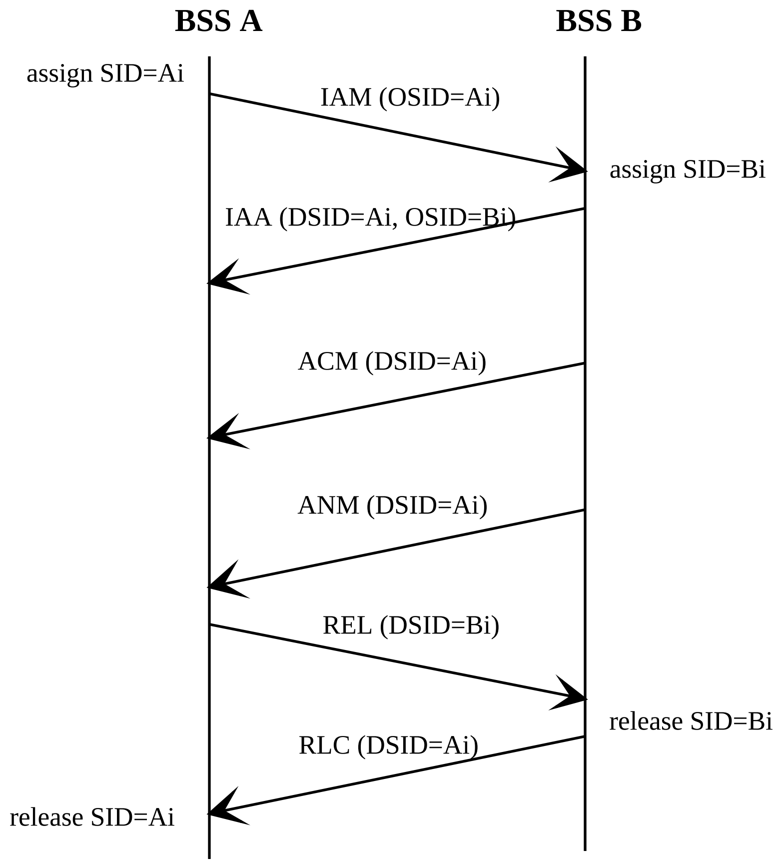


Figure 7.4 Example of a Successful Call and Connection Set up Sequence

Example of a scenario for assigning and releasing of the signaling associations; only the DSID and OSID of the messages are shown in Figure 7.4.

SID: Signaling Identifier
Ai: Signaling ID assigned by BSS A
Bi: Signaling ID assigned by BSS B
DSID: Destination Signaling Identifier (Parameter)
OSID: Origination Signaling Identifier (Parameter)

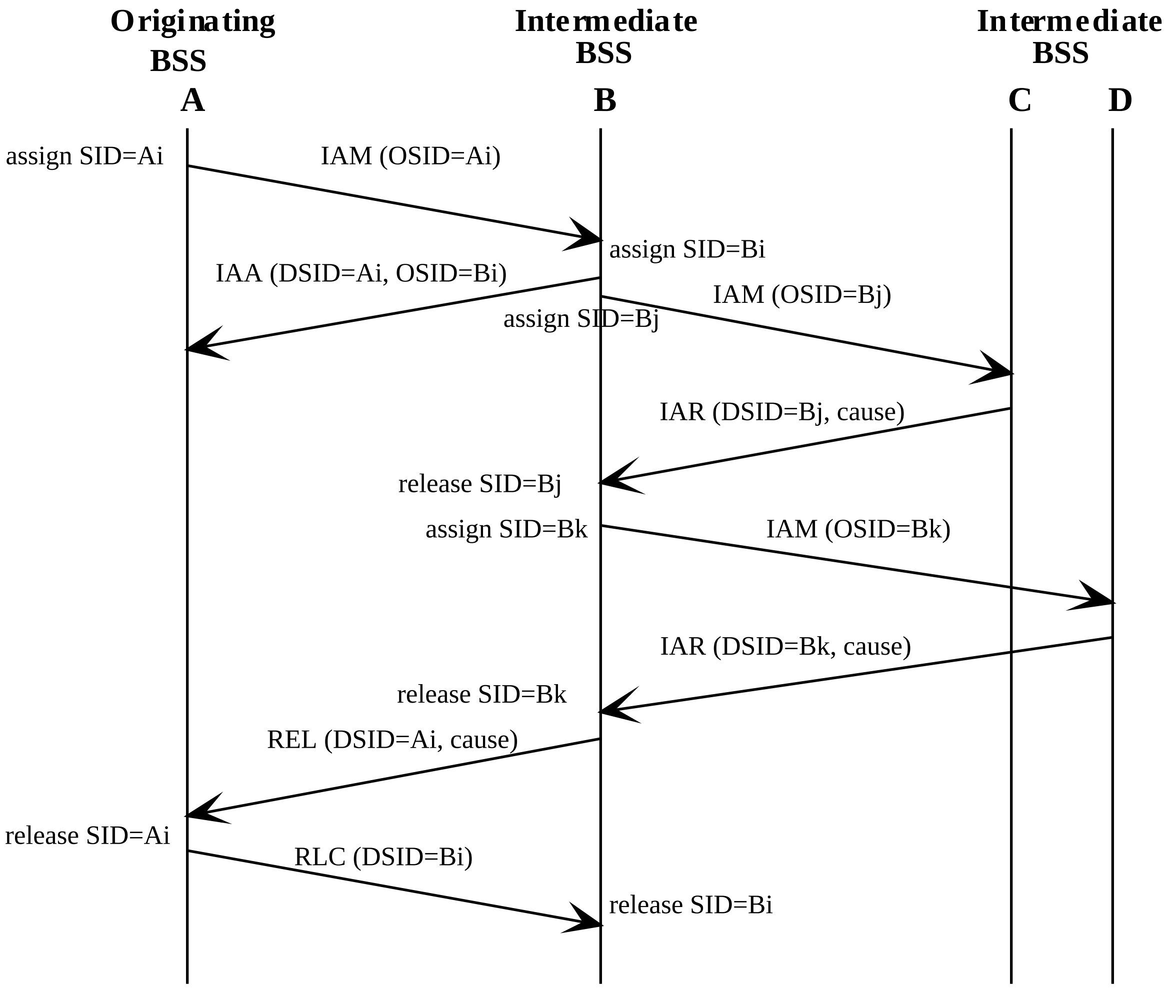


Figure 7.5 Example of an Unsuccessful Call and Connection Set up Sequence

7.8.4 Addresses and Address Formats

(R) 7-22 The BSS at the B-ICI shall:

- accept the E.164 address structure for the Called Party Number (CdPN) and Calling Party Number (CgPN) parameters

- accept the three formats of the AESA structure as defined in UNI 3.1 (Section 5.1.3.1) for the transparent transport via AESA for Called Party and AESA for Calling Party parameters.

As an option, a carrier may support DCC and ICD AESAs in the CdPN IE of the incoming SETUP message at the UNI. It is the responsibility of the carrier to produce a valid IAM to be propagated across the B-ICI. If the Transit Network Selection (TNS) IE is present in the SETUP message, it will be used for routing purposes as specified in (R) 7-24.

The ATM Forum's UNI Specification supports only the International Format of the E.164 address structure. To be consistent and ease the interoperability, the B-ICI will also support only the International Format of the E.164 address structure.

7.8.5 Successful Call Set Up

Figure 7.6 shows an example of the reference configuration for the B-ICIs supporting SVC service. Calling party is the user that sends a DSS2 SETUP message to the ATM network to request a switched virtual connection. Originating BSS is the ATM switch that receives and processes the SETUP message. When the originating BSS has received a valid DSS2 SETUP message from the calling party and has determined that the call is to be routed to another BSS, route and virtual channel selection take place. If the call needs to be routed to another carrier, it will be set up either on a direct connection from the originating BSS to a BSS in the other carrier's network or on a connection through an intermediate BSS. In the former case, the originating BSS provides the connection to the BSS belonging to the other carrier's network via the B-ICI. In the latter case, the intermediate BSS provides the connection to the BSS belonging to the other carrier's network via the B-ICI.

The call may be handled by one or more transit carriers before reaching the terminating carrier. In some cases, the call may not be handled by a transit carrier at all. The call may pass to the terminating BSS on a direct connection from the preceding carrier or via an intermediate BSS belonging to the terminating carrier. In the former case, the terminating BSS provides the B-ICI and, in the latter case, the intermediate BSS provides the B-ICI. Terminating BSS is the ATM switch that processes the incoming call request (IAM) and sends a DSS2 SETUP message to the called party. The called party is the destination UNI identified in the calling party's SVC request. It is assumed that both the calling and the called parties use public UNIs and all carriers involved are public carriers.

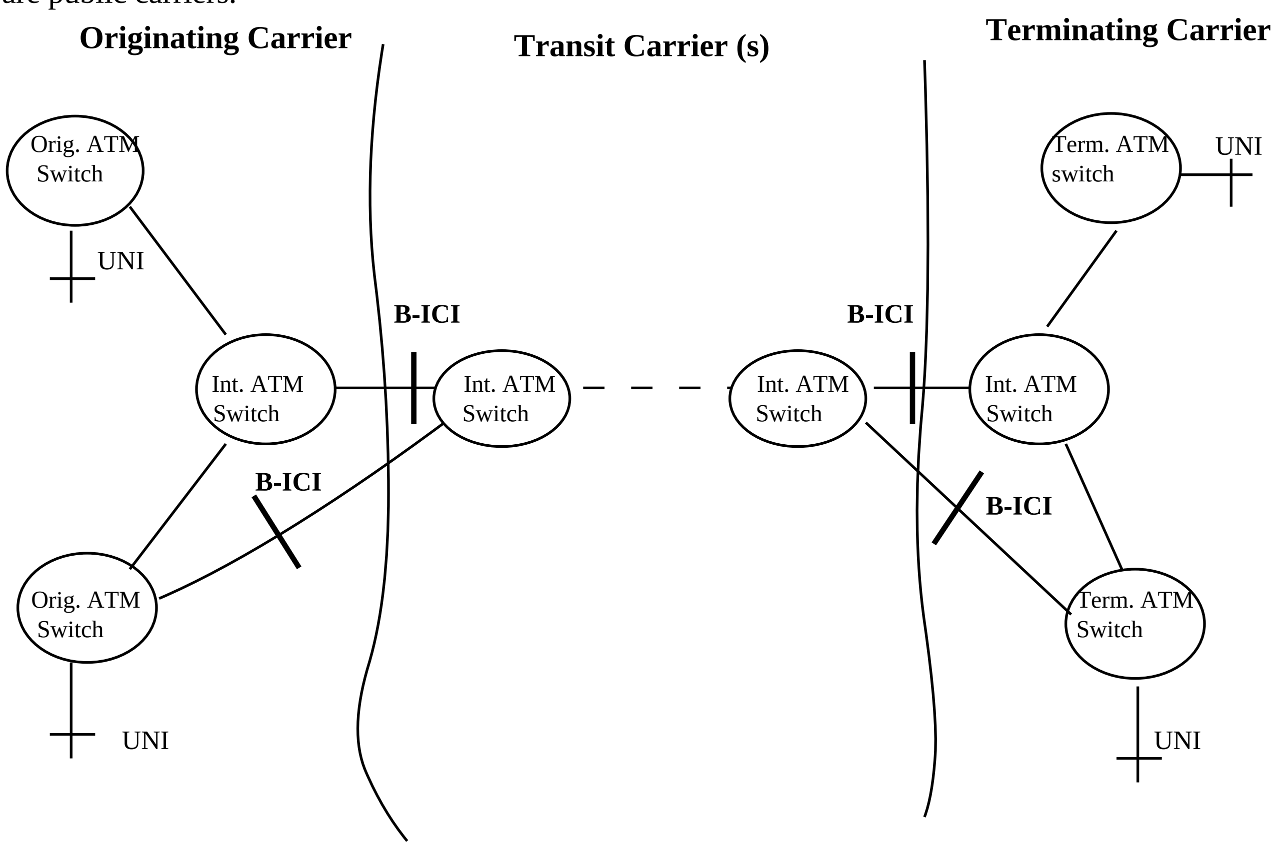


Figure 7.6 An Example of B-ICI Reference Configuration Supporting SVC Services

7.8.5.1 Forward Address Signaling

7.8.5.1.1 Actions Required at the Originating BSS

(a) Route and Virtual Channel Selection - Assigning BSS

Appropriate routing information is stored either at the originating BSS or at a remote database to which a request is made. Route selection will depend on the information contained in the SETUP message (e.g., Called Party Number, Broadband Bearer Capability, ATM Cell Rate, QOS, and TNS), subscription parameters applicable to the originating interface and the applicable network resources and their status.

Example codings of the message and parameter compatibility information are given in Appendices I and II of Q.2764, respectively.

When a call needs to be routed to another carrier, it will be set up either on a direct connection from the originating BSS to a BSS in the other carrier's network or on a connection through an intermediate BSS. In the latter case, the intermediate BSS provides the connection to the BSS belonging to the other carrier via the B-ICI.

The BSS shall deliver a valid E.164[55] address in the CdPN parameter across the B-ICI.

The selection of the route can depend on the Called Party Number, Broadband Bearer Capability, ATM Cell Rate, QOS, TNS, and the outcome of the virtual channel assignment procedure (see Section 7.8.2.2 (a)). The selection process may be performed at the BSS or with the assistance of a remote database.

> **(R) 7-23** The originating BSS that acts as an assigning BSS for the call shall assign VPCI/VCI values and bandwidth as described in Section 7.8.2.2 (a).

Currently, carriers in the U.S. (e.g., IECs) are identified by 3-digit carrier identification codes (XXX codes). Starting in 1995, these codes are allowed to be expanded to 4-digit codes (XXXX). Therefore, the requirements in this document take into account the possibility of both 3- and 4-digit carrier identification codes.

> **(R) 7-24** As a carrier option (See Section 7.3.2.2), if a Transit Network Selection IE is included in the SETUP message, and the call is accepted by the network, the call shall be routed to the carrier indicated in the Transit Network Selection IE. The mandatory Called Party Number IE may contain no address digits or a valid set of address digits.

If a Transit Network Selection IE is not included, routing is based on the analysis of the Called Party Number in the Called Party Number IE in the SETUP message.

> **(R) 7-25** As a carrier option (See Section 7.3.2.2), if a Transit Network Selection IE is not included and the Called Party Number IE indicates that the call needs to be routed to another carrier, the call shall be routed to the carrier identified by subscription at the Calling Party interface.

(b) Route and Virtual Channel Selection - Non-assigning BSS

(R) 7-26 For the originating BSS that acts as a non-assigning BSS for the call, the route and virtual channel selection procedures shall be as defined in (a) Route and Virtual Channel Selection - Assigning BSS above for an assigning BSS except that the VPCI/VCI and bandwidth assignment procedures shall be according to Section 7.8.2.2 (b) Outgoing Calls from the Non-Assigning BSS to the Assigning BSS.

(c) Address Information Sending Sequence

(R) 7-27 The sending sequence of address information shall be the country code followed by the national (significant) number.

(d) IAM - Sent by the Assigning BSS

The IAM in principle contains all the information that is required to route the call to the destination BSS and connect the call to the called party (see Section 7.8.5.1.1 (a)).

(R) 7-28 The originating BSS that acts as an assigning BSS for this call shall include the CEI (containing the selected VPCI/VCI values) in the IAM as described in Section 7.8.2.2 (a).

(R) 7-29 The originating BSS shall include the OSID (containing the selected SID) as described in Section 7.8.3.

Broadband Bearer Capability Information Element (IE) is received in the SETUP message from the user. This IE indicates the broadband connection oriented bearer service requested by the calling user.

(R) 7-30 The originating BSS shall include the Broadband Bearer Capability (BBC) parameter in the IAM. The coding of the coding standard subfield shall be identical with the corresponding subfield coding in the received IE. The contents of the parameter starting from octet 2 shall be identical with the contents of the IE starting from octet 5.

The ATM Traffic Descriptor IE in the SETUP message from the user indicates the required traffic parameters for the requested call. Traffic parameters include peak forward and backward cell rates with Cell Loss Priority (CLP) = 0 and 0+1, sustainable cell rate, etc. Requirements in the current version of this document support symmetric and asymmetric switched connections characterized by forward and backward peak cell rate, sustainable cell rate, and maximum burst size with CLP = 0 and 0+1. Symmetric connections are characterized by identical sets of traffic parameters for the forward and backward directions. Asymmetric connections are characterized by two sets of traffic parameters, one each for the forward and backward directions.

(R) 7-31 The originating BSS shall include the ATM Cell Rate parameter in the IAM. The coding of this parameter shall be based on the ATM Traffic Descriptor IE in the SETUP message from the user. The only allowed codings of the cell rate identifier subfields shall be forward and backward peak cell rate, forward and backward sustainable cell rate, and forward and backward maximum burst size for CLP = 0 and 0+1. The cell rate subfields shall be coded according to the cell rates requested by the user. Symmetric and asymmetric cell rate connections for CLP = 0 and 0+1 shall be supported.

The Quality of Service IE in the SETUP message from the user indicates the requested quality of service class for the call. Quality of Service includes the QOS class forward and QOS class backward. Requirements in the current version of this document support connections with five possible QOS classes as defined in the ATM Forum UNI 3.1 specification (Unspecified, Class 1, Class 2, Class 3 and Class 4).

(R) 7-32 The originating BSS shall include the Quality of Service parameter in the IAM. The coding of this parameter shall be based on the Quality of Service IE in the SETUP message from the user. The allowed codings of the QOS class forward and backward include Unspecified, Class 1, Class 2, Class 3 and Class 4. If information about the requested QOS Class is not available at the destination BSS, the destination BSS shall generate the default value ("unspecified QOS Class") for the QOS parameter IE in the SETUP message to the called user.

(R) 7-33 The originating BSS shall include the Calling Party's Category parameter coded as "ordinary calling subscriber" in the IAM.

(R) 7-34 The originating BSS shall include the Called Party Number parameter in the IAM. In addition, AESA for Called Party Number parameter shall be included if the received Called Party Number IE in the SETUP message contains AESA (as indicated by the code "0010" in the Addressing/Numbering Plan Identification subfield).

Inclusion of an AESA for Called Party Number parameter does not preclude the inclusion of the optional Called Party Subaddress parameter.

(R) 7-35 The address digits in the Called Party Number IE in the SETUP message shall determine the coding of the address digits and the nature of address in the Called Party Number parameter.

(R) 7-36 The Called Party Number parameter shall be formulated as follows:

Octet 1:

Bit 8 (the odd/even bit) shall be coded as follows:

0 If an even number of address digits or no address digits are included in the address information field (beginning with octet 3)

1 If an odd number of address digits are included in the address information field.

Bits 7654321 (nature of address indicator) shall be codes 0000100 (international number).

Octet 2:

Bit 8 (the internal network number indicator) shall be coded 0 indicating that routing to an internal network number is allowed.

Bits 765 (the numbering plan indicator) shall be coded 001 (ISDN numbering plan - E.164).

Bits 4321 are spare and shall be coded 0s.

Octets 3-n:

The address digits shall be mapped from the address digits in the Called Party Number IE (if Addressing/Numbering Plan Identification = 0001) or from the IDI of the AESA in the Called Party Number IE (if Addressing/Numbering Plan Identification = 0010). The coding of the address digits within the address information field shall be in Binary Coded Decimal (BCD) form. The first octet of this field shall contain the BCD code of the first address digit in bits 4321, and the BCD code of the second address digit in bits 8765. If an odd number of digits are sent, bits 8765 of the last octet of this field shall be set to 0000.

(R) 7-37 If the Called Party Number IE received by the originating BSS carries an E.164 AESA, the originating BSS shall map the E.164 part of the AESA (i.e., IDI) from the Called Party Number IE into the Called Party Number parameter as described in the preceding requirement. The called party number, containing only the E.164 part of the AESA, can be used together with other parameters (see Section 7.8.5.1.1 a), for routing the call through public networks. The entire AESA (20 octets) shall be carried in the AESA for Called Party parameter.

The Calling Party Number (CgPN) parameter can be sent from the originating BSS towards the destination BSS as part of the IAM. If the call is to be routed to another carrier, the CgPN is included provided the originating carrier and the other carrier have made a prior agreement to transfer it across the B-ICI. The call may be routed from the originating BSS to the other carrier on a direct connection or on a connection to an intermediate BSS for a subsequent routing to the other carrier.

(R) 7-38 The originating BSS shall have the capability to be set to include or not include in the IAM the CgPN on a per connecting carrier basis.

(R) 7-39 If the call is to be routed to another carrier, the CgPN shall be included in the IAM if allowed for the specific carrier selected to route the call further.

(R) 7-40 The originating BSS shall include the CgPN in the outgoing IAM if its inclusion is allowed. If the Calling Party Number IE is provided by the calling party in the SETUP message, the BSS shall verify the validity of the E.164 address in this IE (if Addressing/Numbering Plan Identification = 0001) or the E.164 part of the AESA in this IE (if Addressing/Numbering Plan Identification = 0010) by screening it against the set of addresses assigned to the interface. If the user provided calling number is valid, it shall be used to code the CgPN. The default address applicable to the originating interface shall be used when either no Calling Party Number IE is included in the SETUP message or the Calling Party Number information in the SETUP message is invalid (i.e., it does not pass screening).

(R) 7-41 The coding of the CgPN shall be as follows:

Octet 1:

Bit 8: Odd/Even Indicator - Coded as for the CgPN Parameter

Bits 7654321 - Nature of Address Indicator. Allowable codings are as follows:

0000100 (unique) international number
1110100 (non-unique) international number

The type of number and numbering plan identification information in the Calling Party Number IE in the received SETUP message shall be used to code the nature of address indicator and numbering plan indicator subfields of the CgPN. If a user provided number that has passed screening is to be included in the CgPN, then a coding indicating unique shall be used. If a default number is included in the CgPN, then the determination of unique or non-unique is based on whether the number is associated with a unique calling party.

Octet 2:

Bit 8: Calling Party Number incomplete indicator. Code as “0” if a user provided number is included (that is, the number has passed screening) or if a default number is provided. Code as “1” if neither a user supplied nor a default calling party number is available, and the CgPN is to be included in the IAM.

Bits 765: Numbering Plan Indicator.
This indicator shall be coded 001 (ISDN numbering plan - E.164).

Bits 43: Address presentation restricted indicator. This field is coded based on information received in the calling party number IE or from subscription information associated with the default number. Expected codings are:
00 - presentation allowed
01 - presentation restricted (default)

Bits 21: Screening indicator. Expected codes are:
01 - user provided, verified and passed
11 - network provided

Octets 3-n:

When the address digits are derived from the received Calling Party Number IE, the address digits shall be mapped from the address digits in the calling party number IE (if Addressing/Numbering Plan Identification = 0001) or from the IDI of the AESA in the calling party number IE (if Addressing/Numbering Plan Identification = 0010).The coding of the calling party address digits within the address information field shall be in Binary Coded Decimal (BCD) form. The first octet of this field shall contain the BCD code of the first address digit in bits 4321, and BCD code of the second address digit in bits 8765. If an odd number of digits are sent, bits 8765 of the last octet of this field shall be set to 0000.

(R) 7-42 If the received Calling Party Number IE in the SETUP message contains an AESA (as indicated by the code "0010" in the Addressing/Numbering Plan Identification subfield), the AESA for Calling Party parameter will be included in the IAM provided its inclusion is allowed by subscription or prior arrangement. The entire AESA (20 octets) shall be carried in the AESA for Calling Party parameter. The inclusion of the AESA for Calling Party parameter in the IAM is in addition to the inclusion of the Calling Party Number parameter.

The Calling Party Subaddress, Called Party Subaddress, Broadband High Layer Information, Broadband Low Layer Information and ATM Adaptation Layer (AAL) parameters can be transparently sent (i.e., without processing in the network) from the originating BSS towards the destination BSS using the IAM. The transfer of this information is based on meeting the following two conditions:

1. The transfer is allowed by the subscription parameters applicable to the originating user access interface. The originating BSS uses these subscription parameters to determine the applicability of call requests and services.

2. The originating carrier and the connecting carrier have made a prior agreement to transfer this information across the B-ICI if the call is to be routed to that carrier. The call may be routed from the originating BSS to the connecting carrier on a direct connection or on a connection to an intermediate BSS for a subsequent routing to that carrier.

(R) 7-43 The originating BSS shall have the capability to be set to include or not include in the IAM the Calling Party Subaddress, Called Party Subaddress, Broadband High Layer Information, Broadband Low Layer Information and AAL parameters based on the subscription parameters applicable to the originating UNI and on a per connecting carrier basis.

(R) 7-44 If the call is to be routed to another carrier, the parameters mentioned in the preceding requirement shall be included in the IAM provided the transfer of this information is allowed both by the user subscription and the specific connecting carrier selected to route the call further.

(R) 7-45 The originating BSS shall include the *Calling Party Subaddress parameter* in the outgoing IAM if its inclusion is allowed and the Calling Party Subaddress IE is received in the SETUP message from the calling user. The coding of the standard subfield shall be identical with the corresponding subfield coding in the received IE. The contents of the parameter starting from octet 2 shall be identical to the contents of the IE starting from octet 5.

Inclusion of an AESA for Calling Party Number parameter does not preclude the inclusion of the Calling Party Subaddress parameter.

(R) 7-46 The originating BSS shall include the *Called Party Subaddress parameter* in the outgoing IAM if its inclusion is allowed and the Called Party Subaddress IE is received in the SETUP message from the calling user. The coding of the standard subfield shall be identical with the corresponding subfield coding in the received IE. The contents of the parameter starting from octet 2 shall be identical to the contents of the IE starting from octet 5.

(R) 7-47 The originating BSS shall include the *Broadband High Layer Information parameter* in the outgoing IAM if its inclusion is allowed and the Broadband High Layer IE is received in the SETUP message from the calling user. The coding of the standard subfield shall be identical with the corresponding subfield coding in the received IE. The contents of the parameter starting from octet 2 shall be identical to the contents of the IE starting from octet 5.

(R) 7-48 The originating BSS shall include the *Broadband Low Layer Information parameter* in the outgoing IAM if its inclusion is allowed and one or more Broadband Low Layer IEs are received in the SETUP message from the calling user. Based on the user subscription only the first or all the Broadband Low Layer information IEs are accepted by the BSS for transfer. The repeat indicator shall be coded 0 if only one IE is included and 1 if more than one IEs are included in the Broadband Low Layer Information parameter. The priority subfield shall be coded according to the priority (ascending, descending or no prioritized order) of the IEs included in the parameter. The parameter field starting at octet 2 contains all Broadband Low Layer Information IEs as received in the SETUP message. The order of the IEs is not changed.

(R) 7-49 The originating BSS shall include the *AAL parameter* in the outgoing IAM if its inclusion is allowed and the AAL parameter IE is received in the SETUP message from the calling user. The coding of the standard subfield shall be identical with the corresponding subfield coding in the received IE. The contents of the parameter starting from octet 2 shall be identical with the contents of the IE starting from octet 5.

(R) 7-50 As a carrier option (See Section 7.3.2.2), the originating BSS shall include the *Transit Network Selection (TNS) parameter* in the IAM if it needs to indicate to a succeeding BSS the carrier selected for subsequent routing of the call.

(R) 7-51 As a carrier option (See Section 7.3.2.2), when included, the TNS shall include either 3-digit carrier identification code (XXX) or 4-digit carrier identification code (XXXX) identifying a succeeding carrier.

(R) 7-52 As a carrier option (See Section 7.3.2.2), the *Charge Number and Originating Line Information (OLI) parameters*, as a pair shall be configurable to be included, or not, in the IAM based on the connecting carrier and the subscribed service.

The Charge Number and OLI parameters are used to transfer information about the number to be charged for the call and about the calling party.

(R) 7-53 As a carrier option (See Section 7.3.2.2), when included in the IAM, the Originating Line Information parameter shall be coded according to the service characteristics of the originating line. These codes are the binary equivalents of the decimal codes used in the II digits of inband BSS access signaling.

The coding of the OLIP is presented in ANSI-T1.113.

If included in the IAM, the Charge Number parameter provides an Automatic Number Identification (ANI) to the succeeding carrier.

(R) 7-54 As a carrier option (See Section 7.3.2.2), when the Charge Number parameter is included in the IAM, it shall contain the NPA+NXX+XXXX address digits of this ANI in the address information field of the parameter. The odd/even indicator bit shall be coded “even number of address digits,” and the nature of address shall be coded “ANI of the calling party; national number.” If the ten address digits are not available, but the NPA digits are available, then only the three NPA digits shall be sent in the address information field. The odd/even indicator bit shall be coded “odd number of address digits,” and the nature of address field should be coded “ANI of the calling party; national number.” The numbering plan field shall be coded “ISDN numbering plan (Recommendation E.164)” when either three or ten digits are sent.

If no ANI address digits are available, the odd/even bit shall be coded “even number of address digits” and the nature of address field shall be coded “ANI not available or not provided.” In this case, the octet containing the nature of address code shall be the last octet of the charge number parameter.

(R) 7-55 As a carrier option (See Section 7.3.2.2), if the CgPN parameter is included in the IAM, the Charge Number parameter shall be omitted from the IAM if the following conditions are met:

- The Originating Line Information parameter and the charge number address digits are to be provided to the selected carrier.
- The CgPN parameter is included in the IAM.
- The charge number address digits agree with CgPN address digits.

The presence of the Originating Line Information parameter together with the absence of the Charge Number parameter will inform a succeeding carrier that the charge number address agrees with the calling party address.

The Carrier Identification Parameter (CIP) code is included in the IAM on a per carrier identification code (XXX or XXXX) basis provided the originating carrier and the connecting carrier have made a prior agreement to transfer it across the B-ICI if the call is to be routed to that carrier. The call may be routed from the originating BSS to the connecting carrier on a direct connection or on a connection to an intermediate BSS for a subsequent routing to that carrier. Note that multiple carrier identification codes may be assigned to a carrier. Such a carrier may choose to receive the CIP only for a selected subset of the carrier identification codes assigned to it.

(R) 7-56 As a carrier option (See Section 7.3.2.2), the originating BSS shall have the capability to be set to include or not include in the IAM the CIP on a per carrier identification code (XXX or XXXX) basis.

(R) 7-57 As a carrier option (See Section 7.3.2.2), the originating BSS shall include the CIP in the outgoing IAM if its inclusion is allowed. When included, the CIP shall be coded as follows:

Octet 1:

Bits 765 - Type of network identification
010 national network identification

Bits 4321 - Network identification plan
0001 3-digit carrier identification code
0010 4-digit carrier identification code

The carrier identification code digits XXX (XXXX) shall be coded in octets 2 and 3 in BCD form starting with the first digit (most significant) in bits 4321 of octet 1, digit 2 in bits 8765 of octet 2, digit 3 in bits 4321 of octet 3, etc. For 3-digit carrier identification code, bits 8765 of octet 3 shall be coded 0s.

The Carrier Selection Information parameter allows a carrier to determine whether a call is routed to that carrier (1) because of pre-subscription, or (2) because the end user provided a carrier identification code in the Transit Network Selection IE.

(R) 7-58 As a carrier option (See Section 7.3.2.2), an originating BSS shall be able to include or not include the Carrier Selection Information parameter in the IAM based on the connecting carrier to which the call is routed.

(R) 7-59 As a carrier option (See Section 7.3.2.2), when included, the Carrier Selection Information parameter shall be coded as follows:

The "selected carrier identification code pre-subscribed and not input by calling party" code shall be used to inform the selected carrier that the 3/4-digit (XXX/XXXX) carrier identification code used for delivering the call to that carrier is the pre-subscribed code associated with the originating access for the call, and that XXX/XXXX was not input to the BSS during call setup by the calling party. (A Transit Network Selection IE was not included in the SETUP message).

The "selected carrier identification code pre-subscribed and input by calling party" code shall be used to inform the selected carrier that the 3/4-digit (XXX/XXXX) carrier identification code used for delivering the call to that carrier is the pre-subscribed code associated with the originating access for the call, and that XXX/XXXX was input to the BSS during call setup. (A Transit Network Selection IE with XXX/XXXX was included in the SETUP message).

The "selected carrier identification code not pre-subscribed and input by calling party" code shall be used to inform the selected carrier that the 3/4-digit (XXX/XXXX) carrier identification code used for delivering the call to that carrier is not the pre-subscribed code associated with the originating access for the call, and that XXX/XXXX was input to the BSS during call setup. (A Transit Network Selection IE with XXX/XXXX was included in the SETUP message).

The Originating ISC Point Code parameter is used for statistical purposes, e.g., accumulation of the number of incoming call/connections on an originating inter-carrier switching center basis.

(R) 7-60 If the originating BSS has been assigned an Originating ISC Point Code, it shall have the capability to be set to include or not include in the IAM the Originating ISC Point Code parameter.

(R) 7-61 On sending the IAM, timer T_{40b} shall be started. Timer T_{40b} shall be stopped on receipt of an IAA or an IAR. If neither an IAA nor an IAR has been received when timer T_{40b} expires, then the reset procedure described in Section 7.8.1 shall be followed, the management system shall be alerted, and the VPCI/VCI and bandwidth shall be released.

The received IAA will have the OSID containing the SID value, say Bi, selected by the succeeding BSS. The originating BSS will use the SID assigned by it and Bi to establish the bearer control association as described in Section 7.8.3. As explained in that section, all subsequent messages from the originating to the succeeding BSS will contain Bi in the DSID.

Refer to Section 7.8.2.3 for procedures applicable to abnormal conditions related to assignment of VPCI/VCI and bandwidth. Refer to Section 7.8.6 for unsuccessful call and connection set up procedures.

(O) 7-2 On receipt of IAR, the call should be re-attempted. The call can be re-attempted on a different route.

(R) 7-62 On sending the IAM, the originating BSS shall start timer T_{7b}. T_{7b} shall be stopped on receipt of an ACM, ANM or receipt of an indication of release from the calling party. If an ACM, ANM , or calling party release is received before timer T_{7b} expires, the originating BSS shall stop timer T_{7b} and process the received message or indication. If timer T_{7b} expires before receipt of the ACM, ANM, or calling party release, then the call shall be released using the procedures described in Section 7.7.7. The cause indicators parameter shall be coded as:

General location: public network serving the local user
Cause value: 102 "recovery on timer expiry"

(e) IAM - Sent by the Non-Assigning BSS

(R) 7-63 The originating BSS that acts as a non-assigning BSS for this call shall follow the procedures described in (d) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(f) Completion of Transmission Path

(R) 7-64 Through connection in both directions shall be completed on receipt of an ANM.

The current version of this document does not support narrowband bearer capabilities including voice over ATM. To support such capabilities, the BSS will have to support different cut-through requirements.

7.8.5.1.2 Actions Required at an Intermediate BSS - Originating Network

In this case, the IAM is received from the originating BSS.

7.8.5.1.2.1 Incoming Side of the BSS

(a) Assigning BSS

(R) 7-65 After receiving the IAM, the intermediate BSS that acts as an assigning BSS for this call shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (b). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

The received IAM will have the OSID containing the SID value, say Ai, selected by the originating BSS. The intermediate BSS will use the SID assigned by it and Ai to establish the bearer control association as described in Section 7.8.3. As explained in that section, all subsequent messages from the intermediate to the originating BSS will contain Ai in the DSID.

(R) 7-66 The IAA shall include the DSID containing the SID assigned by the originating BSS and OSID containing the SID assigned by the intermediate BSS.

(R) 7-67 The IAA shall include the CEI (containing the selected VPCI/VCI values) .

Refer to Section 7.8.2.3 for procedures applicable to abnormal conditions related to assignment of VPCI/VCI and bandwidth. Refer to Section 7.8.6 for unsuccessful call and connection set up procedures.

(b) Non-Assigning BSS

(R) 7-68 After receiving the IAM, the intermediate BSS that acts as a non-assigning BSS shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (a). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

(R) 7-69 Further procedures shall be as for the assigning BSS described in (a) above except that CEI shall not be included in the IAA.

7.8.5.1.2.2 Outgoing Side of the BSS

(a) Virtual Channel Selection

(R) 7-70 After sending the IAA, an intermediate BSS shall analyze the called party number and the other routing information (see Section 7.8.5.1.1) to determine the routing of the call. If the intermediate BSS can route the call using the ATM Cell Rate, QOS, and BBC parameters specified to the selected carrier, it shall send an IAM to that carrier. The BSS shall follow the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2.

(b) Parameters in the IAM Sent by the Assigning BSS

(R) 7-71 The intermediate BSS that acts as an assigning BSS for this call shall include the CEI (containing the selected VPCI/VCI values) in the IAM for the outgoing connection as described in Section 7.8.2.2 (a).

(R) 7-72 The intermediate BSS shall include in the IAM the OSID (containing the selected SID) as described in Section 7.8.3.

(R) 7-73 The intermediate BSS shall include in the IAM the ATM Cell Rate, Broadband Bearer Capability, Called Party Number, AESA for Called Party Number if received, and Calling Party's category parameters. This signaling information will be identical with that in the IAM received from the preceding BSS.

(R) 7-74 As a carrier option (See Section 7.3.2.2), if the call is to be routed to a connecting carrier and the TNS would be needed by this carrier for further routing of the call, the TNS included in the IAM received from the preceding BSS is passed on transparently in the IAM for the outgoing connection. Otherwise, the TNS in the IAM received from the preceding BSS shall be discarded.

(R) 7-75 If the call is to be routed to another carrier, the IAM shall include the received Called Party Subaddress, Calling Party Subaddress, AESA for Called Party Number if received, AAL parameter, Broadband High Layer Information, Broadband Low Layer Information, CgPN, CIP, Charge Number, OLI, and Carrier Selection Information parameters based on prior agreements between the connecting carriers. The BSS shall transfer these parameters transparently (i.e., without any processing) from the incoming IAM to the outgoing IAM. See Section 7.8.8 - "Propagation Delay Determination" for an exception.

(R) 7-76 If the intermediate BSS has been assigned an Originating ISC Point Code, it shall have the capability to be set to include or not include in the IAM the Originating ISC Point Code parameter.

(R) 7-77 The procedures to be followed after sending the IAM shall be as described in Section 7.8.5.1.1 (d) for the originating BSS except that the timer T_{7b} related procedures shall not be applicable.

(c) Parameters in the IAM Sent by the Non-Assigning BSS

(R) 7-78 The intermediate BSS that acts as a non-assigning BSS for this call shall follow the procedures described in (b) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(d) Sending of Exit Message

An Exit Message (EXM) is needed for a call routed to another carrier. It is generated at an outgoing gateway BSS in a network and sent in the backward direction to notify preceding BSSs that call set up information has successfully progressed to the succeeding network. This message generally does not cross a network boundary.

(R) 7-79 As a carrier option (See Section 7.3.2.2), after sending the IAM to a connecting carrier, the intermediate BSS shall await the IAA, or IAR from that carrier. If an IAA is received for the outgoing connection, the intermediate BSS shall formulate and send an EXM to the originating BSS. The sending of an EXM shall precede any ACM or ANM for the call sent to the originating BSS.

(R) 7-80 As a carrier option (See Section 7.3.2.2), if an IAR is received and an automatic re-attempt is made by the intermediate BSS, the procedure described in the preceding requirement shall be repeated when the IAM associated with the re-attempt is sent.

The Outgoing Facility Identifier parameter carries the identification of the outgoing facility on which the call attempt to the connecting carrier was made by the intermediate BSS. This parameter consists of the VPCI used for the outgoing call attempt and the signaling point code of the BSS at the far-end of this VPCI.

(R) 7-81 After sending the IAM to a connecting carrier, the intermediate BSS shall send an REL towards the originating BSS in response to the received IAR (when no re-attempt is made) or T_{40b} expiry. As a carrier option (See Section 7.3.2.2), the REL shall include the Outgoing Facility Identifier parameter if the intermediate BSS can identify the outgoing facility on which the call attempt to the connecting carrier was made.

(R) 7-82 As a carrier option (See Section 7.3.2.2), the EXM shall include the DSID containing the SID assigned by the originating BSS.

(R) 7-83 As a carrier option (See Section 7.3.2.2), the EXM shall include the Outgoing Facility Identifier parameter.

(e) Completion of Transmission Path

(R) 7-84 Through connection in both directions shall be completed on receipt of an ANM. The B-ICI Version 2.0 does not support narrowband bearer capabilities including voice over ATM. To support voice over ATM, the BSS will have to support different cut-through requirements which are for further study.

7.8.5.1.3 Actions Required at an Intermediate BSS - Transit Carrier

A transit carrier would be any carrier between the originating and terminating carriers. A call may be handled by one or more transit carriers. In some cases, a call may be routed directly from the originating carrier to the terminating carrier without passing through a transit carrier.

(R) 7-85 An intermediate BSS in a transit carrier shall meet the same requirements described above for the intermediate BSS in the originating carrier.

(R) 7-86 If the intermediate BSS has been assigned an Originating ISC Point Code, it shall have the capability to be set to delete the Originating ISC Point Code parameter from the outgoing IAM.

7.8.5.1.4 Actions Required at an Intermediate BSS - Terminating Network

This section gives requirements for an intermediate BSS that receives a call from another carrier and routes it to a terminating BSS serving the called party. As an example, a call can originate in a LEC, pass through a transit carrier (e.g., an IEC) and is routed to a (possibly another) LEC serving the called party.

7.8.5.1.4.1 Incoming Side of the BSS

(a) Assigning BSS

(R) 7-87 Same requirements as in Section 7.8.5.1.2.1 (a) shall be applicable except that the preceding BSS in this case is the BSS belonging to the carrier routing the call to the terminating carrier.

(b) Non-Assigning BSS

(R) 7-88 The requirements in Section 7.8.5.1.2.1 (b) shall apply.

7.8.5.1.4.2 Outgoing Side of the BSS

(a) Virtual Channel Selection

(R) 7-89 If the intermediate BSS receives the TNS from the preceding carrier, it shall release the call as described in Section 7.8.7. The cause indicators parameter shall be coded as:

General location: public network serving the remote user
Cause value: 111 "protocol error - unspecified"

(R) 7-90 After sending the IAA to the preceding carrier, an intermediate BSS shall analyze the Called Party Number. If the intermediate BSS can route the call using the ATM Cell Rate, QOS, and BBC parameters specified to the destination, it shall send an IAM to the destination BSS. The BSS shall follow the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2.

(b) Parameters in the IAM Sent by the Assigning BSS

(R) 7-91 The intermediate BSS that acts as an assigning BSS for this call shall include the CEI (containing the selected VPCI/VCI values) in the IAM for the outgoing connection as described in Section 7.8.2.2 (a).

(R) 7-92 The intermediate BSS shall include in the IAM the OSID (containing the selected SID) as described in Section 7.8.3.

(R) 7-93 The intermediate BSS shall include in the outgoing IAM the ATM Cell Rate, BBC, Called Party Number, AESA for Called Party Number if received, and Calling Party's Category parameters as in the received IAM.

(R) 7-94 The business arrangement between the terminating and the preceding networks shall determine whether the CgPN and AESA for CgPN parameters (if received), the information whose transfer is governed by user subscription parameters (if received), described in Section 7.8.5.1.1 (d) or other parameters are accepted and included (as received) in the outgoing IAM. (See Section 7.8.8 - "Propagation Delay Determination" for an exception). The BSS shall have the capability to be set to include or not include any of the above parameters in the outgoing IAM.

(R) 7-95 The preceding requirement shall take precedence over the compatibility instructions included in such parameters and the instructions notwithstanding, the intermediate BSS may discard these parameters or any unrecognized parameter or a parameter with unrecognized value. In other words, the screening (policing) functions specified in the preceding requirement shall take precedence over compatibility instructions.

(R) 7-96 If the intermediate BSS has been assigned an Originating ISC Point Code, it shall have the capability to be set to delete the Originating ISC Point Code parameter from the outgoing IAM.

(R) 7-97 The procedures to be followed after sending the IAM shall be as described in Section 7.8.5.1.1 (d) for the originating BSS except that the timer T_{7b} related procedures shall not be applicable.

(c) Parameters in the IAM Sent by the Non-Assigning BSS

(R) 7-98 The intermediate BSS that acts as a non-assigning BSS for this call shall follow the procedures described in (b) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(d) Completion of Transmission Path

(R) 7-99 The requirements in Section 7.8.5.1.2.2 (e) shall apply.

7.8.5.1.5 Actions Required at the Destination BSS - Terminating Network

The terminating BSS may receive a call from another carrier either on a direct connection or via an intermediate BSS. The requirements in this section are applicable for both of these cases.

(a) Incoming Side - Assigning BSS

(R) 7-100 After receiving the IAM, the destination BSS that acts as an assigning BSS for this call shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (b). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

The received IAM will have the OSID containing the SID value, say Ai, selected by the preceding BSS. The destination BSS will use the SID assigned by it and Ai to establish the bearer control association as described in Section 7.8.3. As explained in that section, all subsequent messages from the destination to the preceding BSS will contain Ai in the DSID.

(R) 7-101 The IAA shall include the DSID containing SID assigned by the preceding BSS and OSID containing the SID assigned by the destination BSS.

(R) 7-102 The IAA shall include the CEI (containing the selected VPCI/VCI values).

Refer to Section 7.8.2.3 for procedures applicable to abnormal conditions related to assignment of VPCI/VCI and bandwidth. Refer to Section 7.8.6 for unsuccessful call and connection set up procedures.

(b) Incoming Side - Non-Assigning BSS

(R) 7-103 After receiving the IAM, the destination BSS that acts as a non-assigning BSS shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (a). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

(R) 7-104 Further procedures shall be as for the assigning BSS described in (a) above except that CEI shall not be included in the IAA.

(c) Call Processing

(R) 7-105 If the call is coming in on a direct connection from another carrier, the business arrangement between the terminating carrier and the preceding carrier (the carrier routing the call to the terminating carrier) shall determine whether the Calling Party Number and AESA for Calling Party Number parameters (if received), the information whose transfer is governed by user subscription parameters (if received), described in Section 7.8.5.1.1 (d) or other parameters are accepted. The BSS shall have the capability to be set to accept and process or not accept any of the above parameters.

(R) 7-106 The preceding requirement shall take precedence over the compatibility instructions included in such parameters and the instructions notwithstanding, the destination BSS may discard these parameters or any unrecognized parameter or a parameter with unrecognized value. In other words, the screening (policing) functions specified in the preceding requirement shall take precedence over compatibility instructions. In particular, if the BSS receives the TNS from the preceding carrier, it shall release the call as described in Section 7.8.5.1.4.2 (a).

(R) 7-107 If the destination BSS has been assigned an Originating ISC Point Code, it shall have the capability to be set to delete the Originating ISC Point Code parameter from the SETUP to the called party.

(R) 7-108 After sending the IAA, the destination BSS shall analyze the called party number to determine to which party the call should be connected. It shall also check the called party's access condition and perform various checks to determine whether or not the called party is allowed to receive the call.

If the connection is allowed, the destination BSS will proceed to offer the call to the called party by sending a DSS2 SETUP message.

(R) 7-109 On sending the SETUP message, the BSS sets timer T_{303}. If a DSS2 ALERTING, a CONNECT or a RELEASE COMPLETE message is received before this timer expires, an ACM, an ANM or an REL, respectively, shall be sent to the preceding BSS. If timer T_{303} expires, the SETUP message is sent again, T_{303} is restarted and an ACM is sent. If a CALL PROCEEDING message is received before expiry of T_{303}, timer T_{310} is set awaiting ALERTING, CONNECT or a RELEASE message.

(R) 7-110 If the IAM contains information from the originating access (in the SETUP message) carried in the parameters mentioned in Section 7.8.5.1.1 (d), it shall be transferred unaltered in the SETUP message sent to the called user.

(R) 7-111 If the destination BSS receives the AESA for Called Party in the IAM, it shall map the AESA into the Called Party Number IE to be included in the SETUP message.

Both the CgPN parameter and the AESA for Calling Party parameter may be present in the IAM. The selection between the two parameters for mapping into the CgPN IE in the SETUP message shall depend on the services operating at the destination local BSS.

7.8.5.2 Address Complete Message

7.8.5.2.1 Actions Required at the Destination BSS

(R) 7-112 An ACM shall be sent from the destination BSS as soon as it has been determined that the complete called party number has been received and to convey indications of the called party's status.

(R) 7-113 The called party's status indicator in the called party's indicators parameter included in the ACM shall be coded as follows.

(a) "No indication" if the ACM is sent because of T_{303} expiry.
In this case, the indication that the destination user is being alerted is transferred in a Call Progress Message (see Section 7.8.5.3).

(b) "Alerting" if an ALERTING message is received.

(R) 7-114 The called party's category indicator in the called party's indicators parameter shall be set as "ordinary subscriber".

(R) 7-115 The ACM shall include the DSID containing the SID assigned by the preceding BSS.

7.8.5.2.2 Actions Required at an Intermediate BSS

(R) 7-116 On receipt of the ACM, an intermediate BSS shall send the corresponding ACM towards the preceding BSS.

7.8.5.2.3 Actions Required at the Originating BSS

(R) 7-117 On receipt of the ACM at the originating BSS, timer $T7_b$ shall be stopped.

7.8.5.2.4 Through Connection and Answer Indication at the Destination BSS

(R) 7-118 The destination BSS shall through connect after receiving the CONNECT message from the called party and before sending the ANM.

7.8.5.3 Call Progress Message (Basic Call)

For a basic call, the Call Progress Message (CPG) is sent only after the ACM. The CPG is sent from a BSS in the backward direction indicating that an event has occurred during call set-up which should be relayed to the calling party.

7.8.5.3.1 Actions Required at the Destination BSS

(R) 7-119 The CPG shall be sent from the destination BSS if the ACM has been sent and subsequently:

- an ALERTING message is received from the called party. The CPG shall contain the called party's Indicators parameter with the called party's status set to "alerting". The called party's category indicator in the called party's indicators parameter shall be set as "ordinary subscriber".

(R) 7-120 The CPG shall include the DSID containing the SID assigned by the preceding switch.

7.8.5.3.2 Actions Required at an Intermediate BSS

(R) 7-121 On receipt of the CPG, an intermediate BSS shall send the corresponding CPG to the preceding BSS.

7.8.5.3.3 Actions Required at the Originating BSS

(R) 7-122 On receipt of the CPG at the originating BSS, no call state change shall occur.

7.8.5.4 Answer Message

7.8.5.4.1 Actions Required at the Destination BSS

(R) 7-123 When the DSS2 CONNECT message is received from the called party, the destination BSS shall send an ANM to the preceding BSS.

(R) 7-124 The ANM shall include the DSID containing the SID assigned by the preceding BSS.

The ANM can transport AAL-parameters parameter and broadband low layer information parameter transparently from the terminating access to the originating BSS.

(R) 7-125 The destination BSS shall include the AAL-parameters parameter and Broadband Low Layer Information parameter in the ANM if their inclusion is allowed and the AAL-parameters IE and Broadband Low Layer Information IE are received in the CONNECT message from the called user.

The coding of these parameters shall be as described in Section 7.8.5.1.1 (d). The AAL- parameters IE and only one Broadband Low Layer Information IE will be transferred.

Through connection: see Section 7.8.5.2.4.

7.8.5.4.2 Actions Required at an Intermediate BSS

(R) 7-126 Upon receipt of the ANM, the intermediate BSS shall through connect the virtual connection in both directions and send the corresponding ANM towards the preceding BSS.

7.8.5.4.3 Actions Required at the Originating BSS

(R) 7-127 When the originating BSS receives the ANM indicating that the required call and connection have been completed, the following occurs:
- the timer T_{7b} shall be stopped if it is still running,
- the virtual connection to the calling party shall be connected in both directions, and
- a DSS2 CONNECT message shall be sent to the calling party.

If the ANM contains information from the terminating access carried in the parameters mentioned in Section 7.8.5.4.1, it shall be transferred in the CONNECT message to the calling user.

7.8.5.5 Storage and Release of Information

(R) 7-128 During the call and connection set-up itself, each relevant BSS shall store information contained in the IAM sent by the originating BSS or received at the intermediate or destination BSS. The information that must be stored shall include all parameters within the IAM.

(R) 7-129 The IAM information shall not be released from memory:

(a) in the originating or intermediate BSS, before the ACM or ANM has been received.

(b) in the destination BSS, before the ACM or ANM has been sent.

The IAM information can be released from memory in all BSSs when the call is released prematurely and no automatic repeat attempt is to be made.

7.8.6 Unsuccessful Call and Connection Set Up

7.8.6.1 Lack of Resources at the Incoming Side

(R) 7-130 If at any time a call or connection leg cannot be completed due to a lack of resources at the incoming side (e.g., SIDs, VPCI/VCI or bandwidth), the BSS receiving the IAM shall immediately start the release of the call and connection and send an IAR towards the preceding BSS. The IAR shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs were available; cause value 45 (no VPCI/VCI available) shall be included in the case of a lack of VPCI/VCI; and cause value 37 (ATM Cell Rate not available) shall be included in the case of a lack of bandwidth. The incoming signaling association shall be deleted.

7.8.6.2 Lack of Resources at the Outgoing Side

(R) 7-131 If at any time a call or connection leg cannot be completed due to a lack of resources at the outgoing side (e.g., SIDs, VPCI/VCI or bandwidth), the BSS shall immediately start the release of the call and connection and shall send an REL towards the preceding BSS. The REL shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs were available, cause value 45 (no VPCI/VCI available) shall be included in the case of a lack of VPCI/VCI; and cause value 37 (ATM Cell Rate not available) shall be included in the case of a lack of bandwidth. Further procedures shall be as in Section 7.8.7.1.

7.8.6.3 Actions at a BSS Receiving an IAM Reject Message.

(R) 7-132 On receipt of an IAR, a BSS shall release the VPCI/VCI and the bandwidth (if applicable), and shall terminate the outgoing signaling association, i.e., it shall release the SID assigned to the outgoing connection. The BSS may re-attempt the call on an alternate route.

(R) 7-133 If all attempts to route the call have failed, the BSS shall:

(a) Immediately start the release of the call and connection.

(b) If this is an intermediate BSS, it shall send an REL with the received cause value towards the preceding BSS. Further procedures shall be as in Section 7.8.7.1.

(c) If this is an originating BSS, it shall send a DSS2 RELEASE message with the received cause value to the calling user.

7.8.6.4 Actions at a BSS Receiving a Release Message

(R) 7-134 On receipt of an REL from the succeeding BSS after receipt of the IAA, but before receipt of the ACM or ANM, the BSS shall release the VPCI/VCI and the bandwidth, and shall send an RLC. The outgoing signaling association shall be terminated, i.e., it shall release the SID assigned to the outgoing connection.

(a) If this is the controlling BSS (i.e. the BSS controlling the call), it may attempt to re-route the call.

(b) If this is not the controlling BSS or if all attempts to re-route the call have failed:

(i) If this is an intermediate BSS, it shall send an REL with the received cause value towards the preceding BSS. Further procedures shall be as in Section 7.8.7.1.

(ii) If this is an originating BSS, it shall send a DSS2 RELEASE message with the received cause value to the calling user.

7.8.6.5 Address Incomplete

(R) 7-135 If a BSS determines that the proper number of digits for routing the connection has not been received, an REL shall be sent towards the preceding BSS with cause "address incomplete".

7.8.7 Normal Call Release

7.8.7.1 General

The release procedure is a confirmed operation. The REL initiates release of the call and virtual channel connection, and the RLC signifies completion of the release. The same procedures are used in the network irrespective of whether they are initiated by the calling party, the called party or the network.

(R) 7-136 The REL shall include the DSID and cause indicators parameter coded with the appropriate cause value and location. These are specified in ITU-T Recs. Q.850 and Q.2610. On sending an REL, a BSS shall start timer T_{1b} and await receipt of an RLC. If an RLC is received before timer T_{1b} expires, the timer shall be stopped and the requirements listed in this section shall be followed. If timer T_{1b} expires before receipt of an RLC, the BSS shall alert the management system and reset the VPCI/VCI using the procedures given in Section 7.9.1.

(R) 7-137 Any BSS receiving an REL shall perform the following actions in the order shown:

- the associated VPCI/VCI shall be made available for new traffic,
- the bandwidth shall be made available for new traffic (applicable for an assigning BSS),
- an RLC shall be returned,
- the signaling association (SIDs) shall be terminated.

(R) 7-138 A BSS that has initiated the release procedure by sending an REL shall perform the following actions on receipt of the RLC:

- stop timer T_{1b}
- the associated VPCI/VCI shall be made available for new traffic,
- the bandwidth shall be made available for new traffic (applicable for an assigning BSS),
- the signaling association (SIDs) shall be terminated.

The following sections describe additional required actions.

7.8.7.2 Release Initiated by a Calling Party

(a) Actions Required at the Originating BSS

(R) 7-139 On receipt of a request to release the call from the calling party, the originating BSS shall immediately start the release of the ATM connection. An REL shall be sent towards the succeeding BSS with the cause indicators parameter. The cause indicators parameter shall be coded as:

general location: user
cause value: 16 "normal clearing".

In case of a premature release by the calling party, a release indication is received from the calling party before the call is established.

(R) 7-140 In case of a premature release by the calling party, the BSS shall immediately release the resources towards the calling party, but shall delay the release of the connection towards the succeeding BSS until receipt of the IAA.

(b) Actions at an Intermediate BSS

(R) 7-141 On receipt of the REL, an intermediate BSS shall send an REL towards the succeeding BSS with the received cause indicators parameter. The release of the connection towards the succeeding BSS shall not occur until after the receipt of the IAA.

(c) Actions Required at the Destination BSS

(R) 7-142 On receipt of the REL from the preceding BSS, the destination BSS shall immediately release the resources towards the called party by sending the DSS2 RELEASE message including a cause IE. The cause IE shall be mapped from the received cause indicators parameter.

(d) Collision of Release Messages

(R) 7-143 If two points in a connection initiate release of a call, an REL may be received at a BSS from a succeeding or preceding BSS after the release of the call is initiated. In this case, the BSS shall return an RLC towards the BSS from which it received the REL. The RLC shall be sent when the call and connection have been cleared.

7.8.7.3 Release Initiated by a Called Party

(R) 7-144 The procedures in Section 7.8.7.2 shall apply, except that the functions at the originating and destination BSSs are transposed.

7.8.7.4 Release Initiated by the Network

(R) 7-145 The procedures in Section 7.8.7.2 shall apply, except that they can be initiated at any BSS. To initiate release of incoming and outgoing connections, RELs shall be sent to the preceding and succeeding BSSs with the cause indicators parameter coded with the appropriate cause value. When the originating and destination BSSs receive the RELs, they shall send DSS2 RELEASE messages to the calling and called users, respectively. The cause IEs in the RELEASE messages shall be mapped from the cause indicators parameter in the corresponding REL.

7.8.7.5 Suspend, Resume (Network Initiated)

The suspend and resume (network initiated) procedures are only applicable in the case of interworking with N-ISDN User Part. An interworking BSS is defined as the switch performing interworking between B-ISDN User Part and N-ISDN User Part (N-ISDN interworking switch). The suspend and resume procedures will be invoked only by a destination BSS when the called party has a non-ISDN access. Suspend and resume messages will be received by an ATM switch only through an interworking BSS, i.e., these messages will be generated by N-ISUP and simply passed through by BISUP.

The current version of this document does not address BISUP requirements to support interworking with N-ISDN. Therefore, requirements for suspend and resume (network initiated) procedures are not provided in the current version of this document.

7.8.8 Propagation Delay Determination

The propagation delay determination procedure using BISUP is defined in ITU-T Rec. Q.2764. This procedure provides a means to determine the total propagation delay for a connection.

A propagation delay value would be measured and pre-stored for each virtual path going out of every BSS for which the BSS is the assigning BSS.

The propagation delay information is accumulated during call set up in the forward direction by increasing the propagation delay counter parameter contained in the IAM. The cumulative delay value is sent in the backward direction as call history information parameter in the ANM before the active phase of a call.

The ATM Forum UNI Specification Version 3.1 does not provide access protocol requirements for supporting end-to-end propagation delay determination. Therefore, the current version of this document does not address BISUP requirements to support end-to-end propagation delay determination.

7.9 BISUP Maintenance Control Functions

This subsection contains the description of the maintenance control functions relating to:

- The reset of resources
- The blocking of virtual paths
- Remote User Part availability procedure
- Transmission alarm handling
- Automatic congestion control
- Signaling congestion control procedure
- Destination unavailability control
- VPCI/VPI consistency check procedure

The BISUP messages associated with maintenance control functions are: Blocking (BLO), Blocking Acknowledgment (BLA), Unblocking (UBL), Unblocking Acknowledgment (UBA), Reset (RSM), Reset Acknowledgment (RAM), User Part Test (UPT), User Part Available (UPA), Consistency Check Request (CCR), Consistency Check Request Acknowledgment (CCRA), Consistency Check End (CCE), and Consistency Check End Acknowledgment (CCEA).

7.9.1 Reset Procedure

The reset procedure is used to return signaling identifiers and connection elements (virtual channel links/path connections) to the idle condition. The procedure is invoked under abnormal conditions when the current status of the Signaling Identifiers (SIDs) or the Connection Element Identifiers (CEIs) is unknown or ambiguous. For example, a switching system that has suffered memory mutilation will not know the status of SIDs and virtual channel connections, e.g., idle, busy incoming, busy outgoing, etc. The identifiers and virtual channel links/path connections (and any associated bandwidth) between the two adjacent nodes should therefore be reset to the idle condition and the resources made available for new traffic.

In order to indicate what resources are to be reset, the Reset message contains a Resource Identifier parameter. This parameter consists of two subfields: "Resource Indicator" and "Resource Value". The resource indicator identifies the resource type to be reset (e.g., VPCI) and the resource value identifies the specific instance of the resource to be reset. If the resource indicator in this parameter is set to "remote SID" the resource value will indicate the local SID reference at the sending node (the remote reference at the receiving node). If the resource indicator is set to "local SID" then the resource value will indicate the remote SID reference at the sending node (the local reference at the receiving node). If the resource indicator is set to "VPCI," or "VPCI/VCI" the resource value will indicate the virtual channel/path link common to both the sending and receiving nodes.

(R) 7-146 The reset procedure shall be initiated for the following signaling anomalies detected by the B-ISDN signaling system. These anomalies are detected by the protocol procedures, reported to the BSS management functions, and thus initiate the reset procedure:

An unexpected message is one which contains a message type code that is within the set supported by the BSS but is not expected to be received in the current state of the call.

An unexpected message for the following requirement is any message other than an IAA or IAR.

- If an unexpected message is received while awaiting the IAM Acknowledge message, the BSS shall send a reset message to reset the remote SID.

An unexpected message for the following requirement is any message other than an ACM, ANM, or REL.

- If an unexpected message is received while awaiting the Address Complete message, the BSS shall send a reset message to reset the local SID.

- On the expiry of Timer T_{1b}, "Await Release Complete", the BSS shall send a reset message to reset the VPCI/VCI.

- If an unexpected message is received relating to an unallocated SID, the BSS shall send a reset message to reset the remote SID.

- On the expiry of Timer T_{40b}, "Await IAM Acknowledgment", an assigning BSS shall send a reset message to reset the VPCI/VCI and remove the VPCI/VCI and bandwidth from service; a non-assigning BSS shall send a reset message to reset the remote SID.

- If the BSS detects a missing mandatory parameter, then the BSS shall send a reset message to reset the local SID.

- If a maintenance action is invoked due to memory mutilation, e.g., losing the association information between a signaling ID and a Connection Element identifier, the BSS shall send a reset message to reset each affected VPCI.

- If a maintenance action is invoked involving start-up and restart of a BSS and/or a signaling system, the BSS shall send a reset message to reset each affected VPCI.

7.9.1.1 Actions at Reset Initiating BSS

(R) 7-147 To initiate reset procedures, a RSM message shall be sent. The message shall contain the resource identifier parameter.

(R) 7-148 On sending the RSM message, the BSS shall stop sending ATM cells on the connection, if applicable.

(R) 7-149 On sending the RSM message, the BSS shall start timers T_{16b} and T_{17b}, and wait for the RAM message. Timers T_{16b} and T_{17b} shall be stopped on receipt of the RAM message. If timer T_{16b} expires before receipt of RAM, the procedure in Section 7.9.1.3 shall be followed.

(R) 7-150 On receiving the RAM, the affected BSS (the reset initiating BSS) will place the referenced resource it controls in the "idle" state, and return all associated bandwidth on the virtual path which the BSS controls to the "available" state (i.e., send indication to resource control mechanism).

(R) 7-151 If the resource reset was "VPCI," the BSS shall idle all associated signaling identifiers, i.e., delete all signaling associations related to that VPCI.

The Virtual Path blocking conditions are affected by reset of "VPCI" as follows:

(R) 7-152 Any local blocking condition related to the reset VPCI shall be removed when the RAM is received.

(R) 7-153 Any remote blocking condition related to the reset VPCI shall be removed when the RAM is received, unless a BLO message has been received since the sending of the RSM message relating to the concerned VPCI, in which case the remote blocking condition shall be reinstated.

(R) 7-154 The blocking conditions shall be unaffected by other types of reset.

(R) 7-155 The BSS shall notify the management system of the outcome of the VPCI reset procedure when blocking is active on that VPCI.

7.9.1.2 Actions at Reset Responding BSS

(R) 7-156 On receiving a RSM message, the receiving (unaffected) BSS shall:

(a) If it is the incoming or outgoing BSS on a connection in any call/connection state, the BSS shall accept the message as a request to idle resources it controls. It shall respond by sending a RAM after the indicated resource, the bandwidth if it is the controlling BSS for the virtual path affected, and all associated identifiers (SIDs, VPCI/VCIs, where applicable) on the concerned link have been made available for new traffic.

If a "CEI: VPCI" is reset, then all VCIs and SIDs associated with the virtual path link shall be released;

(b) If the received resource (SID, VPCI/VCI, VPCI) is not allocated (idle condition), the BSS shall accept it as a release request and therefore respond by sending a RAM message;

(c) Any interconnected virtual path/channel links and all associated resources shall be released by an appropriate method (e.g., Release) except in the case of call/connections that are currently awaiting the IAM Acknowledgment; in this case, an automatic repeat attempt is applicable.

(d) If the RSM message is received after having sent a RSM message, the BSS shall respond with a RAM. The associated identifiers and the bandwidth, if applicable, shall be made available for service.

(e) If the Resource indicator is set to "CEI: VPCI" and if the affected virtual path is in the locally blocked state, the RSM message shall be accepted as a request to idle all resources (signaling identifiers, VPCI, VPCI/VCI). The affected virtual path shall be returned to the locally blocked state. A BLO message with a Resource indicator set to "CEI: VPCI" indicating the affected virtual path shall be sent. A RAM message shall be sent following the BLO message.

(f) If the Resource indicator is set to "CEI: VPCI" and if the affected virtual path is in a remotely blocked state, the remotely blocked state shall be removed.

7.9.1.3 Abnormal Reset Procedures

(R) 7-157 If a RAM is received which is not a correct response to a sent RSM message, it shall be discarded.

(R) 7-158 If a RSM message is received requesting reset of a resource (e.g., connection element identifier) that is not controlled by the B-ISDN User Part, it shall be discarded.

(R) 7-159 If the RAM is not received before expiry of T_{16b}, the RSM shall be sent again and T_{16b} shall be restarted. If T_{17b} expires before receipt of the RAM, T_{16b} shall be stopped, T_{17b} shall be restarted, management system shall be notified and RSM shall be sent again. Subsequently, RSM shall be sent at intervals of T_{17b} until the RAM is received or maintenance intervention occurs.

7.9.1.4 Performance Monitoring Counts of Resets

Note: There is an agreement to include a count of resets performed by the BSS, but no text is proposed for the requirement at this time.

7.9.2 Blocking and Unblocking of Virtual Paths

The virtual path blocking procedure is provided to prevent a virtual path from being selected for carrying new non-test call/connections. This procedure can be initiated automatically, e.g., under fault conditions, or manually, to permit testing or other BSS management functions, e.g., to perform the VPCI Consistency Check procedure.

Blocking can be initiated by the BSS at either end of a virtual path. The virtual path is put into a blocked state at both ends and the bandwidth becomes unavailable. A blocked virtual path cannot be selected for new non-test traffic by either BSS; however, test call/connections can be completed in either direction independent of the blocking state. Test calls must not return a virtual path to service.

(R) 7-160 An Acknowledgment message shall be required for each blocking and unblocking request. The Acknowledgment is not sent until the appropriate action, blocking or unblocking, has been taken.

(R) 7- 161 Unblocking shall only be initiated by the same BSS which initiated the blocking by sending an UBL or RSM (VPCI) message (see Section 7.8.1.1 also). At either end of a virtual path, the blocked state is removed and the bandwidth becomes available again.

7.9.2.1 Initiating Blocking

(R) 7-162 When the assigning or non-assigning BSS initiates the blocking procedure it shall send the BLO message with the Resource identifier set to "CEI: VPCI," indicating the affected VPCI. The virtual path shall be put into the locally blocked state, and no new non-test call/connections can be completed over this virtual path, in either direction.

(R) 7-163 On sending the BLO message, the BSS shall start timer T_{12b} awaiting the BLA message. When the BLA message is received, timer T_{12b} shall be stopped. If the BLA message is not received before timer T_{12b} expires, then the management system shall be informed.

(R) 7-164 When the BLA message is received, the management system shall be informed of the completion of the blocking.

7.9.2.2 Initiating Unblocking

(R) 7-165 When the BSS initiates the unblocking procedure, it shall send the UBL message with the Resource identifier set to "VPCI," indicating the affected VPCI.

(R) 7-166 On sending the UBL message, the BSS shall start timer T_{14b} and wait for the UBA message. When the UBL Acknowledgment message is received, timer T_{14b} shall be stopped. If the UBA message is not received before timer T_{14b} expires, then the management system shall be informed.

(R) 7-167 When the UBA message is received, the local blocking condition for the virtual path shall be removed. The management system shall be informed.

7.9.2.3 Receiving Blocking

(R) 7-168 When the BSS receives the BLO message indicating the affected VPCI, the virtual path shall be put into the remotely blocked state and the bandwidth shall become unavailable. No new non-test calls/connections can be completed over this virtual path in either direction. A BLA message shall then be sent.

7.9.2.4 Receiving Unblocking

(R) 7-169 When the BSS receives the UBL message indicating the affected VPCI, the remotely blocked state for the virtual path shall be removed, the bandwidth shall become available again for traffic, and the UBA message shall be sent.

7.9.2.5 Abnormal Procedures

(R) 7-170 (a) If a BLO message is received for a virtual path connection which is already in a remotely blocked state, a BLA message shall be sent.
(b) If an UBL message is received for a virtual path connection which is not in a remotely blocked state, an UBA message shall be sent.

(c) If a BLO message is received for a virtual path connection which is not under the control of the B-ISDN User Part, it shall be discarded.

7.9.3 User Part Availability Procedure

User part availability procedure is not supported.

7.9.4 Transmission Alarm Handling

(R) 7-171 Since fully digital transmission systems are provided between two BSSs, which have some inherent fault indication feature giving an indication to the switching system when faults on transmission path level and/or virtual path level are detected, the switching system shall inhibit selection of the virtual paths concerned for the period the fault conditions persist. No special actions are required for active call/connections.

7.9.5 Automatic Congestion Control

Automatic congestion control is used when a BSS is in an overload condition. Two levels of congestion are distinguished, a less severe congestion threshold (congestion level 1) and a more severe congestion threshold (congestion level 2). These congestion levels are dependent on the implementation of the BSS.

(R) 7-172 The call control and maintenance control functions shall be able to communicate to meet the following requirements.

(R) 7-173 If either of the two congestion thresholds is reached, an Automatic Congestion Level parameter shall be included in all Release messages. This parameter indicates the level of congestion (congestion level 1 or 2) to the adjacent switches.

(R) 7-174 The adjacent switches, when receiving this Automatic Congestion Level parameter, shall reduce their traffic to the overloaded BSS.

(R) 7-175 If the overloaded BSS returns to a normal traffic load, it shall no longer include the Automatic Congestion Level parameters in Release messages.

(R) 7-176 The adjacent switches, after a predetermined time, shall then automatically return to their normal status.

7.9.5.1 Receipt of a Release Message Containing an Automatic Congestion Level Parameter

(R) 7-177 When a Release message is received containing an Automatic Congestion Level (ACL) parameter, the BISUP shall pass the appropriate information to the signaling system-independent network management/overload control function within the BSS. This information shall consist of the received congestion level information and the node identification to which the congestion level applies.

(R) 7-178 Automatic congestion level actions are only applicable to switches adjacent to the congested switch. Therefore, a BSS that receives a Release message containing an Automatic Congestion Level parameter shall discard that parameter (i.e., not pass it in any REL message sent to a preceding or succeeding switch) after notifying the network management/overload control function.

7.9.5.2 Actions Taken by the Congested BSS During Overload

(R) 7-179 Whenever a BSS is in an overload state (congestion level 1 or 2), the signaling system-independent network management/overload control function shall direct the B-ISDN User Part to include an Automatic Congestion Level parameter in every Release message sent by the BSS.

(R) 7-180 The network management/overload control function shall indicate which congestion level (1 or 2) to code in the Automatic Congestion Level parameter.

(R) 7-181 When the overload condition has ended, the network management/overload control function shall direct the B-ISDN User Part to cease including the Automatic Congestion Level parameter in the Release messages.

7.9.6 BISUP Signaling Congestion Control

On detection of signaling network congestion (local transmit buffer congestion), a BSS reduces signaling traffic load in a step-wise manner. The signaling congestion control procedures currently implemented for CCS networks in the U.S. are based on message priorities. On the other hand, ITU-T BISUP Rec. Q.2764 defines signaling congestion control procedures based on stepwise reduction and increase of total BISUP traffic load. The ITU-T procedures do not make use of message priorities.

The BISUP message priorities are currently under discussion. Provisional BISUP message priorities for use with MTP congestion control procedures are accepted for inclusion in ANSI T1.111. Message priorities are not intended to indicate which messages should be processed first, but are instead used to determine which messages should be discarded in the event of signaling network congestion. Four priority levels (0, 1, 2, and 3) are defined, 0 being the lowest and 3 the highest priority level.

(R) 7-182 Based on network provider preference, the Broadband Switching System (BSS) shall support one of the MTP congestion control procedures specified in Sections 3.8 and 11.2.3-11.2.5 in ITU-T Recommendation Q.704. For U. S. networks, the BSS shall support the MTP congestion control procedures specified in Section 3.8 and 11.2.4 of ANSI T1.111.4.

(R) 7-183 The BSS shall support the passing of the appropriate congestion status information in MTP-STATUS primitives to the MTP users.

(R) 7-184 When the B-ISUP in a BSS receives an MTP-STATUS primitive indicating MTP congestion toward an affected point code, the B-ISUP shall control generation of signaling messages as follows:

For the international network, the BSS shall control signaling messages as specified in Section 3.7 of ITU-T Recommendation Q.2764.

For U. S. networks, the BSS shall only generate signaling messages with priorities greater than or equal to the congestion status toward the affected point code.

7.9.7 Destination Availability

(R) 7-185 On receipt of a Destination Unavailable indication via MTP-PAUSE primitive, the BISUP shall take the following action:

If the affected destination Signaling Point is not known by the BISUP (not connected by virtual paths/channels to the BSS), no action shall be taken.

If the affected destination Signaling Point is known by the BISUP, all virtual paths/channels to that destination shall be blocked for new call/connections.

Call/connections in progress (already set up) need not be released even though signaling messages cannot be sent to the affected BSS. (While it may not be technically necessary to release call/connections in progress, a carrier may choose to release such call/connections, perhaps after some time interval, if there is a concern about over charging due to the inability of the BSS to completely clear the call/connection when either the calling or called party disconnects.)

(R) 7-186 On receipt of a Destination Available indication via MTP-RESUME primitive, the BISUP shall take the following action:

If the affected destination Signaling Point is not known by the BISUP (not connected by virtual paths/channels to the BSS), no action shall be taken.

If the affected destination Signaling Point is known by the BISUP, the virtual paths/channels shall be unblocked and any of them in the idle state can be used for call/connections immediately. Normal call/connection release procedures that may have started during the period of signaling isolation shall continue and will ensure that affected virtual paths/channels shall be returned to idle state.

7.9.8 Consistency Check

The VPCI Consistency Check is provided to verify the consistent and correct allocation of a logical VPCI to a Virtual Path on an interface in both connected switches. The check is performed to guarantee that a user plane information flow is possible between the two adjacent switches using the bi-laterally agreed upon logical VPCI. The consistency of the logical VPCI is checked at the far end by monitoring the receipt of a user plane test flow in the Virtual Path at a particular interface that is indicated by the VPCI. After the performance of the check, the result of the Loopback test (continuity at the Virtual Path level) is available in the initiating node. The result of the monitoring function (receipt of Loopback cells at the Virtual Path Connection level) is available at the adjacent node and is sent back to the initiating BSS. The procedure can be initiated automatically (i.e., by the BSS) or manually (i.e., by the management system).

(R) 7-187 The VPCI Consistency Check shall be initiated for only one Virtual Path Connection to any adjacent node at a time.

(R) 7-188 A BSS at either end of a Virtual Path Connection shall be able to initiate the VPCI Consistency Check.

(R) 7-189 The Virtual Path Connection to be tested shall be blocked when the procedure is initiated.

(R) 7-190 The CCR and CCE are confirmed operations. The CCRA or CCEA shall not be sent until the appropriate action - start or stop of the management plane test flow supervision procedure - has been taken.

(R) 7-191 The end of the VPCI Consistency Check can only be initiated by the same BSS which initiated the procedure and shall be accomplished by sending a CCE message.

7.9.8.1 Initiating Consistency Check Request

(R) 7-192 When the BSS initiates the Consistency Check procedure, it shall send the CCR message. The Resource Identifier parameter in the CCR shall be set to "Connection element identifier: VPCI" and the affected VPCI shall be included.

(R) 7-193 On sending the CCR message, the BSS shall start timer T_{41b} and wait for the CCRA message. When the CCRA message is received, timer T_{41b} shall be stopped. If the CCRA message is not received before timer T_{41b} expires, then the management system shall be informed.

(R) 7-194 When the CCRA message is received, the management system shall be informed about the completion of the VPCI Consistency Check connection setup and the management plane test flow (i.e., OAM cell(s) such as Loopback) shall be initiated on the VPCI using VCI = 4 (the standard identifier for F4 flows; see ITU-T I.610).

7.9.8.2 Receiving Consistency Check Request

(R) 7-195 When the BSS receives the CCR message indicating the affected Virtual Path Connection, the message shall be accepted as a request for a VPCI Consistency Check connection set-up and the management system shall be informed. The BSS shall monitor for receipt of an OAM cell (e.g., Loopback) on VCI = 4 of the expected VPCI. The BSS shall also send a CCRA message.

7.9.8.3 Initiating Consistency Check End

(R) 7-196 When a BSS initiates the end of the Consistency Check procedure, the user plane test flow shall be stopped and the CCE message shall be sent.

(R) 7-197 On sending the CCE message, the BSS shall start timer T_{42b} and wait for the CCEA message. When the CCEA message is received, timer T_{42b} shall be stopped. If the CCEA message is not received before timer T_{42b} expires, then the management system shall be informed.

(R) 7-198 When the CCEA message is received, it shall contain the Consistency Check Result Information parameter. The VPCI Check Result Indicator in this parameter shall be set to the result of the user plane test flow monitoring function at the logical Virtual Path Connection level. The maintenance system shall be informed about the completion and the result of the check and the VPCI Consistency Check connection shall be released.

7.9.8.4 Receiving Consistency Check End

(R) 7-199 When a BSS receives the CCE message, the user plane test flow monitoring function shall be disconnected. The management system shall be informed about the completion of the test. The VPCI Consistency Check connection shall be released and the CCEA message shall be sent. The CCEA message shall contain the consistency check result information parameter. The VPCI check result indicator in this parameter shall be set to "VPCI check successful" or "VPCI check not successful" depending on the result of the user plane test flow monitoring function at the logical Virtual Path Connection level. If, due to any reason, the monitoring function could not be performed properly, the VPCI check result indicator shall be set to "virtual path connection identifier check not performed".

7.9.8.5 Abnormal Procedures

(R) 7-200 (a) If a CCRA message is received which is not a correct response to a sent CCR message, it shall be discarded.

(b) If a CCEA message is received which is not a correct response to a sent CCE message, it shall be discarded.

(c) If a CCR message is received requesting a VPCI Consistency Check for a Virtual Path Connection that is not controlled by the B-ISDN User Part, it shall be discarded.

(d) If a CCR message is received requesting a VPCI Consistency Check for a Virtual Path Connection for which a CCR message has been sent, it shall be discarded.

7.10 BISUP Compatibility Functions

7.10.1 Introduction

7.10.1.1 Unrecognized Messages and Parameters

Unrecognized messages are those having a message type code that is not recognized by a BSS. The processing of an unrecognized message is specified by the contents of the Message Compatibility Information field.

Unrecognized parameters are parameters having a parameter name coding that is not recognized by a BSS. Unrecognized parameters can appear in any message, and the handling of such parameters is specified by the contents of the Parameter Compatibility Information field.

7.10.1.2 General Requirements on Receipt of Unrecognized Signaling Information

Every message will contain a Message Compatibility Information field. Every parameter will contain a Parameter Compatibility Information field. Compatibility information will be received in the same message/parameter as the unrecognized information.

It may happen that a BSS receives unrecognized signaling information, i.e., messages, parameter types or parameter values. This can typically be caused by the upgrading of the signaling system used by other switches in the network. In these cases the following compatibility procedures are invoked to ensure predictable network behavior.

The procedures to be used on receipt of unrecognized information make use of the compatibility information received in the same message as the unrecognized information and the following messages and cause indicators:

- the Confusion (CFN) message,
- the Release (REL) message,
- the Release Complete (RLC) message,
- the IAR message
- the Cause Indicators parameter.

The following cause values are used:

- "message type non-existent or not implemented, discarded"
- "parameter non-existent or not implemented, discarded"
- "message with unrecognized parameter, discarded"

(R) 7-201 For the above cause values, a diagnostic field shall be included that contains the unrecognized parameter name(s), the message type code, or the message type code and the unrecognized parameter name(s), depending on the cause value.

The procedures are based on the following assumptions:

(a) The forward compatibility information contains different instructions for different switches. There are two classifications of switches: (1) originating, destination, or interworking and (2) intermediate switches. The mapping of originating, destination, or interworking and intermediate switches to the function a BSS may perform is listed below. It is determined on a per call/connection basis.

(b) If a switch receives a Confusion message, or a Release or Release Complete message indicating an unrecognized message or parameter was received, it assumes that an interaction with a switch at a different functional level has occurred.

(c) When handling recognized information, an intermediate switch acting as a transit node passes on the compatibility information unchanged.

Definitions of the Switch (BSS) Types:

- Originating switch, i.e., the switch in which the call/connection is generated from a public network point of view.
- Destination switch, i.e., the switch to which the call/connection is destined from a public network point of view.
- Interworking switch, i.e., the switch in which interworking is performed between the BISUP and the N-ISDN User Part.
- Intermediate switch, i.e., a switch that acts as a transit node.

When an unrecognized parameter or message is received, the BSS will find the corresponding instructions contained in the parameter compatibility information or message compatibility information field, respectively. The message compatibility information contains the instructions specific for handling of the complete message.

The instruction indicators are a set of Boolean indicators. The following requirement applies to the examination of these instruction indicators:

(R) 7-202 (a) Depending on the role of the BSS in the call/connection, i.e., (1) originating, destination, or interworking and (2) intermediate, and the settings of the indicators, only a subset of the indicators shall be examined and the rest shall be ignored.

Only intermediate BSSs shall examine the "Transit at Intermediate BSS indicator." If it is set to "Transit Interpretation," the other indicators shall be ignored. If it is set to "End Node Interpretation," the intermediate BSS shall examine all instruction indicators.

Originating, destination and interworking BSSs shall always interpret the remaining indicators, i.e., all indicators except the "Transit at Intermediate BSS indicator."

(b) Instruction indicators marked as "spare" shall not be examined. They may be used by future phases of the BISUP; in this case, the future phase of the BISUP will set the currently defined instruction indicators to a reasonable value for the current phase. This rule ensures that more types of instructions can be defined in the future without creating a backward compatibility problem.

(c) When a BSS receives an unrecognized parameter, it shall decide what BSS type it is for the call/connection before performing the compatibility actions.

(d) At an intermediate BSS, the unrecognized information shall be passed on unchanged if the "Transit at Intermediate BSS indicator" is set to "Transit Interpretation."

(e) At an originating, destination, or interworking BSS, the "Transit at Intermediate BSS indicator" shall not be applicable.

(f) At an intermediate BSS that has not been instructed to pass on the unrecognized information, i.e., if the "Transit at intermediate BSS indicator" is not set to "Transit interpretation," or at an originating, destination, or interworking BSS, if the "Release Call indicator" is set to "Release Call," the call/connection shall be released.

(g) At an intermediate BSS that has not been instructed to pass on the unrecognized information or at an originating, destination, or interworking BSS, the following shall be applicable if the "Release Call indicator" is set to "Do Not Release Call":
- if the "Discard Message indicator," or the "Discard Parameter indicator" is set to "Discard Message/Discard Parameter," the message or parameter shall be discarded,
- and then, if the "Send Notification indicator" is set to "Send Notification," a Confusion message shall be sent towards the BSS that sent the unrecognized information.

(h) For the case of an unrecognized parameter it shall be possible for the instruction to require that either the unrecognized parameter or the whole message be discarded. This provides for the case where the sending BSS determines that it is not acceptable for the message to continue being processed without this parameter.

(i) In case a message is used for more than one procedure simultaneously and the codings of the instruction indicator of the message compatibility information required from these procedures are different, the instruction indicator shall be set according to the most stringent combination of the possible codings (i.e., the coding "1" of a bit in the instruction indicator is dominant).

(j) At an originating, destination, or interworking BSS where "pass on" has been specified for a message or parameter and "pass on" is not possible, then the "pass on not possible indicator" and "send notification indicator" shall be examined.

7.10.2 Procedures for the Handling of the Unrecognized Messages or Parameters

(R) 7-203 BSS A shall not send a Confusion message to BSS B in response to a received Confusion message, Release message or Release Complete message from BSS B. Any unrecognized parameters received in a Confusion message or Release complete message shall be discarded by BSS A.

7.10.2.1 Unrecognized Messages

(R) 7-204 Depending on the instructions received in the "Message Compatibility Information field," an originating, destination, or interworking BSS receiving an unrecognized message shall either:

- transfer the message transparently,
- discard the message,
- discard the message and send a Confusion message, or
- release the call/connection.

(R) 7-205 A Release, an IAM Reject or a Confusion message in response to an unrecognized message shall include the cause "message type non-existent or not implemented - discarded," followed by a diagnostic field containing the message type code.

7.10.2.2 Unrecognized and Unexpected Parameters

Unexpected parameters (a parameter in the "wrong" message) are handled like unrecognized parameters.

(R) 7-206 Depending on the instructions received in the "Parameter Compatibility Information sub field ," a BSS receiving an unrecognized parameter shall either:

- transfer the parameter transparently,
- discard the parameter,
- discard the message,
- discard the parameter and send a Confusion message,
- discard the message and send a Confusion message, or
- release the call/connection.

(R) 7-207 A Confusion message shall include the cause "parameter non-existent or not implemented - discarded" followed by a diagnostic field containing the parameter name, or "message with unrecognized parameter discarded," followed by a diagnostic field containing the parameter name, or the message and parameter name and the name of the first detected unrecognized parameter which caused the message to be discarded. A Confusion message may refer to multiple unrecognized parameters.

(R) 7-208 A BSS receiving a message including multiple unrecognized parameters shall process the different instruction indicators, associated with those parameters, according to the following order:

1. release the call/connection,
2. discard the message and send a Confusion Message,
3. discard the message.

(R) 7-209 A Release or IAM Reject message in response to an unexpected parameter shall include the cause "parameter non-existent or not implemented - discarded" (in response to an unrecognized message) followed by a diagnostic field containing the parameter name.

(R) 7-210 If a Release message is received containing an unrecognized parameter, depending on the instructions received in the parameter compatibility information sub field the BSS shall either:

- transfer the parameter transparently,
- discard the parameter, or
- discard the parameter and send a cause "parameter non-existent or not implemented - discarded," in the Release Complete message.

7.10.2.3 Unrecognized Parameter Values

Any parameter values marked as "spare" or "reserved" may be regarded as unrecognized, unless otherwise specified in this document.

(R) 7-211 If a BSS receives and detects a recognized parameter, but the contents are unrecognized, then the procedures as stated for unrecognized parameters shall apply. There is no specific compatibility information sub field for each parameter value. For any unrecognized parameter value contained in a parameter, the compatibility information of the parameter shall apply.

7.10.3 Procedures for the Handling of Responses Indicating Unrecognized Information Has Been Sent

7.10.3.1 Originating, Destination, and Interworking BSSs

Action taken on receipt of messages at an originating, destination, or interworking BSS indicating that unrecognized information has been sent will depend on the call/connection state and the affected service.

The definition of any procedure that is outside the basic call/connection set-up protocol, as defined in these requirements, will include procedures for handling responses that indicate that another BSS has received, but not recognized, information belonging to that procedure.

(R) 7-212 The default action taken on receipt of a Confusion message shall be to discard the message without disrupting normal call/connection processing.

(R) 7-213 Action taken on receipt of a Release, a Release Complete, or an IAM Reject message with a cause indicating unrecognized information shall be as for the normal procedures for these messages.

7.10.3.2 Intermediate BSSs

(a) Confusion message (message type non-existent or not implemented - discarded)

(R) 7-214 A BSS receiving a Confusion message (message type non-existent or not implemented - discarded) shall determine the appropriate subsequent action as described above for originating, destination, or interworking BSSs.

(b) Confusion message (parameter non-existent or not implemented - discarded, or passed on)

(R) 7-215 The actions taken at an intermediate BSS on receipt of a Confusion message with cause "parameter non-existent or not implemented - discarded, or passed on" shall depend on whether the BSS has the functionality to generate the parameter identified in the diagnostic field:

(1) If the BSS does not have the functionality to generate the parameter, the decision on what action should be taken shall be deferred to a BSS that does contain this functionality. This is achieved by passing the Confusion message transparently through the intermediate BSS.

(2) If this BSS does have the functionality to generate the parameter, the procedural element that created or modified the information shall determine any subsequent actions, as described for originating, destination, and interworking BSSs above.

(c) Release message, Release Complete message, or IAM Reject message

(R) 7-216 Action taken on receipt of a Release, a Release Complete, or an IAM Reject message with a cause indicating unrecognized information shall be as for the normal procedures for these messages.

7.10.4 Protocol Monitoring Measurements for Unrecognized Messages and Parameters

The BSS needs to monitor unrecognized BISUP messages and parameters. The BSS shall keep separate counts for each unique OPC/DPC combination ("OPC/DPC signaling relationship") to allow quick identification of the signaling entities that are involved.[18]

(R) 7-217 For each OPC/DPC signaling relationship, the BSS shall count the number of *calls/connections that it releases* due the following:

- Unrecognized BISUP *message*
- Unrecognized *parameter(s)* in a BISUP message

Note that, as discussed earlier, whenever it releases a call/connection due to unrecognized information, the BSS generates an IAM Reject message or Release message.

(R) 7-218 For each OPC/DPC signaling relationship, the BSS shall count the following events (none of the following results in clearing the call/connection):

- It discards a BISUP *message* due to unrecognized BISUP *message*
- It discards a BISUP *message* due to one or more unrecognized *parameter(s)*

[18] When associated mode signaling is used, the signaling link set directly connects the OPC/DPC pair.

- It discards one or more *parameter(s)* in a BISUP message due to unrecognized parameter(s) in the message (Note that in this case the counter is incremented by one, regardless of the number of parameters that are discarded.)

In addition to making the above counts, it is desirable for the BSS to be capable of logging BISUP messages on a given OPC/DPC signaling relation. When active, all messages sent and received over that OPC/DPC signaling relation should be logged. Such a capability should be activated/deactivated by Management System requests.

7.11 Point-to-Multipoint Call and Connection Control

This section specifies the BISUP procedures for establishing, maintaining, and clearing of network point-to-multipoint connections at the B-ICI. This section is based on the basic B-ISDN User Part signaling procedures for point-to-point connection specified in Sections 7.8 to 7.10. The procedures described in this section are based on, and are consistent with, the ITU-T Recommendation Q.2722.1. The access signaling procedures are contained in UNI Specification Version 3.1.

This section specifies the following interactions:

- interaction with a leaf party that does not support multipoint procedures.
- interaction with a leaf party that is not a Broadband user.

The procedures described in this section support the following capabilities. Root is the source of the point-to-multipoint connection. Leaf is one of the destinations of the point-to-multipoint connection.

(i) Establishment of a call containing one point-to-multipoint network connection requested by the root party of the network connection.

(ii) Addition of one new party, requested by the root party of the network connection.

(iii) Drop of a leaf party from an existing call, requested by the root party.

(iv) Drop of a leaf party from an existing call, requested by the leaf party itself.

(v) Release of the call, requested by the root party (en bloc release).

The capabilities above will not be combined with narrowband emulation services. Only unidirectional (forward), single connection point-to-multipoint calls are supported.

7.11.1 Call and Connection Control Functions

Refer to Section 7.8.2 for the management of VPCI/VCI value and bandwidth of each VPC, assignment procedure of VPCI/VCI and bandwidth, and related error conditions. Figures 7.7 show BISUP message flows for the set up and release of point-to-multipoint call and connections.

7.11.2 Successful Call and Connection Set-Up

This section describes procedures for a successful point-to-multipoint call establishment where user plane information is multicasted unidirectional from one root party to a set of leaf parties. These procedures are activated on receipt of a call request from the B-ISDN access indicating, "point-to-multipoint" in the user plane configuration field of the Broadband Bearer Capability parameter.

Section 7.11.2.1 specifies the signaling procedures for the setup of the first leaf party of the point-to-multipoint call initiated by the root party. Section 7.11.2.2 specifies the signaling procedures for the addition of one new leaf party and for the attachment of the party to the point-to-multipoint (Type 2) network connection. This can only be requested by the root party.

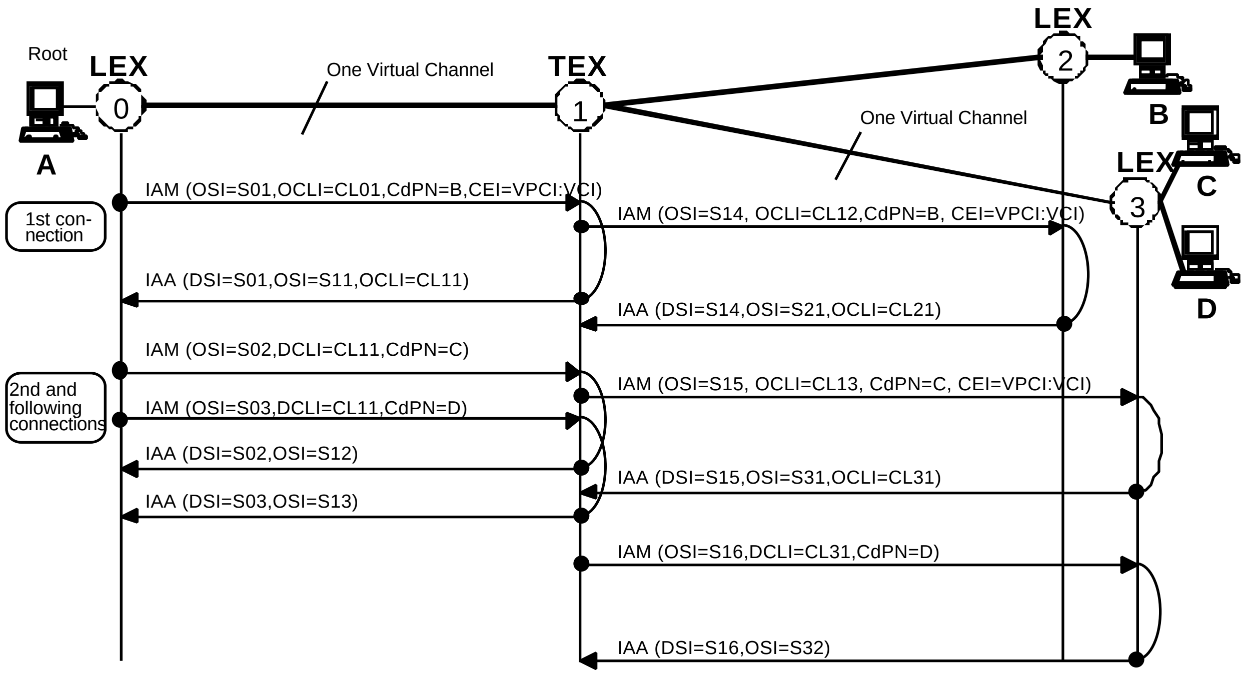


Figure 7.7(a) Set-up of a Unidirectional Point-to-Multipoint Call (Continued)

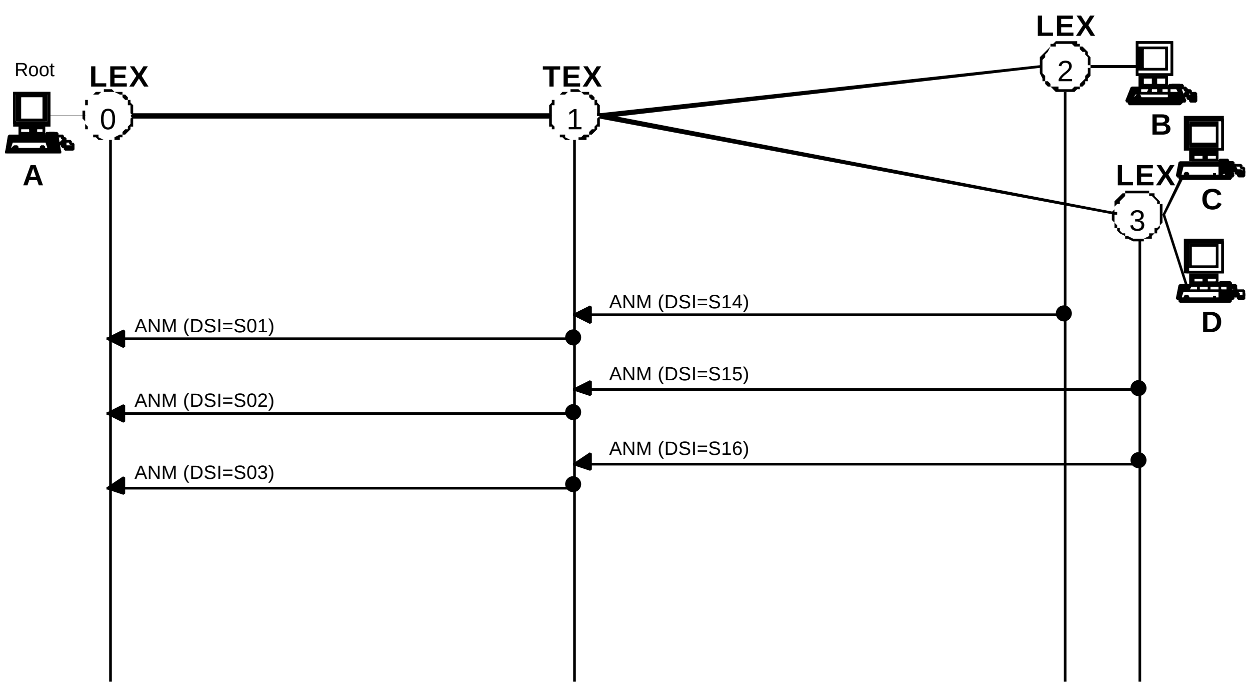


Figure 7.7(b) Set-up of a Unidirectional Point-to-Multipoint Call (Concluded)

OSI	Origination Signalling ID	Sn	Signalling ID value
DSI	Destination Signalling ID	CLn	Connection Link ID value
OCLI	Origination Connection Link ID	A, B, C, D	Address of party A, B, C, D
DCLI	Destination Connection Link ID	VPCI	Virtual Path Connection ID
CdPN	Called Party Number	VCI	Virtual Channel ID
CEI	Connection Element ID	Pt	Point
LEX	Local Exchange	MPt	Multipoint
TEX	Transit Exchange		

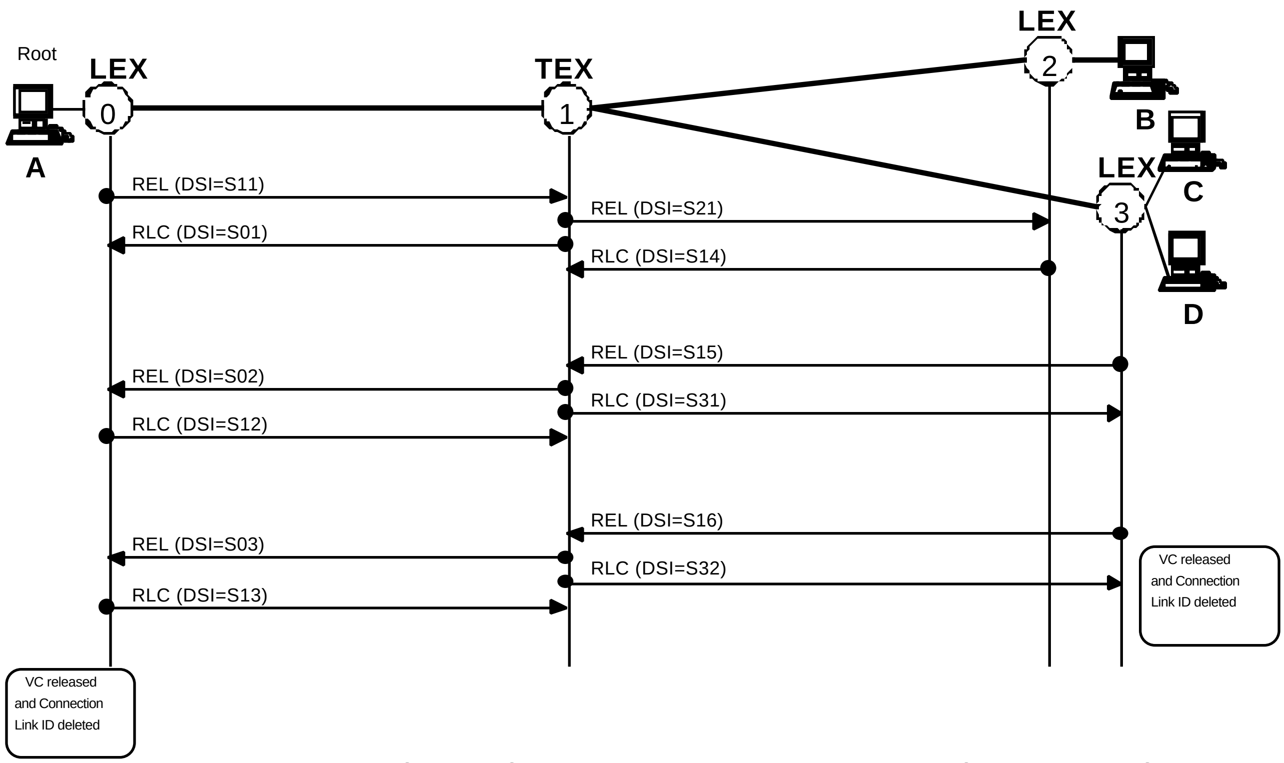


Figure 7.8 Drop of a Leaf Party by the Root or the Leaf Party Itself

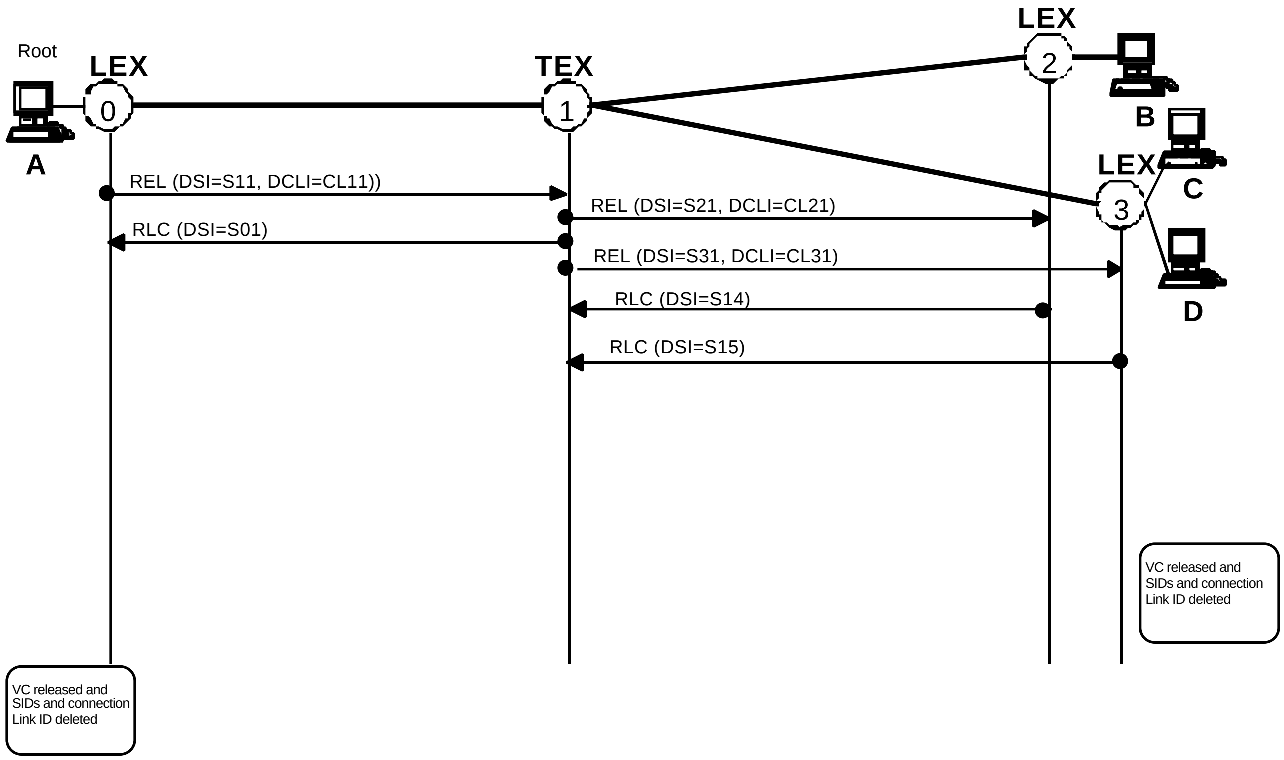


Figure 7.9 En Bloc Release of the Call by the Root

7.11.2.1 Forward Address Signaling - Set-up of the First Leaf Party

7.11.2.1.1 Actions Required at the Originating BSS

(a) Route and Virtual Channel Selection - Assigning BSS

When the originating BSS has received the complete information from the root party of the point-to-multipoint connection and has determined that the call/connection is to be routed to another BSS, route and virtual channel selection takes place.

Appropriate routing information is either stored at the originating BSS or at a remote database. Refer to Section 7.8.5.1.1 (a) for the requirements on selection of the route and virtual channel.

> **(R) 7-219** In addition, the BSS shall assign a connection link identifier to identify the outgoing connection link.

(b) Route and Virtual Channel Selection - Non-assigning BSS

> **(R) 7-220** For the originating BSS that acts as a non-assigning BSS for the connection, the route and virtual channel selection procedures shall be as in (a) above for an assigning BSS except that the VPCI/VCI and bandwidth assignment procedures shall be according to Section 7.8.2.2 (b).

(c) Address Information Sending Sequence

Refer to Section 7.8.5.1.1 (c).

(d) IAM - Sent by the Assigning BSS

The IAM will contain all the information required to route the call/connection to the destination BSS, and to connect the call/connection to the leaf party.

Refer to Section 7.8.5.1.1 (d) for the parameters included in the IAM by the originating BSS and related requirements. In addition, the following requirements apply.

(R) 7-221 The Endpoint reference information element received from the access shall be mapped into the Leaf Party Type parameter. If the Endpoint reference information element has the value 0, then the Leaf Party Type parameter shall be set to 0 ("First endpoint of Type 2 connection"), else it shall be set to 1 ("Subsequent endpoint of Type 2 connection").

(R) 7-222 The IAM shall include the Origination Connection Link Identifier parameter (OCLI) containing the CLI assigned by this BSS.

(R) 7-223 For a point-to multipoint connection, the Broadband Bearer Capability parameter shall indicate "point-to-multipoint" in the user plane connection configuration field. The ATM Cell Rate, Additional ATM Cell Rate, Broadband Bearer Capability and Quality of Service parameters shall be stored at the requesting serving node or associated data base so that identical copies of these parameters can be sent in the subsequent IAMs for the addition of leaf parties.

(R) 7-224 If the call request from the access contains a Broadband Bearer Capability indicating "point-to-multipoint" in the user plane connection configuration field and contains an ATM traffic descriptor information element containing any backward cell rate field which specifies a non-zero value, the call/connection shall be rejected with cause #73, "unsupported combination of traffic parameters".

After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(e) IAM - Sent by the Non-Assigning BSS

(R) 7-225 The originating BSS that acts as a non-assigning BSS for this connection shall follow the procedures described in d) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(f) Completion of Transmission Path

Refer to Section 7.8.5.1.1 (f).

7.11.2.1.2 Actions Required at an Intermediate BSS - Originating Network

7.11.2.1.2.1 Incoming Side of the BSS

(a) Assigning BSS

(R) 7-226 After receiving the IAM, the intermediate BSS shall assign a connection link identifier to identify the incoming connection link. The intermediate BSS that acts as an assigning BSS for this connection shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (b). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

Refer to Section 7.8.5.1.2.1 (a) for the parameters included in the IAA by the intermediate BSS and related requirements. In addition, the following requirements apply.

(R) 7-227 The IAA shall include the origination connection link identifier parameter containing the connection link identifier assigned by this BSS.

(b) Non-Assigning BSS

(R) 7-228 After receiving the IAM, the intermediate BSS that acts as a non-assigning BSS shall perform the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2 (a). If this is successful, the IAA shall be sent immediately without waiting for further call processing.

(R) 7-229 Further procedures shall be as for the assigning BSS described in (a) above except that CEI shall not be included in the IAA.

7.11.2.1.2.2 Outgoing Side of the BSS

(a) Virtual Channel Selection

(R) 7-230 After sending the IAA, an intermediate BSS shall analyze the called party number and the other routing information (see Section 7.8.5.1.1) to determine the routing of the connection. If the intermediate BSS can route the connection, it shall assign a connection link identifier to identify the outgoing connection link, establish a logical association between the incoming and outgoing connections and send an IAM to the selected carrier. The BSS shall follow the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2.

(b) Parameters in the IAM Sent by the Assigning BSS

Refer to Section 7.8.5.1.2.2 (b) for the parameters included in the IAM and related requirements. In addition, the following requirements apply.

(R) 7-231 The IAM shall include the Origination Connection Link Identifier parameter containing the connection link identifier assigned by this BSS.

After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(c) Parameters in the IAM Sent by the Non-Assigning BSS

(R) 7-232 The intermediate BSS that acts as a non-assigning BSS for this call shall follow the procedures described in (b) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(d) Sending of Exit Message

Refer to Section 7.8.5.1.2.2 (d) for related requirements.

(e) Completion of Transmission Path

Refer to Section 7.8.5.1.2.2 (e).

7.11.2.1.3 Actions Required at an Intermediate BSS - Transit Carrier

(R) 7-233 An intermediate BSS in a transit carrier shall meet the same requirements described above for the intermediate BSS in the originating carrier.

7.11.2.1.4 Actions Required at an Intermediate BSS - Terminating Network

7.11.2.1.4.1 Incoming Side of the BSS

(a) Assigning BSS

(R) 7-234 Same requirements as in Section 7.11.2.1.2.1 (a) shall be applicable except that the preceding BSS in this case is the BSS belonging to the carrier routing the call to the terminating carrier.

(b) Non-Assigning BSS

(R) 7-235 The requirements in Section 7.11.2.1.2.1 (b) shall apply.

7.11.2.1.4.2 Outgoing Side of the BSS

(a) Virtual Channel Selection

(R) 7-236 After sending the IAA to the preceding carrier, an intermediate BSS shall analyze the Called Party Number to determine the routing of the connection. If the intermediate BSS can route the connection, it shall assign a connection link identifier to identify the outgoing connection link, establish a logical association between the incoming and outgoing connections and shall send an IAM to the destination BSS. The BSS shall follow the assignment procedure for VPCI/VCI and bandwidth as described in Section 7.8.2.2.

(b) Parameters in the IAM Sent by the Assigning BSS

Refer to Section 7.8.5.1.4.2 (b) for the parameters included in the IAM and related requirements. In addition, the following requirements apply.

(R) 7-237 The IAM shall include the Origination Connection Link Identifier parameter containing the connection link identifier assigned by this BSS.

After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(c) Parameters in the IAM Sent by the Non-Assigning BSS

(R) 7-238 The intermediate BSS that acts as a non-assigning BSS for this call shall follow the procedures described in (b) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(d) Completion of Transmission Path

Refer to Section 7.8.5.1.2.2 (e).

7.11.2.1.5 Actions Required at the Destination BSS

(a) Incoming Side - Assigning BSS

(R) 7-239 Same requirements as in Section 7.11.2.1.2.1 (a) shall be applicable.

(b) Incoming Side - Non-Assigning BSS

(R) 7-240 The requirements in Section 7.11.2.1.2.1(b) shall apply.

(c) Call Processing

(R) 7-241 After sending the IAA, the destination BSS shall analyze the Called Party Number to determine to which party the call should be connected. It shall also check the called (leaf) party's access condition and perform various checks to determine whether the connection is allowed. If the connection is allowed, the destination BSS shall proceed to offer the call/connection to the leaf party. Refer to Section 7.8.5.1.5 (c) for further requirements.

7.11.2.2 Forward Address Signaling - Addition of a New Leaf Party

Case 1 is where a new network connection needs to be established to another BSS because no connection link to that BSS exists for this point-to-multipoint call. Case 2 is where the network connection needs to be routed to another BSS to which there already is a connection link established for this point-to-multipoint call.

(R) 7-242 Connection for a new leaf party shall not be routed over a connection link used for previous leaf parties if the connection link is on a blocked virtual path. Alternative routing may be done using another virtual path. Refer to Section 7.11.6.2.

7.11.2.2.1 Actions Required at the Originating BSS

(a) Route and Virtual Channel Selection - Assigning BSS

When the originating BSS has received the complete information from the root party for the addition of a new leaf party to the existing point-to-multipoint network connection and has determined that the connection is to be routed to another BSS, route and virtual channel selection takes place.

Appropriate routing information is either stored at the originating BSS or at a remote database. Refer to Section 7.8.5.1.1 (a) for the requirements on selection of the route. Note that the relevant information (e.g., called party number, transit network selection, etc.) for the new leaf party will be in the ADD PARTY MESSAGE instead of the SETUP MESSAGE.

(R) 7-243 The ATM Cell Rate, Broadband Bearer Capability, Quality of Service and Additional ATM Cell Rate (if present) parameters shall be retrieved from the call information stored when the connection to the first party of the point-to-multipoint call was established by this BSS.

(R) 7-244 It shall be determined whether the connection is to be routed to another BSS to which a connection has already been established for this call.

(R) 7-245 In Case 1, the procedures defined in section 7.11.2.1.1 (a) shall apply.

(R) 7-246 In Case 2, the existing Outgoing Connection Link identifier shall be used and an IAM shall be sent. No VPCI/VCI and bandwidth assignment procedures shall take place because no new user plane connection is established. The Destination Connection Link Identifier parameter associated with the Outgoing Connection Link shall be included in the IAM.

(b) Route and Virtual Channel Selection - Non-Assigning BSS

(R) 7-247 The route and virtual channel selection procedures shall be as in (a) above for an assigning BSS except that, if required, the VPCI/VCI and bandwidth assignment procedures shall be according to Section 7.8.2.2 (b).

(c) Address Information Sending Sequence

Refer to Section 7.8.5.1.1 (c).

(d) IAM - Sent by the Assigning BSS

Refer to Section 7.8.5.1.1 (d) for the parameters included in the IAM by the originating BSS and related requirements. Note that information from the calling user comes in the ADD PARTY Message instead of the SETUP MESSAGE. In addition, the following requirements apply.

(R) 7-248 In Case 1, the IAM shall contain the Origination Connection Link Identifier and the Connection Element Identifier parameters.

(R) 7-249 In Case 2, the IAM shall contain the Destination Connection Link Identifier parameter and shall not contain the Connection Element Identifier parameter.

(R) 7-250 The IAM shall include the stored values of the ATM Cell Rate, Broadband Bearer Capability, Quality of Service and additional ATM Cell Rate (if present) parameters as used for the initial Set-up.

(R) 7-251 The IAM shall include the Calling Party Number, Calling Party Subaddress, Called Party Subaddress, Broadband High Layer Information, Broadband Low Layer Information, and AAL-parameters parameter if the corresponding IEs are received in the ADD PARTY MESSAGE from the root and the transfer of this information is allowed by subscription and for the specific carrier selected to route the connection for the leaf party. The AESA for Called Party and AESA for Calling Party parameters are included in the IAM if they were generated because the CdPN and/or CgPN IE contained an AESA. This information shall not be retrieved from stored data.

(R) 7-252 As a carrier option (See Section 7.3.2.2), the IAM shall include the CIP, Charge Number, OLI and Carrier Selection Information parameters based on prior agreements between the connecting carriers involved in routing the connection for the leaf party.

(R) 7-253 The IAM shall include the Leaf Party Type parameter set to 1 ("Subsequent end point of Type 2 connection").

(R) 7-254 If the add party request from the access contains a Broadband Bearer Capability indicating "point-to-multipoint" in the user plane connection configuration field and contains an ATM traffic descriptor information element containing any backward cell rate field which specifies a non-zero value, the addition of a new party shall be rejected with cause #73, "unsupported combination of traffic parameters".

After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(e) IAM - Sent by the Non-Assigning BSS

(R) 7-255 The originating BSS that acts as a non-assigning BSS for this connection shall follow the procedures described in (d) above for the assigning BSS with the exception that the CEI shall not be included in the IAM.

(f) Completion of Transmission Path

(R) 7-256 The completion of the transmission path is only applicable for Case 1 (a new user plane connection is established) and the procedures defined in Section 7.8.5.1.1 (f) shall apply. Furthermore, a cell replication function shall be invoked.

7.11.2.2.2 Actions Required at an Intermediate BSS - Originating Network

7.11.2.2.2.1 Incoming Side of the BSS

(R) 7-257 If the received IAM contains the origination connection link identifier (i.e., an incoming connection link does not exist), the procedures shall continue as in Section 7.11.2.1.2.1.

(R) 7-258 If the received IAM contains the Destination Connection Link Identifier parameter, the associated Connection Link and virtual channel already exist for the incoming point-to-multipoint connection. The following procedures shall apply for both the assigning and non-assigning BSSs:

The IAA shall be sent immediately. The IAA shall contain the OSID and DSID, but not the Connection Element Identifier parameter.

7.11.2.2.2.2 Outgoing Side of the BSS

(a) Route and Virtual Channel Selection

(R) 7-259 After sending the IAA, an intermediate BSS shall analyze the called party number and the other routing information (see Section 7.8.5.1.1 a) to determine the routing of the call.

(R) 7-260 The procedures shall continue as in Section 7.11.2.1.2.2 (a)-(c) if the connection for the additional party needs to be routed to another BSS not currently the far end for any of the existing outgoing connection links for the call. (This is Case 1.)

(R) 7-261 If the additional party connection needs to be routed to an BSS that is already the far end of an existing Outgoing Connection Link for this point-to-multipoint call, the following procedures shall apply. (This is Case 2.)

(a) The BSS shall assign a SID, establish a logical association between the incoming and outgoing SIDs used for this connection establishment, and send an IAM. The BSS shall not perform the assignment procedure for VPCI/VCI and bandwidth. The Connection Element identifier (VPCI/VCI) used for the new party shall correspond to the stored values for the Outgoing Connection Link. In case the Destination Connection Link Identifier is not yet known at the BSS, the BSS shall wait for the IAA in response to the first IAM sent for this Outgoing Connection Link.

(b) Parameters in the IAM sent by the Assigning BSS

Refer to Section 7.8.5.1.2.2 (b) for the parameters included in the IAM and related requirements except that the CEI shall not be included. In addition, the IAM shall include the destination connection link identifier parameter.

After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(c) Parameters in the IAM sent by the Non-Assigning BSS

Refer to (b) above.

(b) Sending of Exit Message

Refer to Section 7.8.5.1.2.2 (d) for related requirements.

(c) Completion of Transmission Path

(R) 7-262 The completion of the transmission path is only applicable for Case 1 (a new user plane connection is established) and the procedures defined in Section 7.8.5.1.2.2 (e) shall apply. Furthermore, a cell replication function shall be invoked.

7.11.2.2.3 Actions Required at an Intermediate BSS - Transit Carrier

(R) 7-263 An intermediate BSS in a transit carrier shall meet the same requirements described above for the intermediate BSS in the originating carrier.

7.11.2.2.4 Actions Required at an Intermediate BSS - Terminating Network

7.11.2.2.4.1 Incoming Side of the BSS

Refer to Section 7.11.2.2.2.1.

7.11.2.2.4.2 Outgoing Side of the BSS

(a) Route and Virtual Channel Selection

(R) 7-264 After sending the IAA, an intermediate BSS shall analyze the called party number to determine the routing of the call.

(R) 7-265 The procedures shall continue as in Section 7.11.2.1.4.2 (a)-(c) if the connection for the additional party needs to be routed to another BSS not currently the far end for any of the existing outgoing connection links for the call. (This is Case 1.)

(R) 7-266 If the additional party connection needs to be routed to an BSS that is already the far end of an existing Outgoing Connection Link for this point-to-multipoint call, the following procedures shall apply. (This is Case 2.)

(a) The BSS shall assign a SID, establish a logical association between the incoming and outgoing SIDs used for this connection establishment, and send an IAM. The BSS shall not perform the assignment procedure for VPCI/VCI and bandwidth. The Connection Element identifier (VPCI/VCI) used for the new party shall correspond to the stored values for the Outgoing Connection Link. In case the Destination Connection Link Identifier is not yet known at the BSS, the BSS shall wait for the IAA in response to the first IAM sent for this Outgoing Connection Link.

(b) Parameters in the IAM Sent by the Assigning BSS:
Refer to Section 7.8.5.1.4.2 (b) for the parameters included in the IAM and related requirements except that the CEI shall not be included. In addition, the IAM shall include the destination connection link identifier parameter.
After sending the IAM, a response is awaited, i.e., an IAA or an IAR.

(c) Parameters in the IAM Sent by the Non-Assigning BSS:
Refer to (b) above.

(b) Completion of Transmission Path

(R) 7-267 The completion of the transmission path is only applicable for Case 1 (a new user plane connection is established) and the procedures defined in section 7.8.5.1.2.2 (e) shall apply. Furthermore a cell replication function shall be invoked.

7.11.2.2.5 Actions Required at the Destination BSS

(a) Incoming Side
Refer to Section 7.11.2.2.2.1.

(b) Call Processing
Refer to Section 7.11.2.1.5 c.

7.11.2.3 Address Complete Message

Refer to Section 7.8.5.2.

7.11.2.4 Call Progress Message (Basic Call)

Refer to Section 7.8.5.3.

7.11.2.5 Answer Message

Refer to Section 7.8.5.4.

7.11.2.6 Storage and Release of Information

Refer to Section 7.8.5.5. In addition the following requirement applies.

(R) 7-268 The originating BSS of the connection shall store the ATM Cell Rate, Broadband Bearer Capability, Quality of Service and Additional ATM Cell Rate (if present) parameters contained in the first IAM sent. This call information shall be stored so that identical copies of these parameters can be sent in the subsequent IAMs for setting up connections to additional leaf parties.

7.11.3 Unsuccessful Call/Connection Set-up

Refer to Section 7.11.2.2 for the definitions of Case 1 and Case 2.

7.11.3.1 Lack of Resources at the Incoming Side

(R) 7-269 If at any time the call/connection establishment to the first leaf party or the establishment of a new connection link (leg) for the addition of a new leaf party (Case 1) cannot be completed due to a lack of resources at the incoming side (e.g., SIDs, CLIDs, VPCI/VCI or bandwidth), the BSS receiving the IAM shall immediately send an IAR towards the preceding BSS. The IAR shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs or CLIDs were available; cause value 45 (no VPCI/VCI available) shall be included in the case of a lack of VPCI/VCI; and cause value 37 (ATM Cell Rate not available) shall be included in the case of a lack of bandwidth. The incoming signaling association shall be deleted.

(R) 7-270 If at any time the addition of one new leaf party to an already existing connection link (Case 2) cannot be completed due to a lack of resources at the incoming side (e.g., SIDs), the BSS receiving the IAM shall immediately send an IAR towards the preceding BSS. The IAR shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs were available.

7.11.3.2 Lack of Resources at the Outgoing Side

(R) 7-271 If at any time the call/connection establishment to the first leaf party or the establishment of a new connection link (leg) for the addition of a new leaf party (Case 1) cannot be completed due to a lack of resources at the outgoing side (e.g., SIDs, CLIDs, VPCI/VCI or bandwidth), the BSS shall immediately start to drop the leaf party and shall send an REL towards the preceding BSS. The REL shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs or CLIDs were available, cause value 45 (no VPCI/VCI available) shall be included in the case of a lack of VPCI/VCI; and cause value 37 (ATM Cell Rate not available) shall be included in the case of a lack of bandwidth. Further procedures shall be as in Section 7.11.3.4.

(R) 7-272 If at any time the addition of a new leaf party to an already existing connection link (Case 2) cannot be completed due to a lack of resources at the outgoing side (e.g., SIDs), the BSS shall immediately start to drop the leaf party and shall send an REL towards the preceding BSS. The REL shall contain the DSID and cause indicators parameter. Cause value 47 (resource unavailable - unspecified) shall be included if no SIDs were available. Further procedures shall be as in Sec. 7.11.3.4.

7.11.3.3 Actions at an BSS Receiving an IAR

(R) 7-273 If an BSS receives an IAR during either the call/connection establishment to the first leaf party or the establishment of a new connection link (leg) for the addition of a new leaf party (Case 1), it shall release the VPCI/VCI (if applicable) and the bandwidth, and shall terminate the outgoing signaling association, i.e. the associated outgoing Connection Link ID and the SID. The BSS may attempt to re-route the call/connection.

(R) 7-274 If an BSS receives an IAR during the addition of a new leaf party to an already existing connection link (Case 2), it shall terminate the signaling association, i.e. the associated SID is deleted. The BSS may provide the capability to re-route the call/connection.

(R) 7-275 If all attempts to re-route the connection have failed the BSS shall:

(a) If this is an intermediate BSS, it shall send an REL with the received cause value towards the preceding BSS. Further procedures shall be as in Section 7.11.3.4.

(b) If this is an originating BSS, it shall send an indication to the calling user.

7.11.3.4 Actions at an BSS Receiving a Release Message

(R) 7-276 If during the establishment of a point-to-multipoint network connection for the first leaf party an BSS receives a Release message from the succeeding BSS after the IAA and before the ACM, the BSS shall release the VPCI/VCI (if applicable) and the bandwidth, and shall send an RLC. The outgoing signaling association is terminated, i.e. the associated outgoing Connection Link ID and the corresponding SID are deleted. The BSS may attempt to re-route the connection. If all attempts to re-route the connection have failed, the BSS shall:

(a) If this is an intermediate BSS, it shall send an REL with the received cause value towards the preceding BSS. Further procedures shall be as in Sec. 7.11.4.1.

(b) If this is an originating BSS, it shall send an indication to the calling user.

(R) 7-277 If during the addition of another leaf party and attachment to the point-to-multipoint network connection an BSS receives a Release message from the succeeding BSS after the IAA and before the ACM, the BSS shall take the following actions:

(a) The signaling association is terminated, i.e. the associated SID is deleted.

(b) If there are no other SIDs associated with the concerned Outgoing Connection Link ID, the Outgoing Connection Link ID shall be deleted and the associated VPCI/VCI (if applicable) and the corresponding bandwidth shall be made available for new traffic.

(c) Send an RLC.

(d) The BSS may attempt to re-route the connection. If all attempts to re-route the connection have failed, the BSS shall:

(i) If this is an intermediate BSS, it shall send an REL in order to drop the leaf party with the received cause value towards the preceding BSS. Further procedures shall be as in Sec. 7.11.4.1.

(ii) If this is an originating BSS, it shall send an indication to the calling user.

7.11.3.5 Address Incomplete

(R) 7-278 If a BSS determines that the proper number of digits for routing the connection has not been received, an REL shall be sent towards the preceding BSS with cause "address incomplete". Refer to Section 7.11.4.1 for further procedures.

7.11.4 Normal Call and Connection Release

7.11.4.1 General

The following release procedures are addressed:

- En-bloc release of call/connection requested by the root party: this operation will cause all parties to be dropped and release of the point-to-multipoint call
- Drop of a leaf party from an existing call when requested by the root party
- Drop of a leaf party from an existing call when requested by the leaf party itself

The release procedure is a confirmed operation: the Release message initiates release of the call/connection and/or drop of a party and the RLC signifies completion of the release of the call/connection and/or drop of the party. A set of common procedures are used in the network irrespective of whether they are initiated by the root party, the leaf party or the network.

(R) 7-279 The following actions shall be performed by any BSS receiving a Release message:

(a) The signaling association is terminated, i.e. the associated SID is deleted.
(b) If there are no other SIDs associated with the concerned Incoming or Outgoing Connection Link ID, the Incoming or Outgoing Connection Link ID shall be deleted and the associated VPCI/VCI (if applicable) and the corresponding bandwidth shall be made available for new traffic.
(c) Send an RLC.

(R) 7-280 An BSS that has initiated the release procedure by sending a Release message shall perform the following actions on receipt of the RLC:

(a) The signaling association is terminated, i.e. the associated SID is deleted.
(b) If there are no other SIDs associated with the concerned Incoming or Outgoing Connection Link ID, the Incoming or Outgoing Connection Link ID shall be deleted and the associated VPCI/VCI (if applicable) and the corresponding bandwidth shall be made available for new traffic.

The following sections describe additional required actions.

7.11.4.2 Drop of a Leaf Party Requested by the Root Party

(a) Actions Required at the Originating BSS

(R) 7-281 On receipt of a request from the root party to drop a leaf party, the originating BSS immediately starts the release. An REL is sent towards the succeeding BSS with the DSID corresponding to the remote leaf party to be dropped. The REL shall not contain the Destination Connection Link Identifier parameter.

(R) 7-282 In case of a premature drop of a leaf party by the root party, the BSS shall immediately release the resources towards the root party, but shall delay the release of the connection towards the succeeding BSS until after the IAA is received.

(b) Actions at an Intermediate BSS

On receipt of the Release message, an intermediate BSS will send an REL towards the succeeding BSS with the DSID corresponding to the remote leaf party to be dropped. The release towards the succeeding BSS shall not occur until after the receipt of the IAA.

(c) Actions Required at the Destination BSS

(R) 7-283 If there is no remaining party at the interface, the BSS shall immediately release the resources towards the leaf party.

(d) Collision of Release Messages

(R) 7-284 In the case when two points in the connection initiate the drop of the same leaf party, a Release message may be received at an BSS from a succeeding or preceding BSS after the drop is initiated. In this case, the BSS shall return an RLC towards the BSS from which the concerned REL was received. The RLC shall be sent when the BSS resources have been released.

7.11.4.3 Drop of a Leaf Party Requested by the Leaf Party Itself

(a) Actions Required at the Leaf Party Serving (Destination) BSS

(R) 7-285 On receipt of a request from the access protocol to drop a leaf party, the leaf party serving BSS immediately starts the release. A Release message shall be sent towards the preceding BSS with the DSID corresponding to the leaf party to be dropped.

(b) Actions at an Intermediate BSS

(R) 7-286 On receipt of the Release message, an intermediate BSS shall send a Release message towards the preceding BSS with the DSID corresponding to the leaf party to be dropped.

(c) Actions Required at the Originating BSS

(R) 7-287 The BSS shall notify the root party that the leaf party has dropped.

(d) Collision of Release Messages

Refer to Section 7.11.4.2 (d).

7.11.4.4 Drop of a Leaf Party Initiated by the Network

The procedures in Section 7.11.4.2 and Section 7.11.4.3 apply, except that they can be initiated at any BSS.

7.11.4.5 En-bloc Release of Call/Connection Requested by the Root Party

(a) Actions Required at the Originating BSS

(R) 7-288 On receipt of a request from the root party to release the call, the BSS shall immediately start the release. For each associated Outgoing Connection Link, a Release message is sent towards the succeeding BSS containing the relevant Destination Connection Link Identifier parameter and one of the associated DSID parameters. The transmission path shall be disconnected.

(R) 7-289 When the RLC related to an Outgoing Connection Link is received:

- All the associated SIDs shall be deleted.
- The associated VPCI/VCI (if applicable) and the corresponding bandwidth shall be made available for new traffic, when the last remaining SID associated with the Outgoing Connection Link has been deleted.
- The Outgoing Connection Link ID shall be deleted.

(R) 7-290 In case of a premature release by the root party, the BSS shall:

- Immediately release the resources towards the root party,
- Immediately release each connection link towards the succeeding BSS for which an IAA has been received,
- Delay release of each connection link towards the succeeding BSS for which an IAA has not been received until an IAA is received.

(b) Actions at an Intermediate BSS

(i) *Incoming Side of the BSS*

(R) 7-291 On receipt of a Release message containing a Destination Connection Link Identifier parameter and DSID, an intermediate BSS:

- Shall make the associated VPCI/VCI (if applicable) and corresponding bandwidth available for new traffic
- Shall delete all the other SIDs associated with the incoming Connection Link
- Shall return an RLC to the preceding BSS, when all the other SIDs associated with the Incoming Connection Link have been deleted
- When the RLC has been returned, the last remaining SID (corresponding to the DSID parameter) and the Incoming Connection Link ID shall be deleted.

(ii) *Other Action at the BSS*

See section 7.11.4.5 (a).

(c) Actions Required at the Destination BSS

(i) *Incoming Side of the BSS*

See section 7.11.4.5 (b) (i).

(ii) *Other Actions at the BSS*

The Destination BSS will immediately release the resources towards the leaf parties.

(d) Collision of Release Messages

(i) *Outgoing Side of an BSS*

(R) 7-292 After sending a Release message with the destination Connection Link Identifier parameter, a Release message may be received. In this case, the BSS shall return the corresponding RLC. The RLC shall be sent when the transmission path is disconnected.

(ii) *Incoming Side of an BSS*

(R) 7-293 After sending a Release message, a Release message with a Destination Connection Link identifier parameter may be received. In this case, the BSS shall continue as described in section 7.11.4.5.(b) (i).

7.11.5 Interaction

7.11.5.1 Interaction With a Leaf Party that does not Support Multipoint Procedures

The point-to-multipoint BISUP procedures specified in this section will support connection set up to a **broadband** leaf party that does not support the point-to-multipoint access procedures defined in UNI 3.1.

7.11.5.2 Interaction with a Leaf Party that is not a Broadband User

The network will not support the connection establishment to a user that is not a broadband user.

(R) 7-294 When an BSS has received the complete call information for the establishment of a point-to-multipoint network connection to a remote party or the addition of a remote party to an existing network connection and has determined that the connection has to be routed to a non-Broadband ISDN user, this connection shall be released in accordance with the normal release procedures specified in Section 7.11.4. Such a determination could be made at a broadband/narrowband interworking BSS or at the destination BSS.

7.11.6 Maintenance Control Functions

The procedures defined in Section 7.9 apply also to point-to-multipoint, except for the reset procedures, which are specified in this section.

7.11.6.1 Reset

As explained in Section 7.9.1, the reset procedure is used to return signaling identifiers and connection elements (virtual channel links/path connections) to the idle condition. Refer to Section 7.9.1 for the definitions of "remote" and "local" SIDs to be reset. The procedure is invoked under abnormal conditions when the current status of the Signaling Identifiers (SIDs) or the Connection Element Identifiers (CEIs) are unknown or ambiguous.

(R) 7-295 The reset procedure shall be initiated for the following signaling anomalies detected by the B-ISDN signaling system. These anomalies are detected by the protocol procedures, reported to the BSS management functions, and thus initiate the reset procedure.

An unexpected message is one which contains a message type code that is within the set supported by the BSS but is not expected to be received in the current state of the call.

(1) If an unexpected message (any message other than an IAA or IAR) is received while awaiting the IAA, the BSS shall send a reset message to reset the remote SID.

(2) If an unexpected message (any message other than an ACM, ANM, or REL) is received while awaiting the Address Complete message, the BSS shall send a reset message to reset the local SID.

(3) If the Timer T_{1b}, "Await Release Complete" expires during a drop party operation and there are no other SIDs associated with the corresponding Connection Link, the BSS shall send a reset message to reset the VPCI/VCI.

(4) If the Timer T_{1b}, "Await Release Complete" expires during en bloc release operation, the BSS shall send a reset message to reset the VPCI/VCI.

(5) If the Timer T_{1b}, "Await Release Complete" expires during a drop party operation and there are other SIDs associated with the corresponding Connection Link, the BSS shall send a reset message to reset the local SID

(6) If the Timer T_{40b}, "Await IAM Acknowledgment", expires during connection set up to the first leaf party, an assigning BSS shall send a reset message to reset the VPCI/VCI and remove the VPCI/VCI and bandwidth from service; a non-assigning BSS shall send a reset message to reset the remote SID.

(7) If the Timer T_{40b}, "Await IAM Acknowledgment", expires during an add party operation and there are **no** other SIDs associated with the corresponding Connection Link, an assigning BSS shall send a reset message to reset the VPCI/VCI and remove the VPCI/VCI and bandwidth from service; a non-assigning BSS shall send a reset message to reset the remote SID.

(8) If the Timer T_{40b}, "Await IAM Acknowledgment", expires during an add party operation and there are other SIDs associated with the corresponding Connection Link, the BSS shall send a reset message to reset the remote SID.

(9) If an unexpected message is received relating to an unallocated SID, the BSS shall send a reset message to reset the remote SID.

(10) If the BSS detects a missing mandatory parameter, then the BSS shall send a reset message to reset the local SID.

(11) If a maintenance action is invoked due to memory mutilation, e.g., losing the association information between a signaling ID and a

Connection Element identifier, the BSS shall send a reset message to reset each affected VPCI.

(12) If a maintenance action is invoked involving start-up and restart of a BSS and/or a signaling system, the BSS shall send a reset message to reset each affected VPCI.

7.11.6.1.1 Actions at Reset Initiating BSS

To initiate the reset procedure, the BSS sends a RSM containing the resource identifier parameter. The requirements in Section 7.9.1.1 are applicable. In addition, the following requirements apply for point-to-multipoint.

(R) 7-296 On receiving the RAM, the affected BSS (the reset initiating BSS) shall perform the following actions depending on the type of reset and the number of SIDs associated with the Connection Link.

(a) If the resource to be reset is a SID and other SIDs are associated with the Connection Link, the BSS shall reset the referenced SID and put it in the "idle" state.

(b) If the resource to be reset is a SID and **no** other SID is associated with the Connection Link, the referenced SID and the associated Connection Link identifier shall be put in the "idle" state. Additionally, the related VCI is placed in the "idle" state and all associated bandwidth is put in the "available" state.

(c) If the resource to be reset is VPCI/VCI, the Connection Link identifier and all Signaling identifiers associated with the Connection Link for the referenced VPCI/VCI are put in the "idle" state. Additionally, the related VCI is placed in the "idle" state and all associated bandwidth is put in the "available" state.

(d) If the resource to be reset is VPCI, all Connection Link identifiers and all Signaling identifiers associated with the Connection Links related to the referenced VPCI are put in the "idle" state. Additionally, all related VCIs are placed in the "idle" state and all associated bandwidth on the virtual path is put in the "available" state.

7.11.6.1.2 Actions at Reset Responding BSS

(R) 7-297 On receiving a RSM, the receiving (unaffected) BSS shall take the following actions:

(a) If it is the incoming or outgoing BSS on a connection in any call/connection state, the BSS shall accept the message as a request to idle resources it controls. It responds by sending an RAM after the indicated resources have been made available for new traffic. The specific actions depend on the type of reset and on the number of SIDs associated with the incoming or outgoing Connection Link (see Section 7.11.6.1.1 item (a) to (d)).

(b) Interconnected virtual path/channel links and/or associated resources at the other side of the BSS shall be released according to Section 7.11.4.4 except in the case of call/connections and add party operations that are currently awaiting the IAA; in this case, an automatic repeat attempt is applicable.

(c) Additional actions are described in (b), (d), (e) and (f) of Section 7.9.1.2.

7.11.6.1.3 Abnormal Reset Procedures

Refer to Section 7.9.1.3.

7.11.6.2 Blocking and Unblocking of Virtual Paths

Connection for a new leaf party will not be routed over a connection link used for previous leaf parties if the connection link is on a blocked virtual path. Alternative routing may be done using another virtual path. Refer to Section 7.11.2.2.

7.12 BISUP Administration

(R) 7-298 Each BSS shall have the capability to set the following administrative data:

Each BSS shall be capable of assigning multiple VPCs to a physical path between itself and the BSS at the far-end and shall be capable of assigning bandwidth to each such VPC so that the total bandwidth assigned to all the VPCs does not exceed the bandwidth of the physical path at any point along the physical path. The number of VPCs and the bandwidth assigned to each VPC will be based on specific service needs.

Assignment of a VPCI value to each VPC so that every VPC between this BSS and a given connected BSS has a different value. In other words, the VPCI values between two BSSs shall be unique. Identical VPCI value shall be assigned to each VPC by BSSs at two ends of the VPC.

For each VPCI, the BSS shall be able to designate whether it controls this VPCI, i.e., it can assign VCI associated with this VPCI for an incoming or an outgoing call/connection. If the BSS does not control a VPCI, the BSS at the far-end will be the assigning (controlling) BSS. The default mechanism described in Section 7.8.2.1 for determining assigning/ non-assigning BSS designation shall be supported by every BSS. How many VPCIs an BSS controls will be based on specific service needs.

Certain parameters in the IAM sent by the originating BSS or sent by an intermediate BSS can be set to be included or not included when a call is to be routed to another network. This has been specified in detail in earlier parts of Section 7, but for completeness, a summary of such parameters is given below. The basis for including each parameter is also indicated.

• AAL Parameters	Per succeeding network and user subscription
• Broadband High Layer Information	Per succeeding network and user subscription
• Broadband Low Layer Information	Per succeeding network and user subscription
• Called Party Subaddress	Per succeeding network and user subscription
• Calling Party Number	Per succeeding network
• Calling Party Subaddress	Per succeeding network and user subscription
• Carrier Identification Code (*)	Per CIC
• Carrier Selection Information (*)	Per succeeding network
• Charge Number (*)	Connecting carrier and user subscription
• Originating Line Information (*)	Connecting carrier and user subscription

Those parameters indicated with (*) apply only to networks that support ANSI BISUP procedures. Note that the Charge Number can be different from the Calling Party Number.

(R) 7-299 An intermediate BSS that receives an IAM from a preceding network shall be capable of including or not including the received optional IAM parameters (Calling Party Number, AESA for Calling Party Number, AAL-parameters, Broadband High Layer Information, Broadband Low Layer Information, Calling Party Subaddress and Called Party Subaddress parameters) in the outgoing IAM on a *per preceding* network and on *a per parameter* basis.

(R) 7-300 An intermediate BSS that receives an IAM from a preceding network shall be capable of including or not including the received unrecognized IAM parameters in the outgoing IAM on a *per preceding* network basis.

(R) 7-301 The preceding two requirements shall take precedence over the compatibility instructions included in such parameters and the instructions notwithstanding, the intermediate BSS may discard an optional parameter, an unrecognized parameter, or a parameter with unrecognized value. In other words, the screening (policing) functions specified in the preceding requirements shall take precedence over compatibility instructions.

7.12.1 Additional Management Requirements

The following requirements monitor timer expirations and make counts needed for traffic engineering (i.e., sizing).

7.12.1.1 Requirements for OPC/DPC Signaling Relationships

(R) 7-302 For each OPC/DPC signaling relationship, the BSS shall count the number of BISUP messages for which the timer expired.

The following counts are needed for traffic engineering. These are analogous to "Peg Count" and "Overflow" counts made in narrowband networks.

Note that in the following requirements, the term "call/connection attempts" applies not only to attempts to establish a point-to-point call/connection, but also attempts to establish point-to-multipoint call/connections and add leaves to them.

(R) 7-303 For each OPC/DPC signaling relationship, the BSS shall count, for each ATM layer service category (e.g., CBR, VBR) and for each supported cell rate category (e.g., 173 cells/sec, or 0-500 cells/sec), the following:

- Total (i.e., successful plus unsuccessful) call/connection attempts made by the BSS. (Note that an attempt may result in the BSS sending a connection request message (e.g., IAM), or it might not.)

- Call/connection attempts made by the BSS that are rejected due to resource unavailability. This is the sum of:

  1. Call/connection requests rejected by the BSS in cases where the BSS rejects the call without sending an IAM to the next BSS, plus

  2. The number of call/connection requests where the "remote" BSS rejects calls/connections due to resource unavailability. This case is indicated by receiving one of the following cause codes from the remote BSS:
     - Cause Code 47: resource unavailable, unspecified;
     - Cause Code 51: cell rate not available;
     - Cause Code 34: no VPCI/VCI available.

(R) 7-304 For each OPC/DPC signaling relationship, the BSS shall count, for each ATM layer service category and for each supported cell rate category, the number of call/connection requests rejected by the BSS where the BSS sends an IAR indicating resources/ identifiers unavailability (i.e., having a cause code of 47, 51, or 34).

The precise definitions of "service category" and "cell rate category" are not specified at this time. Different administrations may decide to define these categories differently.

7.12.1.2 Requirements for VPCIs

It is desirable to have a measure of traffic usage of a VPCI.

(O) 7-3 For each VPCI, the BSS should periodically record the total Peak Cell Rate allocated for active calls/connections, and form an estimate of the average usage on the VPCI. For some service categories, other parameters (e.g., Sustained Cell Rate) may need to be recorded as well.

8. PVC-Based Inter-Carrier CRS Support on a B-ICI

The PVC-based ATM Cell Relay Service (CRS) is one of the inter-carrier services supported by a multi-service B-ICI. This section provides the definition, service specific functions (U-Plane), traffic management and network performance, and operations for supporting the inter-carrier CRS on a B-ICI.

Network configurations supporting services across a B-ICI can be very different, depending on the topology and the number of carriers involved. The ATM network segment provides transport functions, and it may also include service layers on the top, where the ATM layer protocol is terminated and the service specific functions are processed.

8.1 Definition

The ATM Cell Relay Service (CRS)[34] [35] is a cell-based, information transfer service which offers users direct access to the ATM layer at virtually any rate up to the access line rate. An end-to-end user access configuration for this service is shown in Figure 8.1. The supported ATM connections can be of two types: Virtual Path Connection (VPC), and Virtual Channel Connection (VCC), depending on which ATM sublayer[36] they refer to. The inter-carrier connectivity is obtained by establishing a VCC and/or a VPC at the B-ICI, with a Quality of Service (QOS) suitable to meet the QOS requested by the user for the end-to-end connection.

The CRS allows flexibility in carrying various user application traffic streams. It supports both Constant Bit Rate (CBR) and Variable Bit Rate (VBR) applications. The CRS can be used with an appropriate ATM Adaptation Layer (AAL) to support a given application. Initially, the CRS will be supported via provisioned PVCs. Switched CRS based on standard signaling protocols will follow.

This section discusses the characteristics of the inter-carrier CRS based on the establishment of PVCs. The term (point-to-point) PVC denotes an ATM layer virtual connection (VPC or VCC) from a source ATM Service Access Point (SAP) to a destination ATM SAP, that allows transmission of sequenced ATM cells through the network. With PVC-based inter-carrier CRS, connections are established through a provisioning process, or a service order process. Multipoint capabilities allow communication from a set of source ATM SAPs to a set of destination ATM SAPs. No call establishment or call termination is associated with a PVC. The PVC connections are not switched by the end-user or the network.

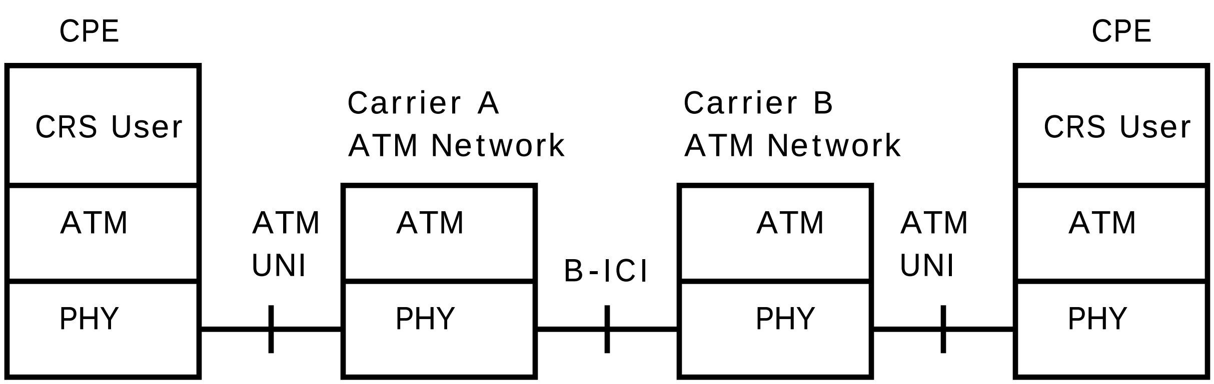


Figure 8.1 Inter-Carrier CRS Support on a B-ICI

8.1.1 Service Rates

The PVC-based inter-carrier CRS rates include up to the DS3, SONET STS-3c/OC-3, and STS-12c/OC-12 rates. Data transfer rates per VCC/VPC for the PVC-based inter-carrier CRS can range up to approximately 570 Mbit/s.

8.1.2 Communication Configuration

The inter-carrier CRS supports point-to-point, multipoint, and multicasting communication configurations[34] capabilities between the public ATM carrier networks. Multipoint capabilities include: (i) point-to-multipoint, (ii) multipoint-to-point, and (iii) multipoint-to-multipoint connections. Multicasting capabilities include broadcasting capabilities. The configurations of information flows that can be established include uni-directional, bi-directional symmetric, and bi-directional asymmetric.

8.1.3 Originating, Terminating, and Transit Inter Carrier CRS

The PVC-based inter-carrier CRS offers originating, terminating, and transit capabilities. Once a connection is established between two carriers, both carriers can transmit and receive correctly formatted ATM cells across the B-ICI. Each carrier processes the ATM cell header to determine the routing information based on VCIs and VPIs. A carrier provides originating inter-carrier CRS when, upon receipt of ATM cells from an end-user, it delivers the cells to the other carrier. A carrier provides terminating inter-carrier CRS when receiving ATM cells from another carrier, for delivery directly to an end-user. A carrier provides transit inter-carrier CRS when receiving ATM cells from a carrier and relaying them to another carrier.

The originating PVC-based inter-carrier CRS supports the service features offered by the Carrier A to the end-user. The terminating PVC-based inter-carrier CRS supports the service features offered by the Carrier B to the Carrier A. For the originating PVC-based inter-carrier CRS, the arrangement of VPCs and/or VCCs established by an end-user is maintained as the Carrier A delivers cells to the Carrier B. For the terminating PVC-based inter-carrier CRS, the arrangement of VPCs and/or VCCs received by the Carrier B from the Carrier A is maintained.

8.1.4 Carrier Selection

The PVC-based CRS allows carrier selection on a pre-selection or pre-subscription basis. The explicit carrier selection feature does not apply for the PVC-based CRS.

8.1.5 Addressing

In general, PVC-based services are offered, for example, by the use of a service order arrangement. The source and destination points of a PVC are pre-defined, and they are fixed for the duration of the connection. Thus, PVC-based CRS, for a point-to-point connection, uses the VPI (for VP service), or VPI/VCI (for VC service) fields as a locally significant address at each end to represent the desired destination(s). These fields are processed by the ATM network element to determine the connecting points and end-points of the ATM connection.

8.1.6 Routing

The routing process for PVC inter-carrier CRS provides a fixed path between the known source and destination points. For the PVC-based CRS, route determination is part of the provisioning and service order process, and will be static. Alternate routing for PVC-based CRS could also be pre-established in those situations when the direct route is not available (e.g., in a failure situation). Alternate routing can be offered as an inter-carrier CRS feature. Coordination of alternate routes between carriers is for further study.

8.1.7 Performance and Quality of Service Objectives

For the PVC-based ATM CRS, only the "information transfer phase" is considered here; the "call establishment" and "call release" phases will be considered for SVC-based ATM CRS in a later Version of this document. The generic performance criteria[37] include the primary (i.e., directly observable) performance parameters, and the derived (i.e., calculated from the primary performance parameters) performance parameters. The first three of the following objectives are the primary performance parameters, and the fourth one is a derived performance parameter:

— Speed (Delay and Bandwidth)

— Accuracy

— Dependability

— Availability

The above objectives are defined by the parameters including[38] : Cell Transfer Delay, Cell Delay Variation (CDV), Cells Mis-insertion Rate, Cell Error Ratio, Cell Loss Ratio, Mean Time Between Service Outages, and Mean Time to Restore.

8.2 CRS Specific Functions

This section addresses B-ICI service specific functions (U-Plane) above the ATM layer, for example, ATM Adaptation Layer (AAL), and network interworking, where applicable.

For the inter-carrier CRS, B-ICI related service specific functions (above the ATM layer) in the U-Plane are not applicable for this Version of the document.

8.3 CRS Traffic Management and Network Performance

This section provides CRS specific traffic management functions and network performance considerations that are required for a B-ICI.

8.3.1 Traffic Management

Traffic management impacts for CRS at a B-ICI are considered here. These are the additional information (beyond that needed for the B-ICI traffic contract) that should be exchanged between carriers to increase the efficiency of each carrier's CAC function, and the preservation of EFCI function's integrity across a B-ICI.

A carrier's CAC function and its engineering of its network portion can generally by facilitated by the availability of additional information beyond that required for the carrier-to-carrier traffic contract at a B-ICI, as given in Section 5.2. Additional information that may — subject to bilateral agreement — be exchanged for a VCC carrying CRS includes (as part of the Source Traffic Descriptor) a VCC's Sustainable Cell Rate and Burst Tolerance[19]. This additional information should be included for both the CLP = 0 and CLP = 0+1 cell streams on any VCC carrying CRS whenever a carrier supports both of these cell streams.

8.3.2 Network Performance

For this Version of the B-ICI Specification, no additional performance considerations are included beyond those given in Section 5.1. Section 5.1 makes use of the ATM layer network performance parameters defined in[19].

8.4 CRS Operations and Maintenance

For the inter-carrier CRS, the common B-ICI operations and maintenance provided in Section 6 apply.

9. PVC-Based Inter-Carrier CES Support on a B-ICI

The PVC-based Circuit Emulation Service (CES) is one of the inter-carrier services supported by a multi-service B-ICI. This section provides the definition, service specific functions (U-Plane), traffic management and network performance, and operations for supporting the inter-carrier DSn (n = 1, 3) CES on a B-ICI. (Note: DS1 and DS3 sub-rate grooming capability is not considered part of the CES support on the B-ICI.)

9.1 Definition

Circuit Emulation Service (CES) provides support for transporting CBR signals (or "circuits") using ATM technology. An example of this service is DS1 and DS3 circuit emulation. The CES allows the CBR users to communicate with each other using an ATM UNI or a DSn interface supported by the respective carriers, and with a B-ICI providing the inter-carrier connectivity.

Figure 9.1 shows examples of CES and its role in supporting CBR services.

In Case (a), a B-ICI supports the transport of DSn signals between the Carrier A and Carrier B networks which are connecting the users with the ATM UNIs at both ends. In this Case, a B-ICI supports the inter-carrier CBR service using CRS. *(Note: This case is covered under the CRS if the AAL Type 1 is only present in the Customer Premises Equipment (CPE), If the network supports the AAL Type 1, higher layer requirements on the B-ICI will apply).*

In Case (b), a B-ICI supports the transport of DSn signals between the Carrier A and Carrier B networks which are connecting the users with an ATM UNI on one end and a DSn interface at the other end. In this Case, a B-ICI supports the inter-carrier CBR service using network interworking functions and the AAL Type 1 performed by the Carrier B.

In Case (c), a B-ICI supports the transport of DSn signals between the Carrier A and Carrier B networks which are connecting the users with the DSn interface at both ends. In this Case, a B-ICI supports the inter-carrier CBR service using network interworking functions and the AAL Type 1 performed by both the Carrier A and Carrier B.

9.2 CES Specific Functions

This section provides the B-ICI service specific functions (U-Plane) above the ATM layer, for example, ATM Adaptation Layer (AAL), and network interworking, where applicable.

The Circuit Emulation Service (CES) specific functions at the sending end converting a DSn signal into ATM cells, and at the receiving end converting the stream of ATM cells back into a DSn signal are shown in Figure 9.2. This section describes the CES specific interworking functions between the DSn and Convergence Sublayer (CS), and between the CS and DSn, as a signal flows from the sending end to the receiving end. In addition, the functions performed by the AAL Type 1 SAR and CS, are also identified.

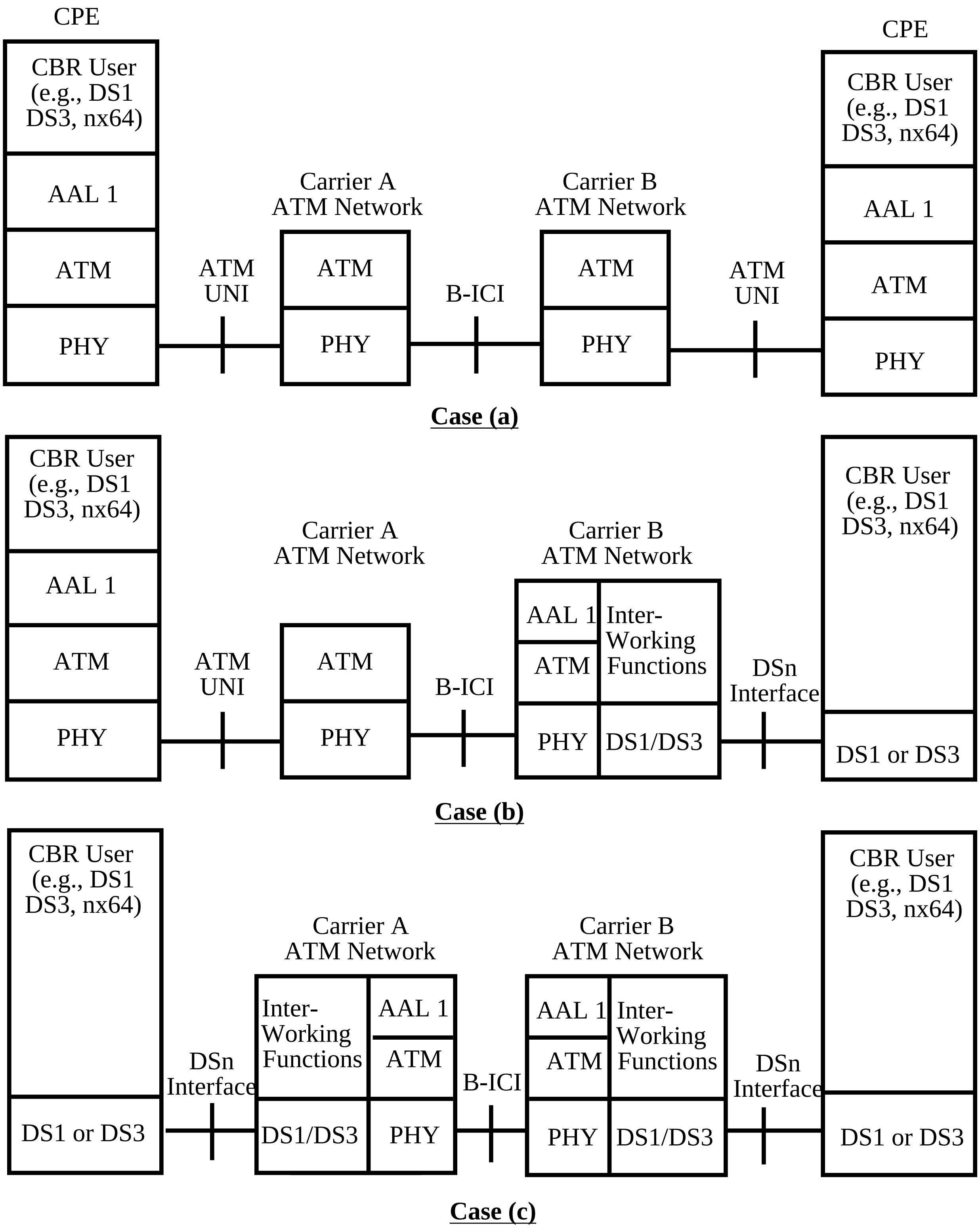


Figure 9.1 CBR Services Support Using Inter-Carrier CES on a B-ICI

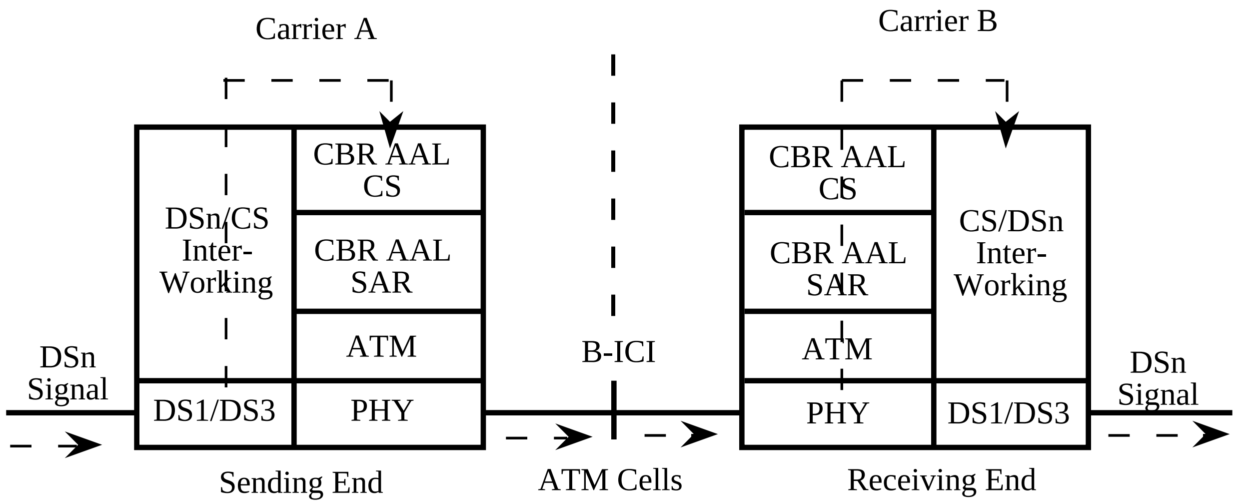


Figure 9.2 CES Specific Functions at the Sending and Receiving Ends

Circuit emulation of Constant Bit Rate (CBR) service, such as DS1 or DS3, is supported with the functions of the CBR ATM Adaptation Layer (AAL) which resides above the ATM Layer. The subset of CBR AAL functions and protocols used to support DS1/DS3 circuit emulation are referred to as Unstructured Data Transfer[19] (UDT).

9.2.1 CBR AAL Functions

This section describes the CBR AAL functions used to support UDT for DS1 and DS3 circuit emulation. The CBR AAL consists of two sublayers, the Segmentation and Reassembly (SAR) sublayer and the Convergence Sublayer (CS). The SAR sublayer is the lower sublayer and the CS is the higher sublayer of the AAL.

Sending End:

At the sending end, DS1 or DS3 termination functions and the interworking between the DSn and CS of the AAL Type 1 are performed.

At the sending AAL-entity, the CS performs the following functions:

1. Blocks DS1 and DS3 bits into 47-octet CS_PDUs for transport as SAR_PDU payloads.

2. Generates sequence count cycle values (Modulo 8) to be associated with each 47-octet CS_PDU blocked.

[19] The transfer of AAL-user information supported by the CBR AAL when the AAL-user data transferred by the AAL is not organized into data blocks.

3. Uses the Synchronous Residual Time Stamp (SRTS) method for clock recovery when a common reference clock is available on both sides of the B-ICI. When a common reference clock is not available, other methods (e.g., Adaptive Clock Recovery) could be used.

4. Specifies the Convergence Sublayer Indicator bit value associated with each sequence count value and 47-octet CS_PDU.

5. Passes the information to the sending-AAL SAR for the generation of SAR_PDUs.

At the sending AAL-entity, the SAR sublayer performs the function of generating the SAR_PDU header, and the SAR_PDU from information parameters provided by the sending-AAL CS. The AAL Type 1 SAR_PDU structure is shown in Figure 9.3.

Sequence Number (SN) 4 bits	Sequence Number Protection (SNP) 4 bits	SAR_PDU Payload (47-Octet)

Figure 9.3 AAL Type 1 SAR_PDU Structure

The sending AAL-entity also assumes in the case of DS1 and DS3 circuit emulation that DS1 and DS3 Loss of Signal (LOS) detection is performed as an interworking function to support fault location. This is required by the ANSI CBR AAL standard. The generation of a DS1 or a DS3 Alarm Indication Signal (AIS) in response to a LOS condition may also be needed as an interworking function, but this is an open issue in standards. LOS and AIS detection are discussed further in Section 9.4.

Receiving End:

At the receiving AAL-entity, the SAR sublayer performs the function of processing cell payloads received as SAR_PDUs to recover the SAR_PDU header and 47-octet SAR_PDU payload of AAL user information, checking the integrity of the SAR_PDU header (i.e., bit error correction/detection), and passing information parameters to the receiving-AAL CS.

At the receiving AAL-entity, the CS performs the following functions[20]:

1. Recognizes a starvation condition to exist when no AAL_SDUs (i.e., user information bits) are available to pass to the AAL user. The starvation condition is cleared through the arrival of CS_PDUs.

2. Detects the loss of CS_PDUs due to cell loss events which do not result in a starvation condition. (These events are detected using the cyclic sequence count values.)

[20] Detailed specifications associated with these functions and further discussion of SRTS clock recovery, can be found in the ANSI CBR AAL standard.

3. Triggers the generation of dummy AAL_SDUs corresponding to a DS1 or DS3 Alarm Indication Signal (AIS) to maintain bit count integrity to the AAL user. For the case of cell loss which results in no starvation condition the AIS generation shall be done in 47-octet segments which replace the AAL_SDUs associated with the CS_PDUs identified as lost. For the case of a starvation condition the AIS generation continues until the starvation condition is cleared and normal operation is resumed.

4. Recovers the DS1 or DS3 asynchronous clock using the SRTS method if the SRTS method is used at the sending end. Other methods (e.g., Adaptive Clock Recovery) could be used when SRTS is not supported.

5. Deblocks the 47-octet CS-PDUs and uses the recovered clock to pass the AAL_SDUs (i.e., user information bits) to the AAL user.

At the receiving end, no CS/DSn interworking functions are performed.

(R) 9-1 Network equipment associated with a multi-service B-ICI supporting DS1 or DS3 CES shall support CBR AAL Unstructured Data Transfer (UDT) functions as specified in ANSI T1.CBR[39].

9.3 CES Traffic Management and Network Performance

This section provides CES specific traffic management functions and network performance considerations that are required for a B-ICI.

9.3.1 Traffic Management

A carrier's CAC function and its engineering of its network portion can generally by facilitated by the availability of additional information beyond that required for the carrier-to-carrier traffic contract at a B-ICI, as given in Section 5.2. Additional information may — subject to bilateral agreement — be exchanged for a VCC carrying the CES.

9.3.2 Network Performance

For this Version of the B-ICI Specification, the network performance considerations are as given in Section 5.1, including use of the ATM layer network performance parameters defined in[19]. DS3 and DS1 CES should receive a QOS class[19] having a stringent objective for Cell Loss Ratio.

9.4 CES Operations and Maintenance

This section provides the AAL Type 1 operations above the ATM layer. Operations for layers above the AAL are not discussed in this Version. Section 9.4.1 discusses operations for the common part of the AAL Type 1, and Section 9.4.2 discusses operations for the service specific part of the AAL Type 1.

9.4.1 Operations for Common Part of the AAL Type 1

This section specifies performance measurements needed to monitor service independent errors for AAL Type 1. Performance measurements are needed at AAL Type 1 entities to record errors in transmission.

At the sending Interworking Function (IWF)[21], it is possible that the ATM Layer is not providing adequate transport for the SAR_PDUs sent by the AAL Type 1. In this case, the sending IWF can become congested and SAR_PDUs may be discarded. At the sending IWF, the following error condition may occur:

- Congestion at the sending IWF: The number of SAR_PDUs discarded to relieve congestion should be counted.

At the receiving IWF, the following error conditions may occur:

- Buffer overflows: The number of SAR_PDUs dropped should be counted.
- Cell losses: Cell loss is detected through sequence count value violations during non-starvation conditions. The number of cell payloads identified as lost is estimated.
- Starvation conditions: Starvation conditions occur when no cells are in the buffer of the receiving IWF. The AAL Type 1 reports the status of a starvation condition by reporting the start and stop times of AIS generation. The number of starvation events during a measurement interval, and the total time in the starvation condition, should be measured.

(R) 9-2 Network equipment at a B-ICI performing receiving IWF functions (with an AAL Type 1 supporting UDT) shall measure buffer overflows, cell loss, number of starvation events, and time in the starvation condition.

A typical value for a measurement interval could be 15 minutes, and at least 8 hours of history should be kept. The measurement interval and amount of history data will be established by bilateral agreements between the carriers.

9.4.2 Operations for Service Specific Part of the AAL Type 1 and IWF

This section discusses the operations functions required to support Unstructured Data Transfer (UDT), which is used to support the inter-carrier DS1/DS3 Circuit Emulation Service (CES). As discussed in the AAL Type 1 Standard[39], many of the operations functions that will be discussed in this section are considered "common". However, AAL Type 1 is not formally divided into a common part and a service-specific part. Thus, although the text in this discussion is written in the service-specific context of DS1/DS3 CES, many of the functions are expected to be generic for all services supported by AAL Type 1.

As discussed in Section 9.2, the DSn/Convergence Sublayer (CS) interworking at the sending Interworking Function (IWF) *must* detect LOS. (This is a requirement stated in the AAL Type 1 Standard[39]). LOS is declared when 175 $\pm$ 75 consecutive 0s, or no pulses, are received.

[21] The sending and receiving IWFs are illustrated in Figure 9.4.

(R) 9-3 A sending IWF supporting UDT at a B-ICI shall detect LOS, as specified in ANSI T1.CBR-1993[39].

DSn/CS interworking may also detect Loss of Frame (LOF) and report it to the DSn/CS interworking function as an LOS.

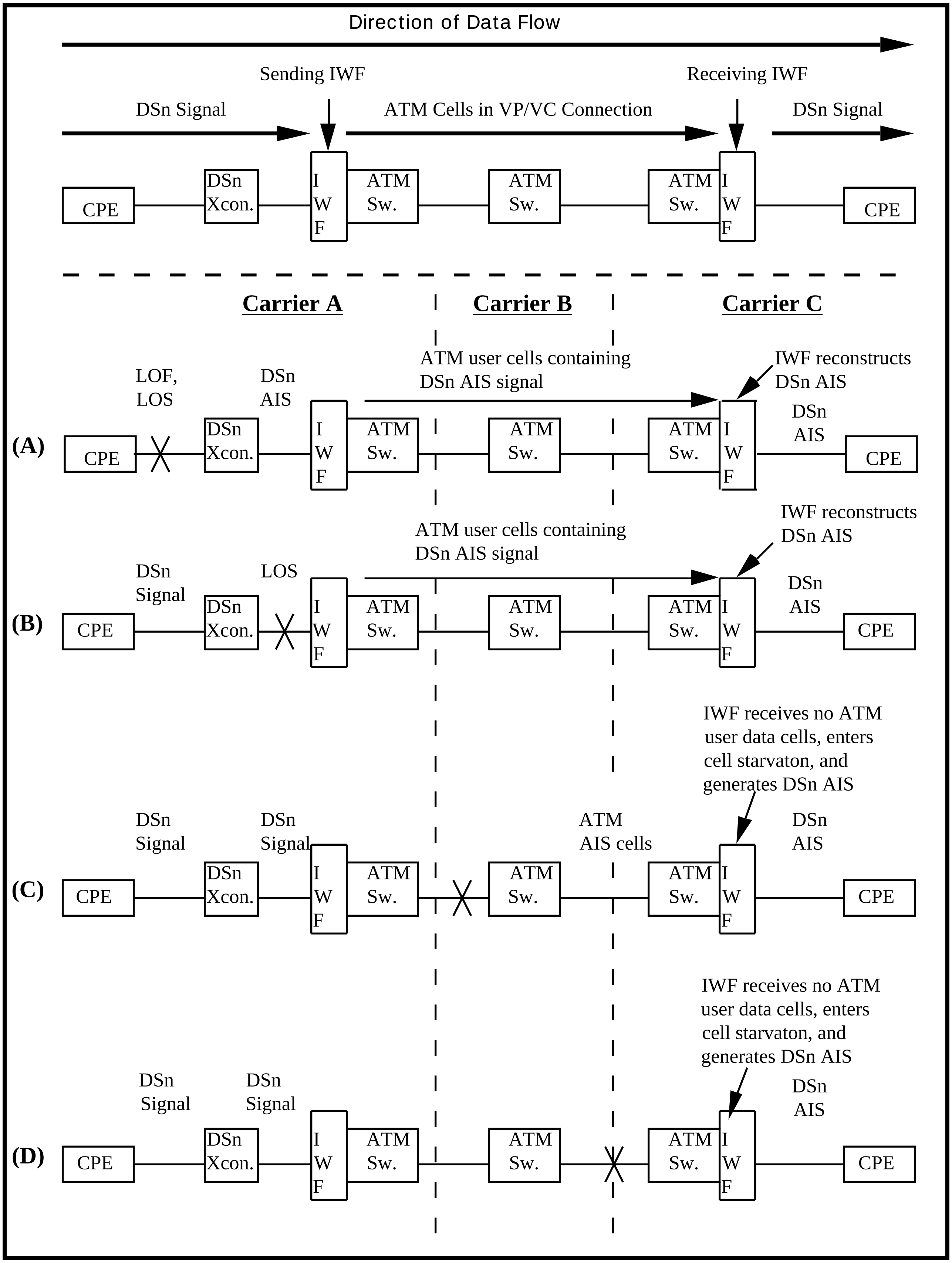
Upon detection of LOS by DSn/CS interworking, two possible options are: (a) the AAL Management can suspend the AAL Type 1 generation of SAR_PDUs, or (b) the AAL Type 1 user (i.e., DSn/CS interworking) can generate a DSn Alarm Indication Signal (AIS) and map it into SAR_PDUs. A drawback of option (a) is that the receiving IWF cannot distinguish between an ATM failure or not. The implementation of option (b) will result in no problem detected at the receiving AAL Type 1 entity when a DSn problem has been detected prior to the DSn signal being converted to ATM cells. The AIS will be detected by DSn equipment downstream of the AAL Type 1 entity. Alarms detected at the receiving IWF will indicate problems in the ATM network only.

(R) 9-4 Network equipment at a B-ICI performing sending IWF functions (with an AAL Type 1 supporting UDT) shall generate a DSn AIS signal, and map it into SAR_PDUs, upon being informed of an LOS by DSn/CS interworking.

The above requirement only applies when the LOS is first detected at the sending IWF. If the sending IWF receives a DSn AIS from an upstream device, it simply transports the AIS. If a fault occurs within the ATM network resulting in a starvation condition occurring at the receiving IWF, the AAL Type 1 at that IWF shall generate dummy AAL-SDUs corresponding to a DSn AIS. Figure 9.4 shows the various places a fault may occur, and the resulting actions in the network. [Note: DSn Xcon. = DSn Cross-connect; ATM Sw. = ATM Switch].

See the Following Page

Figure 9.4 Alarm Propagation Behavior for Different Fault Locations


Direction of Data Flow
Sending IWF
Receiving IWF
DSn Signal
ATM Cells in VP/VC Connection
DSn Signal
CPE
DSn Xcon.
I W F
ATM Sw.
ATM Sw.
ATM Sw.
I W F
CPE
Carrier A
Carrier B
Carrier C
ATM user cells containing DSn AIS signal
IWF reconstructs DSn AIS
LOF, LOS
DSn AIS
DSn AIS
(A)
(B)
DSn Signal
LOS
(C)
IWF receives no ATM user data cells, enters cell starvaton, and generates DSn AIS
DSn Signal
ATM AIS cells
(D)

10. PVC-Based Inter-Carrier FRS Support on a B-ICI

The PVC-based Frame Relay Service (FRS) is one of the inter-carrier services supported by a multi-service B-ICI. This section provides the definition, service specific functions (U-Plane), traffic management and network performance, and operations for supporting the inter-carrier FRS on a B-ICI.

10.1 Definition

The FRS[40] is a connection-oriented data transport service that provides for the bi-directional transfer of variable-length packets for LAN interconnection and terminal-host applications[41].

The FRS[42] requires the initial establishment of end-to-end connections, either through provisioning or call setup procedures. Initial FRS will be based on provisioned PVCs. Requirements for SVC-based FRS are expected to follow in future Versions of this document. Customer access to the FRS will initially be over service specific customer interface. The carrier network or Broadband Customer Premises Equipment (B-CPE) provides an interworking function to convert FRS data to ATM cells as detailed later in this section.

The inter-carrier FRS[43] includes the following[44]:

- Service Characteristics and Attributes: These include FRS rates, FRS feature transparency, and service features, e.g., point-to-point, multipoint, multicasting.
- Network Assumptions
- Carrier Selection
- Addressing
- Routing
- Performance and Quality of Service Objectives: For the PVC-based ATM FRS, only the "information transfer phase" is considered here; the "call establishment" and "call release" phases will be considered for SVC-based ATM FRS in a later Version of this document. The generic performance criteria[37] include the primary (i.e., directly observable) performance parameters, and the derived (i.e., calculated from the primary performance parameters) performance parameters. The first three of the following objectives are the primary performance parameters, and the fourth one is a derived performance parameter:

  — Speed (Delay and Bandwidth)
  — Accuracy
  — Dependability
  — Availability

The above objectives are defined by the parameters including[45]: Frame Transfer Delay, Residual Errored Ratio, Frame Loss Ratio, Bit Loss Ratio, Extra Frame Rate, Mean Time Between Service Outages, and Mean Time to Restore.

10.2 FRS Specific Functions

This section describes a FRS specific functions including the FR//BISDN Inter-Working Function (IWF) which is required to support carriage of PVC FRS across a multiservice B-ICI. This IWF conforms to the CCITT Recommendations I.555[46] and I.365.1[47].

Figure 10.1 illustrates three FRS access configurations labeled A1 through A3 (or B1 through B3) supported by the B-ICI. Interconnection between any of the access configurations shall be supported. These interconnections lead to six possible reference configurations. A complete list of reference configurations is:

1. A1 to B1
2. A1 to B2
3. A1 to B3
4. A2 to B2
5. A2 to B3
6. A3 to B3

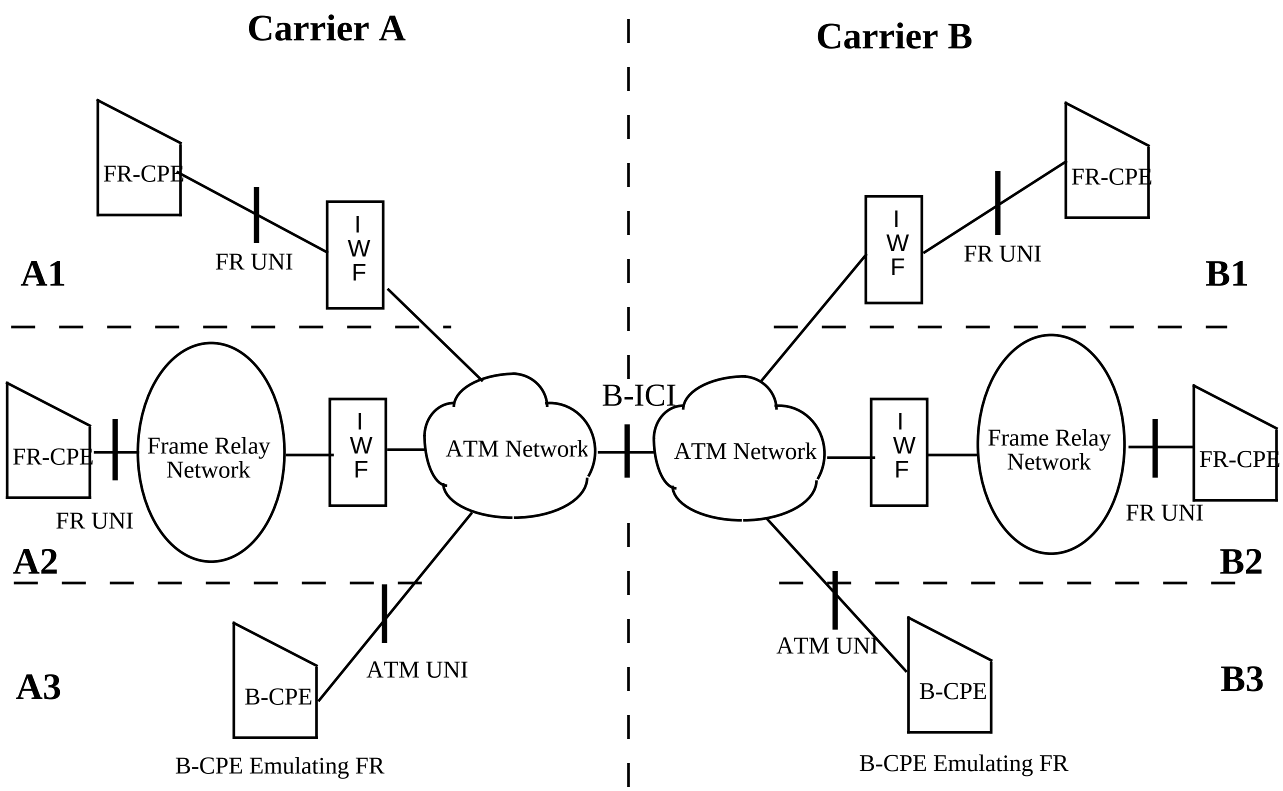


Figure 10.1 FRS Support on an ATM-based Multi-Service B-ICI

Figure 10.1 does not imply any particular physical location for an IWF. Three examples of where the IWF may be implemented are illustrated in Figure 10.2. From the perspective of the B-ICI, all of the examples are functionally equivalent (i.e., provide the same IWF).

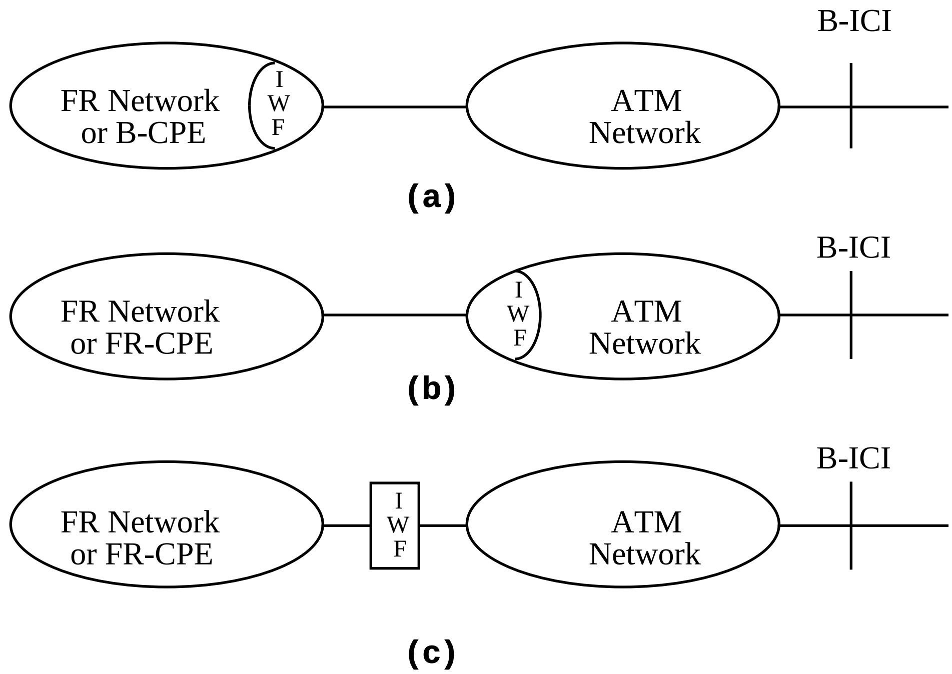


Figure 10.2 Example Realizations of IWF Which are Equivalent for the B-ICI

(a) - Possible realization of access configuration A2 or A3 from Figure 10.1
(b) - Possible realization of access configuration A1 or A2 from Figure 10.1
(c) - Possible realization of access configuration A1 or A2 from Figure 10.1

10.2.1 Network Inter-Working Scenarios

There are two Network Interworking scenarios that are defined in the CCITT Recommendation I.555[46]. Scenario 1 connects two Frame Relay Networks/CPE using BISDN. Scenario 2 connects a Frame Relay Network/CPE with a B-CPE using BISDN. These two scenarios cover the six reference configurations that are described earlier. These two scenarios showing network interworking between Frame Relay Bearer Service (FRBS) and BISDN are described below.

10.2.1.1 Network Inter-Working Scenario 1

The U-plane protocols associated with high speed interconnection based on ATM between two FR Network/CPE are shown in Figure 10.3.

The use of the BISDN network by two FR Networks/CPE is not visible to the end users. The end user protocol suites remain intact. The IWF provides all mapping and encapsulation functions necessary to ensure that the service provided to FR-CPE is unchanged by the presence of an ATM transport. See CCITT Recommendation I.555 [46] for more details.

The reference configurations that are supported by Network Inter-Working Scenario 1 are: A1-B1, A1-B2, and A2-B2 listed earlier.

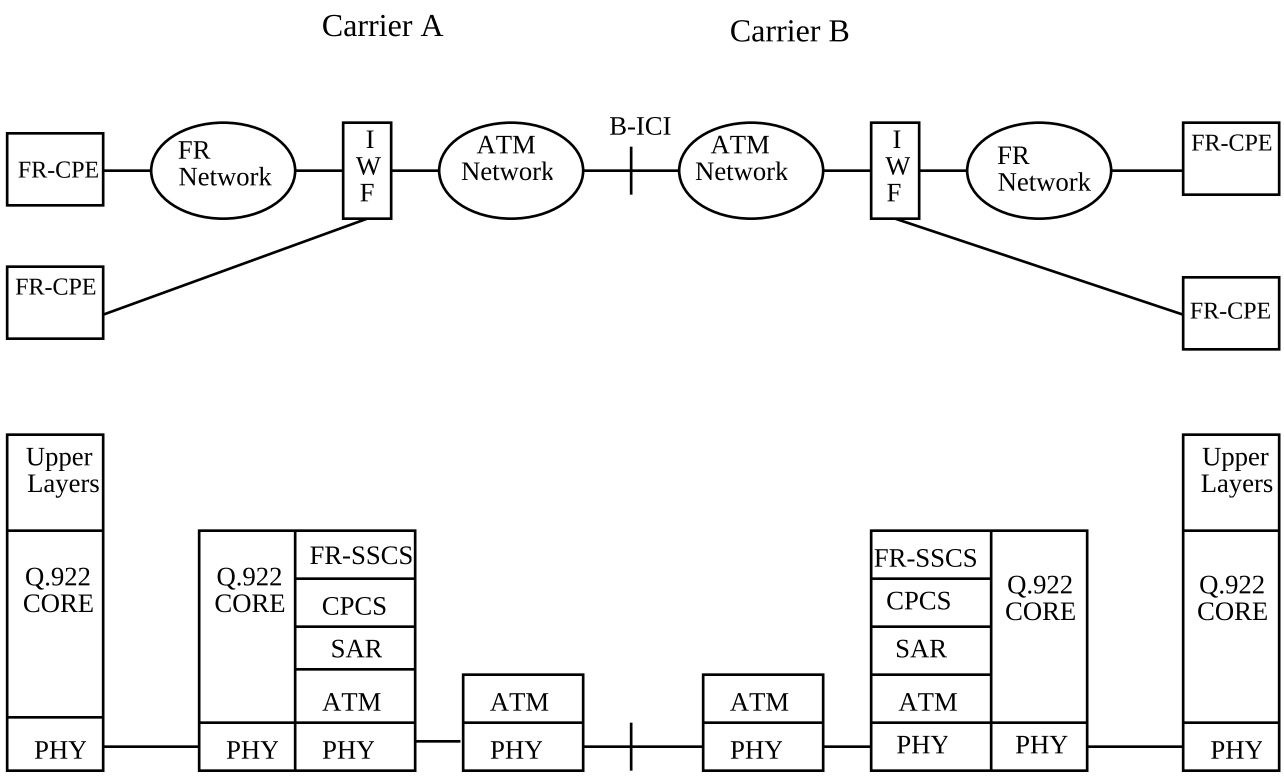


Figure 10.3 Network Inter-Working Between FRBS and BISDN (I.555 Scenario 1)

10.2.1.2 Network Inter-Working Scenario 2

The U-plane protocols associated with interconnection between FR Network/CPE and a B-CPE are shown in Figure 10.4.

The use of the BISDN by a FR Network/CPE and a BISDN CPE is not visible to the FR end users. The BISDN CPE must support the FR Service Specific Convergence Sublayer (FR-SSCS) in its protocol stack. The IWF provides all functions necessary to ensure that the service provided to the FR-CPE is unchanged by the presence of an ATM transport. See CCITT Recommendation I.555 [46] for more details.

The reference configurations that are supported by Network Inter-Working Scenario 2 are: A1-B3 and A2-B3 listed earlier.

Reference configuration (A3-B3), B-CPE to B-CPE, is not explicitly covered by the CCITT Recommendation I.555 Network Inter-Working Scenarios. No IWF exists in the network for this configuration.

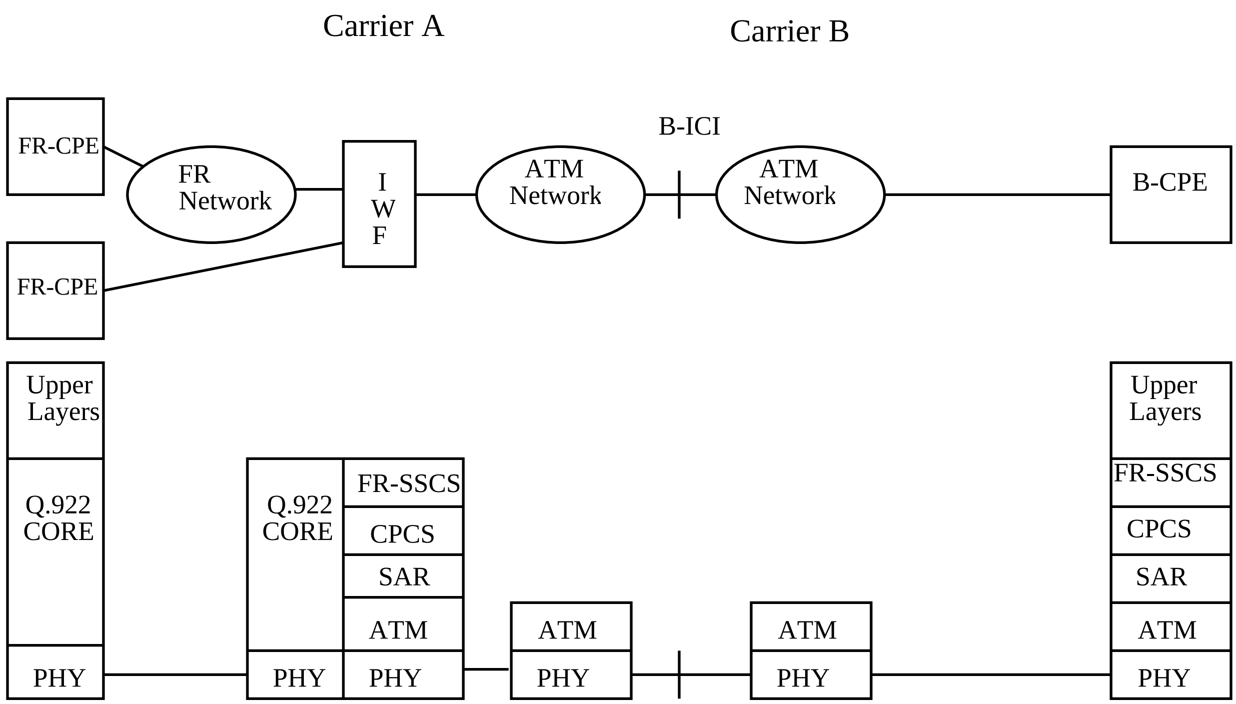


Figure 10.4 Network Inter-working Between FRBS and BISDN (I.555 Scenario 2)

10.2.2 Network Inter-Working Functions

The IWF provides functional mapping between FRS functions and BISDN functions. FRS features to be supported include the following:

1. Variable Length PDU Formatting and Delimiting
2. Error Detection
3. Connection Multiplexing
4. Loss Priority Indication
5. Congestion Indication (Forward & Backward)
6. PVC Status Management

Figure 10.5 illustrates the internal protocol architecture of the FR/BISDN IWF. The BISDN sublayers and the support of the above FRS features by these sublayers are described below.

10.2.2.1 Frame Formatting and Delimiting

The FRS Specific Convergence Sublayer uses a PDU format identical to Q.922 Core minus the CRC-16, FLAGs and zero bit insertion (Figure 10.6).

(R) 10-1 The FR/ATM IWF shall use the FR-SSCS as specified in [47].

(R) 10-2 The default (2 octet) address field format shall be supported.

(O) 10-1 The support of 3 and 4 octet address field formats is an option.

The Segmentation and Reassembly (SAR) and Common Part Convergence Sublayer (CPCS) of the ATM Adaptation Layer (AAL) Type 5 in conjunction with the ATM layer ATM_user_to_ATM_user indication provides segmentation and reassembly (frame delimiting) for FR-SSCS PDUs.

(R) 10-3 The FR/ATM IWF shall utilize the AAL Type 5 CPCS and SAR as specified in the CCITT Recommendation I.363 [48] (Figure 10.7).

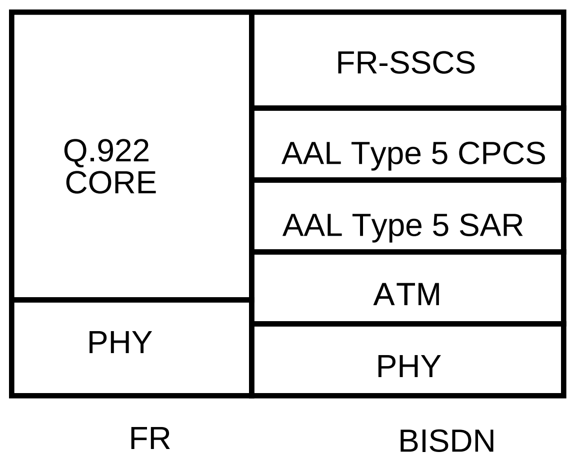
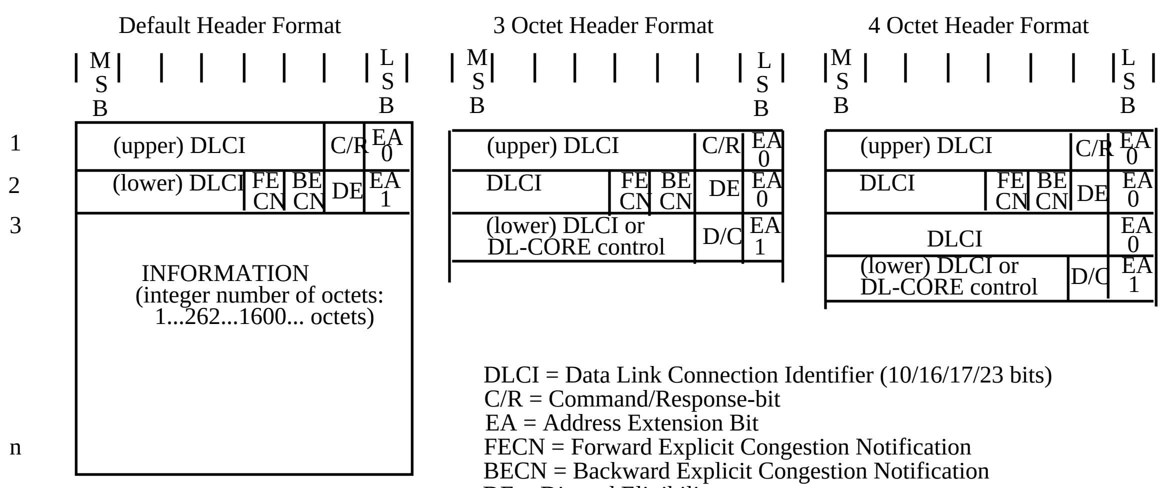


Figure 10.5 FR/BISDN IWF Internal Architecture



DLCI = Data Link Connection Identifier (10/16/17/23 bits)
C/R = Command/Response-bit
EA = Address Extension Bit
FECN = Forward Explicit Congestion Notification
BECN = Backward Explicit Congestion Notification
DE = Discard Eligibility
FCS = Frame Check Sequence
D/C = DLCI or DL-CORE control indicator

Figure 10.6 Structure of FR-SSCS-PDU With 2, 3, 4 Octet Header Formats (I.365.1)

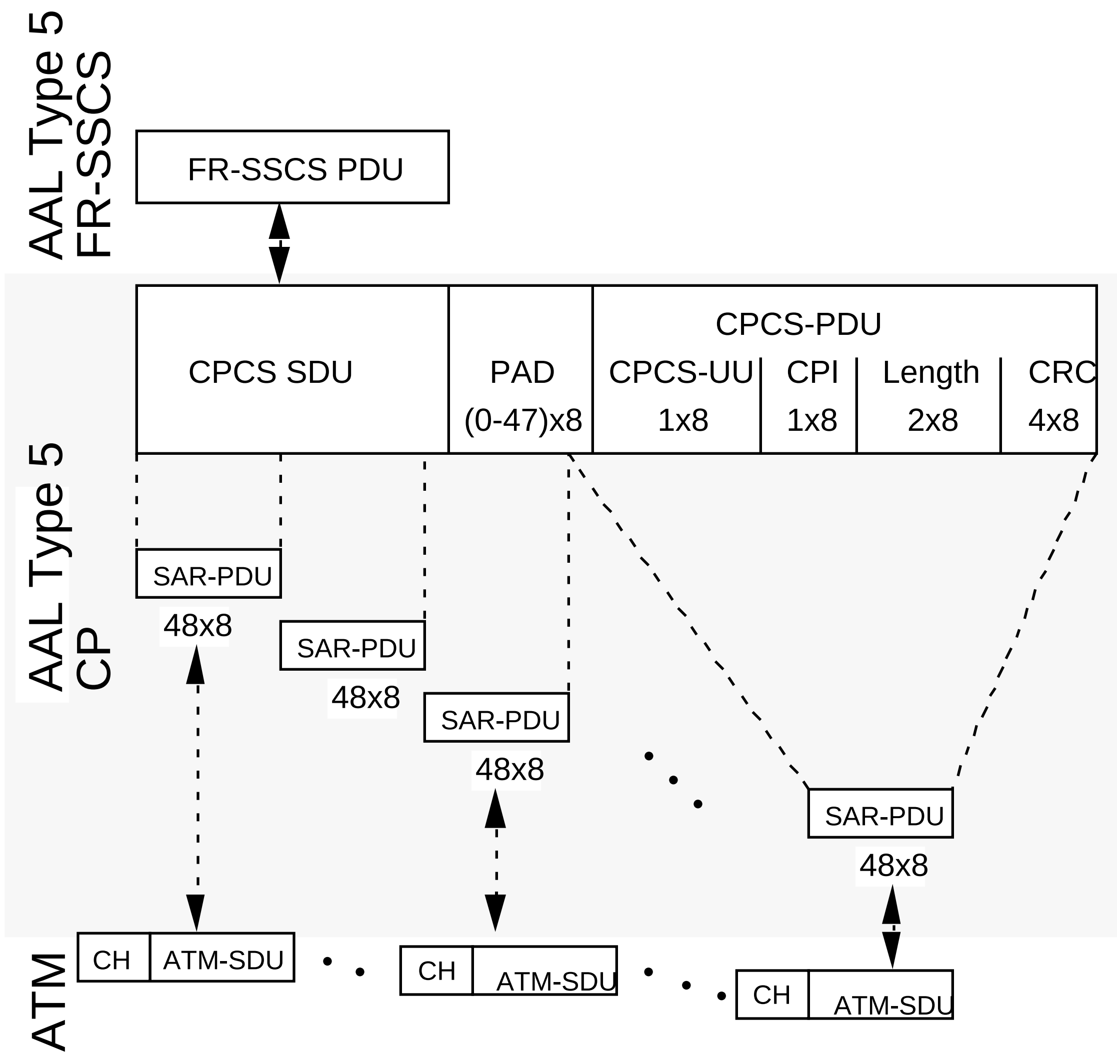


Figure 10.7 AAL Type 5 Common Part (CP) PDU Formats (I.363)

0.2.2.2 Error Detection

The AAL Type 5 CPCS CRC-32 provides error detection over the FR-SSCS PDU.

10.2.2.3 Connection Multiplexing

The FR-SSCS can support connection multiplexing using the DLCI field. In addition, the ATM layer supports connection multiplexing using its VPI/VCI. CCITT Recommendation I.555[46] identifies two methods of multiplexing FR connections over BISDN:

1. **Many-to-One:** Multiple FR logical connections are multiplexed into a single ATM Virtual Channel Connection (VCC). Multiplexing is accomplished at the FR-SSCS sublayer using DLCIs.

(O) 10-2 The IWF may support many-to-one multiplexing. The FR-SSCS DLCI value(s) used should be agreed upon between the two ATM end systems (e.g., ATM end users or IWFs).

Many-to-one method may be used only for FR PVCs that terminate on the same ATM-based end systems (e.g., ATM end users or IWFs).

2. One-to-One: Each FR logical connection is mapped to a single ATM VCC. Multiplexing is performed at the ATM-layer using VPI/VCIs.

(R) 10-4 The IWF shall support one-to-one multiplexing. The FR-SSCS DLCI value used shall be agreed upon between the two ATM end systems (e.g., ATM end users or IWFs).

An objective is that many-to-one and one-to-one multiplexing schemes will interoperate.

10.2.2.4 Discard Eligibility and Cell Loss Priority Mapping

(i) Frame Relay to BISDN Direction

The network provider can select between two modes of operation for loss priority mapping in the FR to BISDN direction (Figure 10.8).

(R) 10-5 IWF equipment shall support both of the following two modes, selectable for each ATM connection:

Mode 1: The Discard Eligibility (DE) field in the Q.922 Core frame shall be copied unchanged into the DE field in the FR-SSCS-PDU header, and mapped to the ATM Cell Loss priority (CLP) of every ATM cell generated by the segmentation process of that frame.

Mode 2: The Discard Eligibility (DE) field in the Q.922 Core frame shall be copied unchanged into the DE field in the FR-SSCS-PDU header, and the ATM Cell Loss Priority (CLP) of every ATM cell generated by the segmentation process of that frame shall be set to a constant value (either 0 or 1). The value is decided when the ATM connection is set up, and is used for all cells generated from the segmentation process of every frame, until the ATM connection characteristics are changed.

(ii) BISDN to Frame Relay Direction

The network provider can select between two modes of operation for loss priority mapping in the BISDN to FR direction (Figure 10.8).

(R) 10-6 IWF equipment shall support both of the following two modes, selectable for each ATM connection:

Mode 1: If one or more ATM cell belonging to a frame has its CLP field set or if the DE field of the FR-SSCS-PDU is set, the IWF shall set the DE field of the Q.922 Core frame.

Mode 2: No mapping shall be performed from the ATM layer to Q.922 Core layer. The FR-SSCS-PDU DE field is copied unchanged to the

Q.922 Core frame DE field, independent of CLP indication(s) received at the ATM layer.

FR-to-BISDN Mode 1

from Q.922 Core DE	mapped to FR-SSCS DE	mapped to ATM layer CLP
0	0	0
1	1	1 (Note1)

Note 1: For all cells generated from the segmentation process of that frame.

FR-to-BISDN Mode 2

from Q.922 Core DE	mapped to FR-SSCS DE	mapped to ATM layer CLP
0	0	Y
1	1	Y (Note 2)

Note 2: Y can be 0 or 1.

BISDN-to-FR Mode 1

from ATM layer CLP	from FR-SSCS DE	to Q.922 Core DE
0	0	0
1 (Note 3)	X	1
X	1	1

Note 3: For 1 or more cells of the frame.

BISDN-to-FR Mode 2

from ATM layer CLP	from FR-SSCS DE	to Q.922 Core DE
X	0	0
X	1	1

Figure 10.8 DE/CLP Mapping

10.2.2.5 Congestion Indication

10.2.2.5.1 Congestion Indication (Forward)

Forward congestion indication is supported at the frame level with Forward Explicit Congestion Notification (FECN) and at the cell level with Explicit Forward Congestion Indication (EFCI).

(i) Frame Relay to BISDN Direction

Frame level FECN is not mapped to cell level EFCI (Figure 10.9).

(R) 10-7 The FECN field of the Q.922 Core frame shall be copied unchanged into the FECN field in the FR-SSCS-PDU. The EFCI field of all ATM cells shall be always set to '0'.

(ii) BISDN to Frame Relay Direction

Cell level EFCI is mapped to frame level FECN (Figure 10.9).

(R) 10-8 If the EFCI field in the last ATM cell of a segmented frame received is set, or if the FECN field of the received FR-SSCS-PDU is set, then the IWF shall set the FECN of the Q.922 Core frame.

FR-to-BISDN

Q.922 FECN	SSCS FECN	ATM EFCI
0	0	0
1	1	0

BISDN-to-FR

ATM EFCI (in last cell)	SSCS FECN	Q.922 FECN
0	0	0
X	1	1
1	X	1

Figure 10.9 FECN/EFCI Mapping

10.2.2.5.2 Congestion Indication (Backward)

Backward congestion indication is supported only at the frame level by the Backward Explicit Congestion Notification (BECN) field (Figure 10.10).

(i) BISDN to Frame Relay Direction

(R) 10-9 The BECN field in the FR-SSCS-PDU shall be copied unchanged into the BECN field of the Q.922 Core frame.

(ii) Frame Relay to BISDN Direction

(R) 10-10 The BECN field in the FR-SSCS-PDU shall be set to "1" by the IWF if either of the following two conditions is met:

1. BECN is set in the Q.922 Core frame relayed in the FR to BISDN direction, or
2. EFCI was set in the last ATM cell of the last segmented frame received in the BISDN to FR direction for this bi-directional

connection (i.e., EFCI = 1 to FECN mapping was performed by the IWF in the BISDN to FR direction).

(O) 10-3 A mechanism may be needed to exit the congestion state dependent on the traffic activity of the ATM virtual channels. As an example (Figure 10.10), a timer can be used to reset the congestion state (condition 2 above) after a time period T if no new congestion information is received in the BISDN to Frame Relay (FR) direction. If the EFCI of the last cell of the next frame received is not set, the congestion state is cleared. Otherwise, the timer is restarted. The value of the FECN received in the FR-SSCS-PDU is not mapped to the BECN of the FR-SSCS-PDU in the opposite direction.

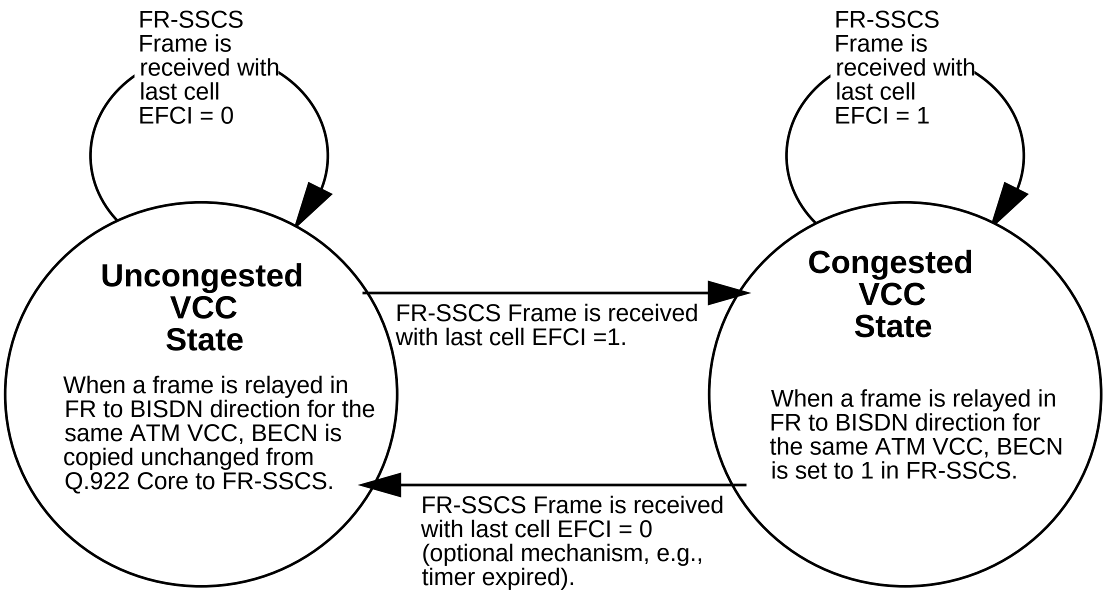
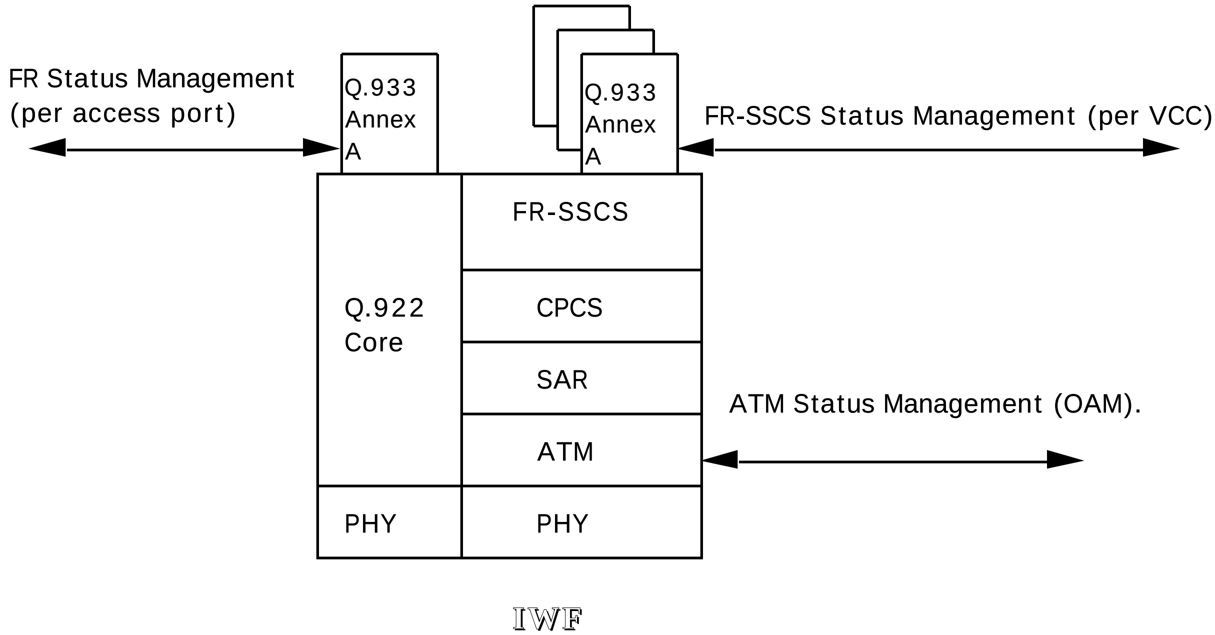


Figure 10.10 Congestion State Diagram for VCC

10.2.2.6 FR PVC Status Management

The management of the ATM layer and the FR PVC Status Management of the FR-SSCS layer can operate independently. Possible interaction between the FR PVC Status Management and the ATM PVC management are for further study. Each layer has its own responsibility for the layer management (e.g., some functions of the management in the ATM layer will be performed by usage of the OAM cell flows).

The management of FR PVCs for FR UNI and FR NNI will remain unchanged. The PVC management procedures described here only covers the management of the FR PVCs carried by the ATM network (i.e., FR-SSCS management). The protocol stacks of the IWF and the FRS supporting B-CPE with status management are shown in Figure 10.11.



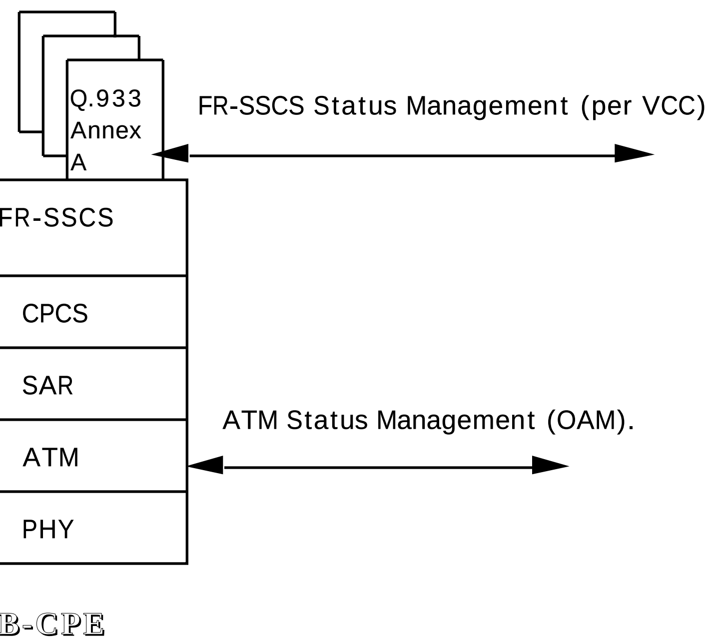


Figure 10.11 Protocol Stacks of IWF and B-CPE With FR PVC Status Management

(R) 10-11 The management of the FR-SSCS layer shall be performed by bi-directional (symmetric) PVC management procedures adopted from the CCITT Recommendation Q.933 Annex A. Selection of specific options within the Q.933 Annex A shall be aligned with the FR Forum Implementation Agreement.

Note: This applies for the B-CPE emulating FR (Figure 10.1). This allows all six connection possibilities of Figure 10.1, including the A3 to B3 Case.

For FR PVC Status Management of FR connection(s) carried by an ATM VCC, DLCI = 0 is used to exchange PVC status management between IWF(s) and/or B-CPE emulating FR.

(R) 10-12 The PVC status from the ATM layer shall be used by the FR-SSCS layer when determining the status of the FR PVCs.

In the case of one-to-one connection multiplexing, the procedures described in ITU-T Recommendation Q.933 Annex A apply as follows:

(1) N391 default is set to 1. Link Integrity Verification of ATM VCC is provided by ATM OAM F5 flow. The ATM VCC status obtained by OAM F5 flow is conveyed to Q.933 Annex A entity.
(2) T391 and T392 timers default value is set to 180 and 200 seconds respectively.

The use of the Frame Relay asynchronous message as specified in Q.933 Annex A procedures is recommended.

10.3 FRS Traffic Management and Network Performance

This section provides FRS specific traffic management functions and network performance considerations that are required for a B-ICI.

10.3.1 Traffic Management

Traffic management impacts for FRS at a B-ICI are considered here. These are the additional information (beyond that required for the carrier-to-carrier traffic contract at a B-ICI) that can increase the efficiency of a carrier's CAC function, and the preservation of Frame Relay's Forward Error Congestion Notification (FECN), Backward Error Congestion Notification (BECN) and Discard Eligibility (DE) functions' integrity across a B-ICI.

A carrier's CAC function and its engineering of its network portion can generally by facilitated by the availability of additional information beyond that required for the carrier-to-carrier traffic contract at a B-ICI. Additional information that may — subject to bilateral agreement — be exchanged for a VCC carrying FRS are: FRS subscriber's Committed Information Rate (CIR), Excess Information Rate (EIR), Committed Burst Length (CBL) and Excess Burst Length (EBL)[40]. The Peak Cell Rate (PCR) and Sustained Cell Rate (SCR) associated with a FRS subscriber are also included with such additional information.

It is important to preserve the integrity of the FECN, BECN and DE functions associated with FRS when that service is supported across a B-ICI. Congestion conditions in an ATM network segment generally cause the ATM layer EFCI code points to be set, and these EFCI code points require translation to the FRS layer FECN and BECN bits that are available to end users of FRS.

In the many-to-one scheme of multiplexing, a VCC may carry a large number of frame relay connections. In the one-to-one scheme of multiplexing, a VPC may carry a large number of VCCs carrying frame relay traffic.

When the number of frame relay connections carried on a single ATM connection is large, the aggregated frame relay traffic may be characterized by a peak cell rate. When the number of multiplexed connections is small, then the traffic at the ATM layer may need to be characterized by the traffic at the FRS layer alone.

Some initial guidelines for the inter-carrier FRS traffic characterization and enforcement including the relationship between Frame Relay's CIR/EIR and BISDN's PCR/SCR are provided in the Appendix A. Examples of ATM traffic conformance definitions to support FRS can be found in the 1993 ATM Forum UNI Specification[19].

10.3.2 Network Performance

Network performance parameters for Frame Relay have been defined[45]. These parameters are generally based on FRS "Frame" protocol data unit. No additional FRS specific performance considerations are included in this Version of the B-ICI Specification.

10.4 FRS Operations and Maintenance

This section provides the AAL Type 5 operations above the ATM layer. Operations for layers above the AAL are not discussed in this Version. Section 10.4.1 discusses operations for the common part of the AAL Type 5, and Section 10.4.2 discusses operations for the service specific part of the AAL Type 5.

10.4.1 Operations for Common Part of the AAL Type 5

This section specifies performance measurements needed to monitor errors for the common part of the AAL Type 5. Figure 10.12 shows the format of the common part of the AAL Type 5 PDU (I.363). In this Figure, the CPCS-UU is the Common Part Convergence Sublayer - User-to-User indication field. It is used to transfer user-to-user information, and so is not monitored by the network.

CPCS-PDU (Multiple of 48 Bytes)

	User Data	PAD	CPCS-UU	Common Part Indicator	Length	CRC
Bytes	0-65535	0-47	1	1	2	4

Figure 10.12 Format of the Common Part of the AAL Type 5 PDU (I.363)

The following error conditions may occur at the receiving point:

- Invalid format of Common Part Indicator (CPI) field. The only valid value currently defined for the CPI field is all 0s.

- Length violation. An error occurs when the Length, which is measured in bytes, is not consistent with the length of the CPCS-PDU. If the length of the CPCS-PDU in bytes minus the value of the Length field is not in the range [8-55], the two are not consistent. One exception is when the Length field has a value of 0, which is an indication of a forward abort. This case shall not be counted as a length violation.

- Oversized Received Service Data Unit (SDU): This error condition occurs if a partial or whole CPCS-PDU is received in which the SDU (i.e., User Data) exceeds the maximum allowed length.

- CRC violation.

- If the receiving entity implements a reassembly timer (which is optional, as specified in I.363), then the number of timer expirations shall be counted.

(R) 10-13 Network equipment at a B-ICI terminating the AAL Type 5 Common Part shall count the occurrences of the listed errors at the receiving point.

At the receiving endpoint where the AAL Type 5 is processed, the discard of cells due to buffer overflow impairs the ability to reconstruct AAL Type 5 PDUs.

(R) 10-13a Network equipment at a B-ICI terminating the AAL Type 5 Common Part shall count occurrences of cell buffer overflow.

One example of an occurrence of cell buffer overflow is overflow of a single cell. However, if this is too complex, a count of "congestion events" as defined for a specific equipment implementation may be adequate as an indication that a performance problem exists.

A typical value for a measurement interval could be 15 minutes, and at least 8 hours of history should be kept. The measurement interval and amount of history data will be established by bilateral agreements between the carriers.

10.4.2 Operations for FRS Specific Part of the AAL Type 5

Operations for FRS specific part of the AAL Type 5 will be provided in future Versions of this document.

11. SMDS Support on a B-ICI

Switched Multi-megabit Data Service[22] (SMDS) is one of the inter-carrier services supported by a multi-service B-ICI. This section provides the definition, service specific functions (U-Plane), traffic management and network performance, and operations for supporting the inter-carrier) SMDS on a B-ICI.

11.1 Definition

SMDS is a public packet-switched service that provides for the transfer of variable length data units at high speeds, without the need for call establishment procedures. These data units can be transferred from a single source to single destination (single cast), or from a single source to multiple destinations (multicast). The integrity of each delivered data unit is preserved with a high degree of reliability. SMDS is specified such that, under normal conditions, end users' end-to-end protocols and applications easily ride on top of the SMDS service layer. This provides the capability of supporting user applications such as LAN interconnection, and data and image transfer. Customers access the SMDS over either a service specific customer interface, i.e., the SMDS Subscriber Network Interface (SNI), or an ATM UNI supporting SMDS[63]. The carrier network provides an interworking function for the necessary encapsulation as detailed later in this section.

The definitions[49] (Figure 11.1) of Exchange SMDS, Exchange Access SMDS, and Inter-Exchange SMDS follow:

- Exchange SMDS: Refers to the end-users in the same exchange serving area communicating using SMDS. A LEC offers the service to the end-users via a SNI or an ATM UNI supporting SMDS.
- Exchange Access SMDS: An access service provided by a LEC to an IEC to support the IEC's inter-exchange service offering. The IEC uses Exchange Access SMDS to originate and/or terminate the delivery of SMDS data units of the end users served directly by the LEC network.
- Inter-Exchange SMDS: Refers to end-users located in different exchange serving areas communicating using SMDS. An IEC offers the service to the end-user. In some jurisdictions, carriers may also offer inter-exchange service within an exchange serving area, if the source explicitly chooses the service of the IEC.

Because SMDS is a public switched service, LECs are expected to offer Exchange SMDS to the end users and Exchange Access SMDS to the IECs to support IECs' inter-exchange SMDS offerings. LECs within an exchange serving area may also establish serving arrangements that define the way the LECs support the exchange and exchange access service each offers. Likewise, IECs also may make serving arrangements with one another to support their inter-exchange services.

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[22] Within the European context, the connectionless data service, called Connectionless Broadband Data Service (CBDS), is specified in [ETSI ETS 300 217 CBDS], and includes SMDS as a subset. The considerations for the support of SMDS are applicable to the CBDS as well.

11.1.1 Exchange SMDS

Exchange SMDS consists of the following features[50]:

- Carrier Selection[23] ;
- Individually Addressed Data Unit Transport;
- Local Communications for Multi-CPE Access Arrangements;
- Addresses;
- Source Address Validation;
- Group Addressed SMDS Data Unit Transport;
- Address Screening;
- Access Classes; and
- Multiple Data Units in Transit Concurrently (over the SNI or over the ATM UNI supporting SMDS).

In addition, the performance and QOS objectives defined in[50] apply to Exchange SMDS.

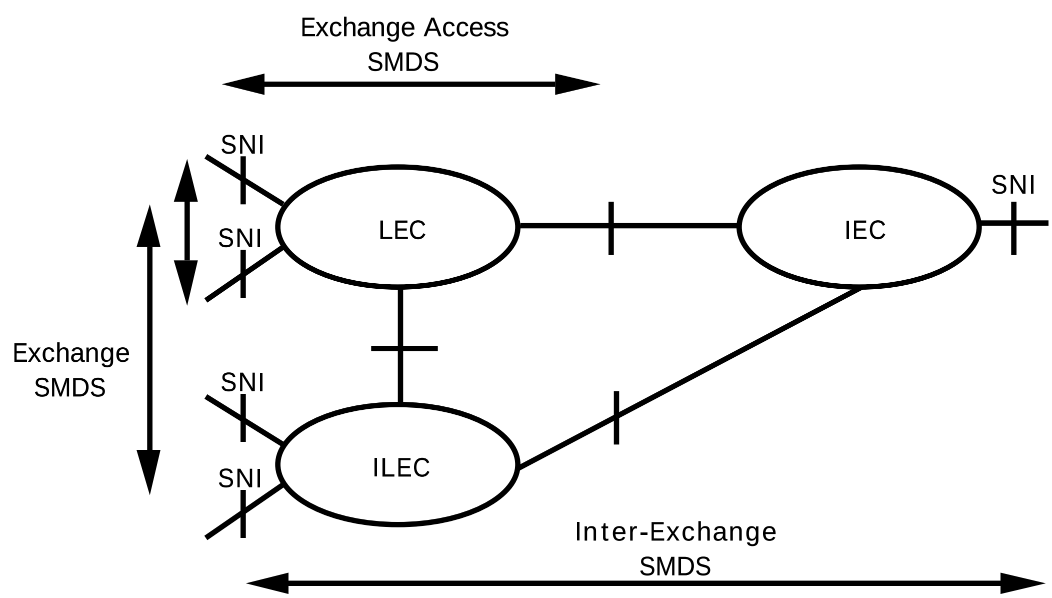


Figure 11.1 Exchange SMDS, Exchange Access SMDS, and Inter-Exchange SMDS Definitions

[23] The Carrier Selection feature defines how a carrier (serving the source) decides whether to provide Exchange SMDS or Exchange Access SMDS when an end user sends a data unit.

11.1.2 Exchange Access SMDS

The source end user is the customer of the IEC for inter-exchange service; the IEC is the customer of the LEC for Exchange Access SMDS. The same SNI or ATM UNI supporting SMDS is used for Exchange and Exchange Access SMDS. The features of Exchange Access SMDS[49] include:

- Individually Addressed Data Unit Transport;
- Addresses (including addresses that identify geographical parts of North America, international addresses, and addresses structured as embodied Service Access Codes (SACs) and External SACs);
- Carrier Selection[24] (by pre-selection and explicit selection);
- Source Address Validation;
- Group-Addressed Data Unit Transport (inter-network aspects);
- End-User Blocking[25];
- Routing to IEC Networks; and
- Other features at the SNI or ATM UNI supporting SMDS (i.e., Access Classes, Address Screening, and Multiple Data Units in Transit Concurrently).

In addition, the performance and quality of service objectives, and usage measurements to support billing for the Exchange Access SMDS defined in[49] apply.

To expedite the availability, Exchange Access SMDS features are phased in[51]. The first phase comprises all features of the Exchange Access SMDS except the following, which are considered as part of the Phase 2 deployment:

- Address feature related to External SACs;
- Carrier Selection feature related to explicit carrier selection;
- Group-Addressed Data Unit Transport feature related to the (local) resolution option[49];
- End-User Blocking.

The B-ICI defined in this document supports Phase 1 of the Exchange Access SMDS. To ensure compatibility, the B-ICI supports the Phase 2 features to the extent possible.

[24] The feature, Carrier Selection, is not yet defined for an international environment.

[25] The feature, End User Blocking, is defined for the US environment. ETSI has not defined this feature yet for the European environment.

11.1.3 Inter-Carrier Serving Arrangements for SMDS

In many exchange serving areas, several carriers can provide telecommunications services. Each carrier may offer services separately to its customers. To provide SMDS, the carriers in an exchange serving area may choose to interoperate. To do so, the carriers establish serving arrangements that define locally the way in which the companies support the services that each offers.

For example, to provide Exchange SMDS to its customer, a LEC that serves the source end user may arrange to use the facilities of another LEC to reach those destinations that the latter LEC serves. The IECs may also make SMDS serving arrangements with one another that define the way in which the IECs support the inter-exchange services that each offers.

11.1.4 Support of SMDS in the European Environment

In the European environment, there is no hierarchy of local carrier networks such as LECs and long distance carrier networks such as IECs in the U.S.A. In Europe, Public Telecommunication Operator (PTO) networks behave much more like peer networks, and Public Telecommunication Operator Domains (PTODs) may cover either an entire country or sometimes only part of a country. In some countries, PTOs may compete; in other countries, PTOs operate as a monopoly. A European PTO may offer the following four services, depending on the source and destination of a particular SMDS packet (Figure 11.1a):

- Intra-network SMDS, which is analogous to Exchange SMDS in the U.S.A., when only one PTO is involved.
- Originating intra-network SMDS, which delivers SMDS packets from a directly attached SNI/UNI to a B-ICI connecting to another PTO network.
- Terminating intra-network SMDS, which delivers SMDS packets from a B-ICI connected to another PTO network to an SNI/UNI that is directly attached.
- Transit intra-network SMDS, which delivers SMDS packets from a B-ICI connected to one PTO network to a B-ICI connected to another PTO network.

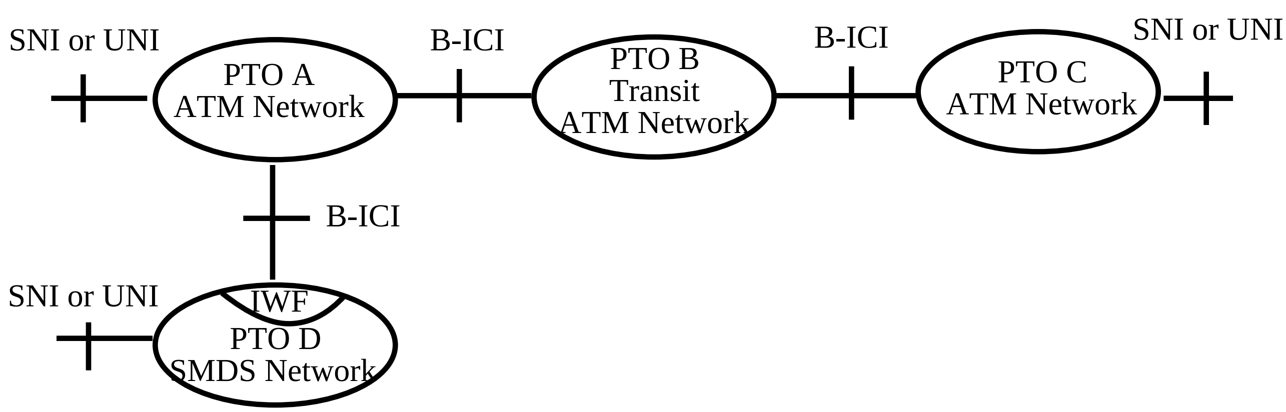


Figure 11.1a Generic Network Model for the European Environment

In the European environment, there may be several paths, through different PTO networks, joining any two end customers. Each of the PTO networks in that path must have sufficient information to decide which is the appropriate PTO network to which send the data unit. This routing information may be arrived at by a number of mechanism, for example:

- Mutual agreement among all PTOs;
- Bilateral agreement among adjacent PTOs; or
- An explicit route selection indicated by the originator of the SMDS data unit.

For the European environment, the inter-network SMDS provides the following features[64]:

- Carrier Selection;
- Individually Addressed Data Unit Transport;
- Addresses;
- Source Address Validation
- Group Addressed SMDS Data Unit Transport;
- Address Screening;
- Access Classes;
- Routing to PTO; and
- Multiple Data Units in Transit Concurrently (Over the SNI/UNI).

The support of SMDS at the B-ICI in European environment, as specified by the applicable requirements in Section 11.2, is compliant to ITU-T Recommendations I.363 and I.364, and ETSI Standards prETS-300478[66] and prETS-300479[67].

11.2 SMDS Specific Functions

This section provides the SMDS specific functions (U-Plane), for example, network interworking, ATM Adaptation Layer (AAL), and the connectionless service layer.

To support SMDS, a carrier may provide processing at several different levels. These levels range from point-to-point traffic transport between carriers to full processing and routing of SMDS packets (e.g., Inter Carrier Interface Protocol Connectionless Service (ICIP_CLS) Protocol Data Units (PDUs)) based on their packet level addresses. The requirements in this document support configurations where each carrier provides full SMDS processing. Additionally, these requirements may support some configurations where not all carriers provide full SMDS processing; however, such configurations require further study.

11.2.1 SMDS/ATM Network Interworking Functions

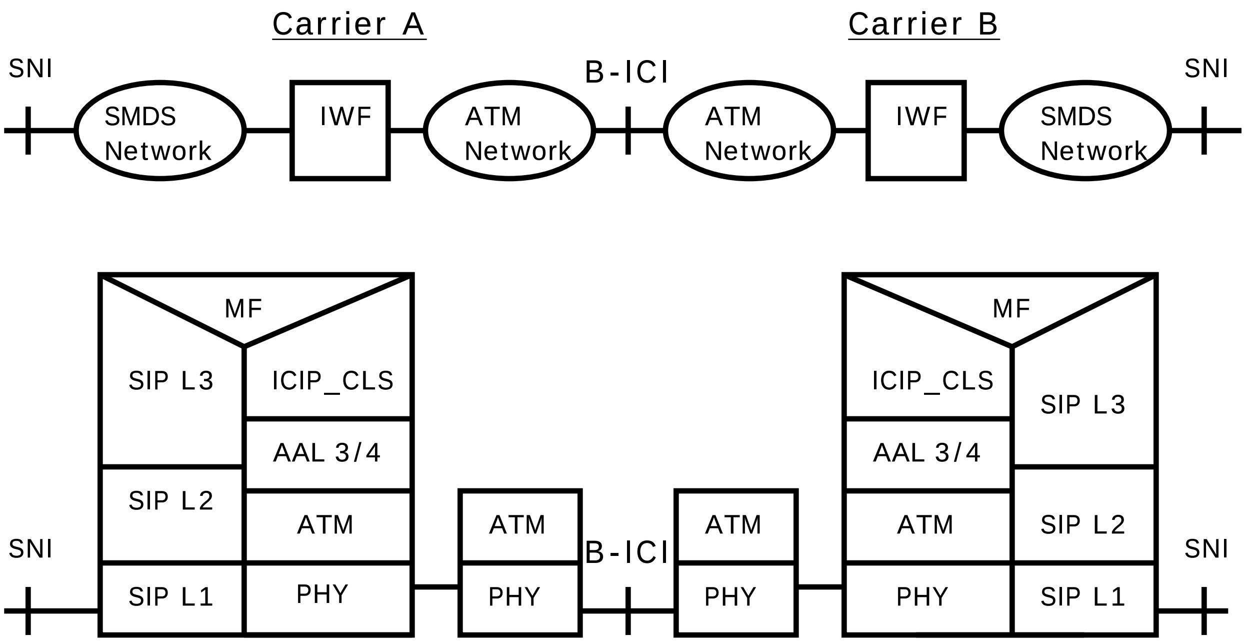
This section describes B-ICI related SMDS/ATM network interworking. In the case of SMDS, when a non-ATM user is connected to a Carrier A's ATM network, this Carrier performs some SMDS/ATM network Inter-Working Functions (IWF) as part of the inter-carrier service before it connects to another Carrier B's ATM network via a B-ICI. The SMDS/ATM network interworking functions that are likely to be performed by the originating Carrier A's network, as part of the processing before delivering to the destination Carrier B's network, include the following:

1. For end user SMDS access over an SNI, the IEEE 802.6-based SIP is mapped to the ATM-based B-ICI protocols. This includes encapsulation of the SIP L3_PDU within an ICIP_CLS_PDU. A similar ICIP_CLS_PDU encapsulation takes place when the end user accesses SMDS over an ATM UNI supporting SMDS. The CCITT AAL Type 3/4 is used to support the transport of an ICIP_CLS_PDU within ATM cells.

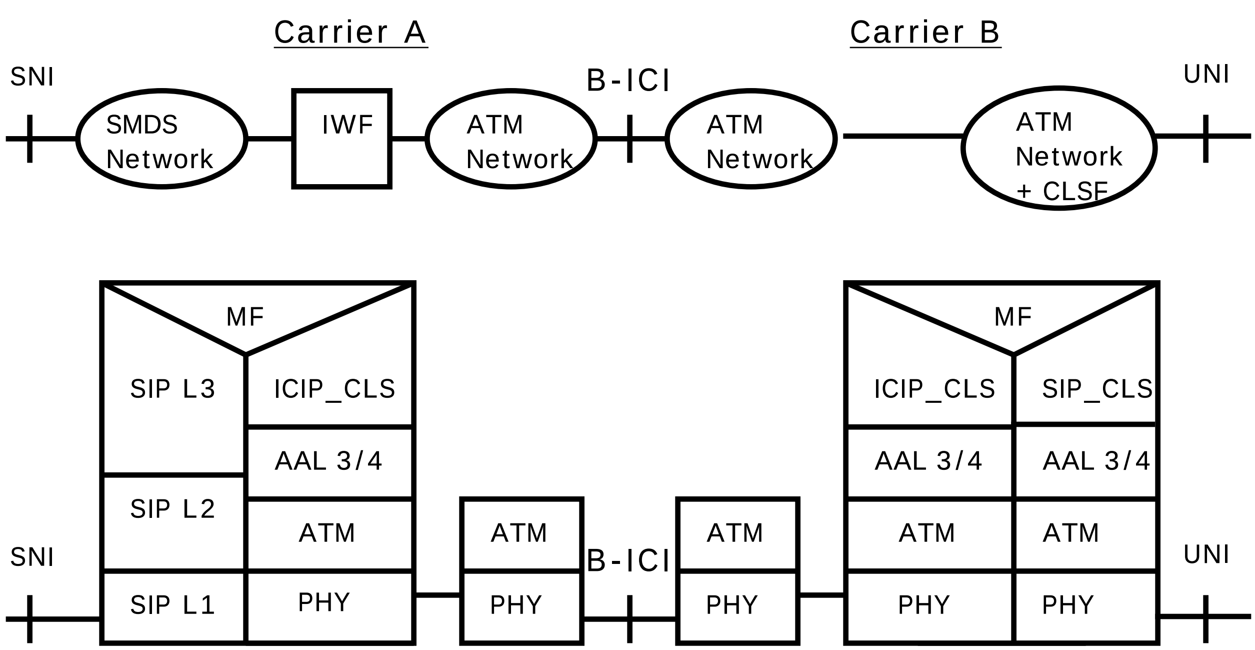
2. Mapping Functions (MF) include routing, carrier selection, group address resolution, etc.

3. Mapping of SMDS related QOS and performance parameters to ATM related QOS Class and network performance parameters are addressed in a later section.

The protocol architecture in Figure 11.2 illustrates the role of SMDS/ATM network interworking functions in supporting an end-to-end inter-carrier SMDS service using a B-ICI.



(a) Interconnection of Two SMDS Networks



(b) Interconnection of SMDS Network and ATM Network Supporting SMDS

Figure 11.2 An Example of SMDS/ATM Network Interworking Functions

11.2.2 AAL Specification

This section describes the AAL to support SMDS on the multi-service B-ICI. The AAL performs the functions necessary to adapt the ATM Layer service to the service provided by the SMDS specific layer above the AAL, called the ICIP Connectionless Service (ICIP_CLS) Layer for the B-ICI.

The AAL defined in this section is based on the AAL Type 3/4 specification in CCITT Recommendation I.363[52]. The criteria in this section represent a specific configuration of the more generic AAL Type 3/4 defined in [52]. This configuration facilitates interoperability with the pre-ATM SMDS. This section defines the mapping of the protocol layer functions in [52] into interface criteria that may be easily verified.

As in reference[52], the AAL is divided into two sublayers: the Segmentation and Reassembly (SAR) Sublayer, and the Common Part Convergence Sublayer (CPCS). This section defines the formats and procedures for the SAR Sublayer and the CPCS. The SAR sublayer and CPCS criteria apply to a single ATM layer connection (e.g., VCC) between the AAL entities.

Protocol Conventions:

The following conventions[26] are followed for the presentation of the AAL protocols:

- A protocol data unit (PDU) is a unit of data that is exchanged between peer entities within a particular layer. For example, peer Common Part Convergence Sublayer (CPCS) entities exchange CPCS_PDUs.
- In the specification of PDU formats, fields are depicted in the order of their transmission (i.e., from left to right). Likewise, the bits of each field are also transmitted left-to-right, with the leftmost, or most-significant bit, transmitted first (see Figure 11.3). When decimal digits are used to represent the value of a field, the most significant bit of the binary representation of the digit is transmitted first.

11.2.2.1 SAR_PDU Format

The format of the SAR_PDU is shown in Figure 11.4 (I.363), along with the lengths of the fields. SAR_PDUs are created by adding a 2-octet SAR_PDU header and a 2-octet SAR_PDU trailer to each 44-octet unit of SAR_PDU payload. Units of SAR_PDU payload result from the segmentation of the variable-length CPCS_PDU. The requirements for the meaning and use of each field of the SAR_PDU are stated below.

(R) 11-1 The SAR_PDU shall have the format shown in Figure 11.4 (I.363).

[26] The conventions for the presentation of the B-ICI Physical Layer specification (Section 3) differ from those presented here which applies to ATM Layer (Section 4) and ATM Adaptation Layer.

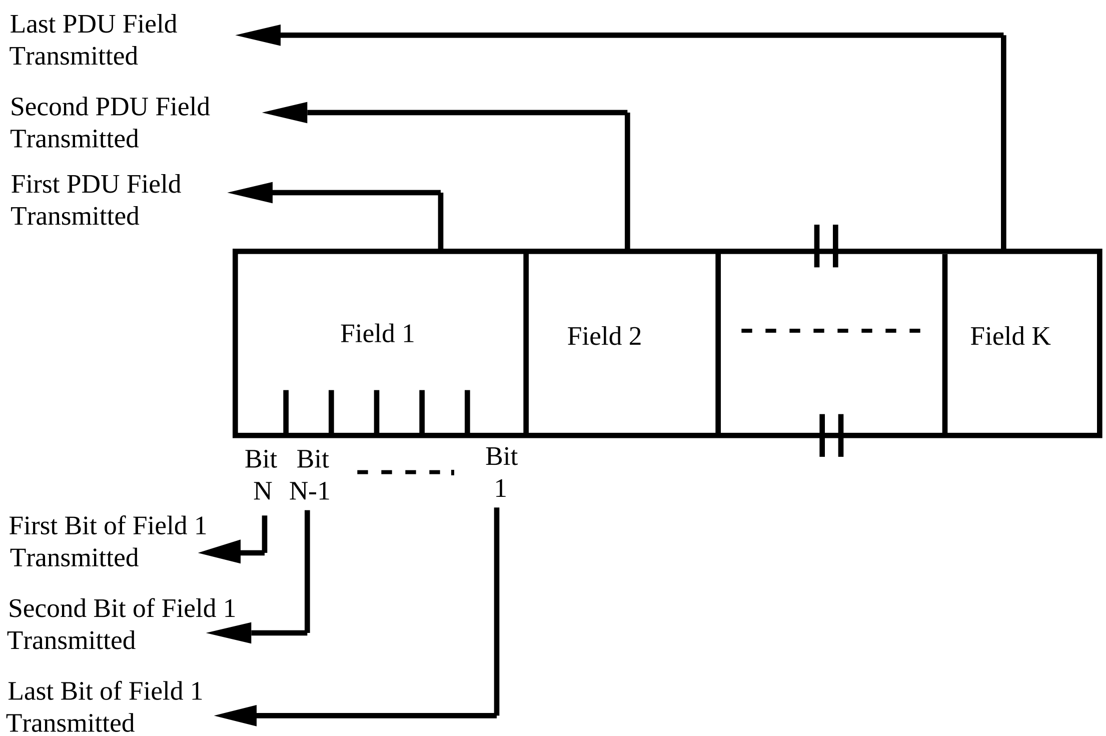


Figure 11.3 Conventions for Specification of PDU Formats

HEADER			SAR_PDU Payload		TRAILER	
ST	SN	MID	User Information	Fill	LI	CRC
2 bits	4 bits	10 bits	44 octets		6 bits	10 bits

ST = Segment Type
SN = Sequence Number
MID = Message IDentifier
LI = Length Indication
CRC = Cyclic Redundancy Check

Figure 11.4 SAR_PDU Format (I.363)

<u>(1) Segment Type (ST)</u>

(R) 11-2 The 2-bit Segment Type field shall be used to delimit CPCS_PDUs. The Segment Type field shall indicate whether the SAR_PDU contains the beginning of a CPCS_PDU (a Beginning of Message SAR_PDU); the continuation of a CPCS_PDU (a Continuation of Message SAR_PDU); the end of a CPCS_PDU (an End of Message SAR_PDU); or fully contains a CPCS_PDU (a Single Segment Message SAR_PDU). The field shall be encoded as in Table 11.1 (I.363)[27].

Table 11.1 Segment Type Values (I.363)

Value	Meaning
00	Continuation of Message (COM)
01	End of Message (EOM)
10	Beginning of Message (BOM)
11	Single Segment Message (SSM)

(2) Sequence Number (SN)

(R) 11-3 The 4-bit Sequence Number field shall be used by the AAL entity in receiving a CPCS_PDU to verify that all of the SAR_PDUs of the CPCS_PDU have been received and concatenated in the correct sequence. The value of this field is incremented (modulo 16) for each successive SAR_PDU derived from the same CPCS_PDU.

(3) Multiplexing Identification (MID)

(R) 11-4 The 10-bit MID field shall contain information used to allow association of SAR_PDUs with a CPCS_PDU. The MID shall be the same for all SAR_PDUs of a given CPCS_PDU, and unique among CPCS_PDUs concurrently in transit in a given direction. Valid MIDs shall range from 1 to 1023. MID = 0 shall not be used.

The MID range is configured in this way to facilitate the transition from IEEE 802.6 to ATM. In the North American environment, the value MID = 0 is excluded because it is a special value that may be treated differently by IEEE 802.6-based equipment and CCITT-compliant equipment[28].

[27] SSMs can never be generated at the B-ICI, because the header information at the CPCS and the ICIP_CLS Layer consumes an entire cell. However, the specification supports procedures for SSMs to be compatible with more general AAL implementations.

[28] IEEE 802.6-based equipment reserves MID = 0 for SSMs, which are never generated at the SMDS ICI. ITU/CCITT- compliant equipment uses MID = 0 too when it supports multiplexing of multiple CPCS_PDUs on a single ATM layer connection, however, SMDS requires implementations that use multiplexing.

(R) 11-4a In the European environment, (R) 11-4 shall apply with the valid MIDs range from 0 to 1023.

(4) SAR-PDU Payload

(R) 11-5 The 44-octet SAR_PDU Payload shall contain a portion of the CPCS_PDU. This field shall be composed of two subfields:

- User Information — This subfield shall contain up to 44 octets of a CPCS_PDU.
- Fill — This subfield shall contain a sufficient number of octets to completely fill the 44-octet SAR_PDU Payload after the User Information subfield is inserted. The Fill subfield shall be encoded with all zeros.

(5) Length Indication (LI)

(R) 11-6 The 6-bit LI field shall indicate how many of the 44 octets of the SAR_PDU Payload contain User Information (i.e., a portion of a CPCS_PDU). For BOM and COM SAR_PDUs, this field shall indicate 44 octets. For EOM SAR_PDUs, this field shall take values 4, 8,.......44 octets. For SSM SAR_PDUs, this field shall take values 8, 12,......44 octets.

(O) 11-1 The LI field value 63 should be used to indicate an Abort_SAR_PDU[52]. The Segment Type of an Abort_SAR_PDU should be encoded as EOM.

(6) Cyclic Redundancy Check (CRC)

(R) 11-7 The 10-bit CRC shall provide for the detection of errors in the SAR_PDU. The value of the CRC field shall be formed by the coefficients of the polynomial remainder of the modulo 2 division by the generating polynomial $x^{10}+x^9-x^5+x^4+x+1$ of the product of x^{10} and the polynomial representing the content of the SAR_PDU. The polynomial representing the content of the SAR_PDU shall be generated by using the first bit of the SAR_PDU as the coefficient of the highest-order term.

11.2.2.2 SAR Sublayer Procedures

11.2.2.2.1 SAR Sender Procedures

Segmentation of the CPCS-PDU

(R) 11-8 A SAR sender shall segment each CPCS_PDU created into one or more units of SAR_PDU payload. Each unit of SAR_PDU payload shall contain 44 octets of the CPCS_PDU, with the exception of the last unit of SAR_PDU payload for a CPCS_PDU, which may contain less than 44 octets of the CPCS_PDU. The order of octets in the CPCS_PDU shall be preserved by the segmentation.

Creation of the SAR-PDUs

(R) 11-9 Upon segmentation of a CPCS_PDU, a SAR sender shall create a SAR_PDU for each unit of SAR_PDU payload created. The type of SAR_PDU created is determined as follows:

- **CPCS_PDU of one unit of SAR_PDU payload:** If the length of the CPCS_PDU is less than or equal to 44 octets, then only one unit of SAR_PDU payload shall be generated, containing the entire CPCS_PDU. The associated SAR_PDU shall be an SSM.

- **CPCS_PDU of two or more units of SAR_PDU payload:** If the length of the CPCS_PDU is greater than 44 octets, then more than one unit of SAR_PDU payload shall be generated. The SAR_PDU associated with the first unit of SAR_PDU payload shall be a BOM. The SAR_PDUs associated with all of the other units of SAR_PDU payload, except the last, shall be COMs. The SAR_PDU associated with the last unit of SAR_PDU payload of the CPCS_PDU shall be an EOM.

(R) 11-10 Each field in a SAR_PDU shall be populated as described in Section — "SAR_PDU Format".

(R) 11-11 A SAR sender shall maintain a Transmit Sequence Number (TxSN) counter for each MID it uses. Prior to transmitting a BOM, the TxSN counter shall have an initial value in the range 0 to 15. For each BOM, COM and EOM SAR_PDU of a CPCS_PDU transmitted, the SAR sender shall insert in the Sequence Number field the value of the TxSN counter associated with the MID. After setting the Sequence Number field of a BOM or a COM SAR_PDU, the SAR sender shall increment the value of the TxSN counter by one (modulo 16) for use with the next SAR_PDU associated with the same MID.

The TxSN counter associated with a particular MID is not required to be maintained between CPCS_PDUs with that MID. For example, implementations where each BOM SAR_PDU has a Sequence Number field value of 0 are allowed.

(R) 11-12 The SAR sender shall transfer each created SAR_PDU to the ATM layer entity, which shall perform the appropriate "ATM Layer Functions Involved at the B-ICI" defined in Section 4.

The inter-layer transaction in the above Requirement may be modeled by the transfer of an ATM-DATA.request primitive from the SAR entity to the ATM layer entity, with the parameters of the ATM-DATA.request set as follows:

- ATM-SDU contains the SAR_PDUs
- SDU-Type is set to 0
- Congestion Experienced is set to False

The setting of the Loss Priority is for further study.

(R) 11-13 A SAR sender shall support the transfer of a maximum of 1023 CPCS_PDUs in transit concurrently.

(R) 11-13a In the European environment, a SAR sender shall support the transfer of a maximum of 1024 CPCS_PDUs in transit concurrently.

11.2.2.2.2 SAR Receiver Procedures

Receiving a SAR-PDU

(R) 11-14 Upon receipt of a SAR_PDU, the SAR receiver shall check that:

- the SAR_PDU CRC is valid; and
- the value in the MID field is in the range [1,1023][29].

If either of these checks fails, the SAR_PDU shall be discarded. If the SAR_PDU passes both checks, the SAR receiver shall forward the SAR_PDU to the Receiver State Machine (RSM) associated with the MID value contained in the SAR_PDU header. In this case, the SAR receiver shall implement the functional equivalent of the Requirements defined for the — "SAR Receive Process".

(R) 11-14a In the European environment, (R) 11-14 shall apply with the MID field range [0, 1023].

(R) 11-15 A SAR receiver shall support 1023 concurrent active RSMs (one per MID).

(R) 11-15a In the European environment, a SAR receiver shall support 1024 concurrent active RSMs (one per MID).

SAR Receive Process

Figure 11.5 (I.363) shows the RSM for a particular MID, X. Only SAR_PDUs with MID = X that pass the appropriate checks are passed to this state machine. In the notes in Figure 11.5, "Process SAR_PDU" refers to CPCS processing, ICIP_CLS Layer processing, ICIP User processing, and service feature processing. This processing can be characterized as either pipelining or reassembly. In the case of reassembly, SAR_PDU processing will include storing the payload of the SAR_PDU until the entire CPCS_PDU is completely received. Pipelining has no such storage requirements, and SAR_PDUs may be forwarded before the entire CPCS_PDU is completely received.

(R) 11-16 If a SAR_PDU is received with Segment Type = BOM and MID = X, the SAR_PDU shall be processed as follows:

1. If the RSM for MID = X is in the REASS state, any partially received CPCS_PDU for the associated receive process shall be considered to be unusable.

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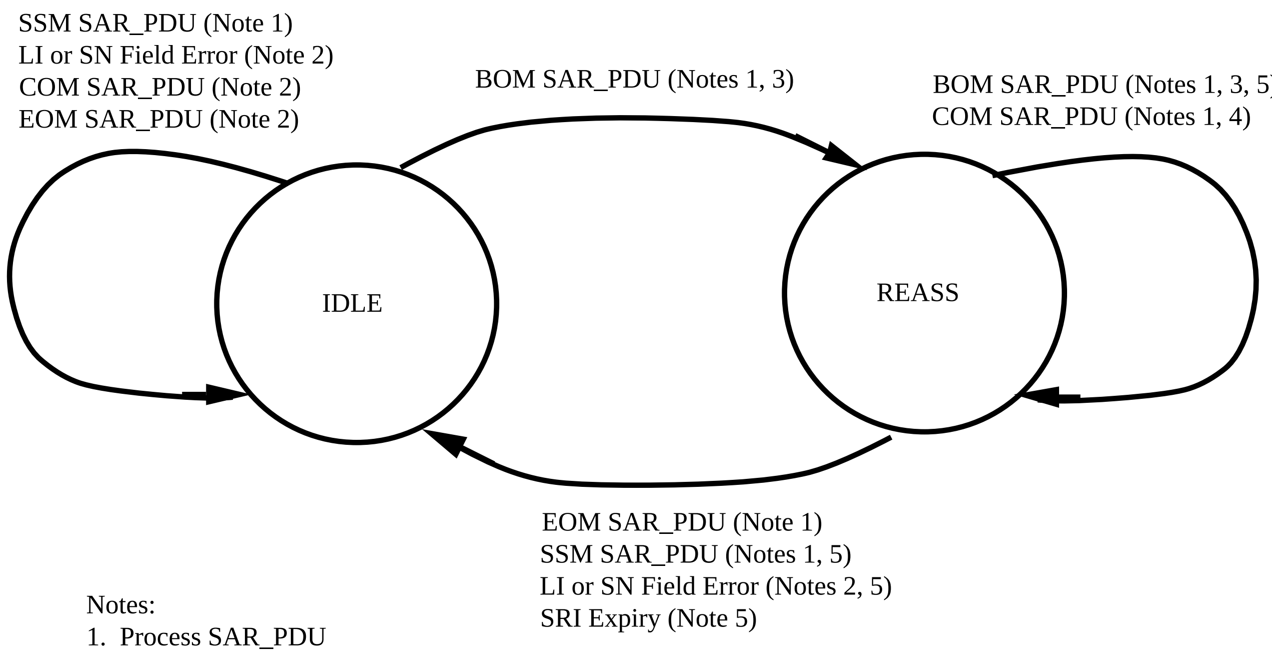
29 This check enforces the MID configuration defined earlier.

2. The receive process is started for the new BOM. The RSM for MID = X shall be in the REASS state. The SAR receiver shall begin measuring the time elapsed while the process is in the REASS state.

3. If the value of the LI field in the BOM SAR_PDU is different than 44, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall return to the IDLE state. Otherwise, the SAR receiver shall continue with step 4.

4. The SAR receiver shall establish a Receive Sequence Number (RxSN) counter, associated with MID = X. The SAR receiver shall initialize the value of the RxSN counter to the value of the Sequence Number field of the BOM SAR_PDU plus one (modulo 16).



Notes:
1. Process SAR_PDU
2. Discard SAR_PDU
3. Set RxSN, Start meansurement of elapsed time
4. Increment RxSN
5. Do not deliver CPCS_PDU associated with previous SAR_PDUs

Figure 11.5 Instance of SAR Receiver State Machine for MID-X (I.363)

(R) 11-17 If a SAR_PDU is received with Segment Type = COM and MID = X, the SAR_PDU shall be processed as follows:

1. If the RSM for MID = X is in the IDLE state, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall remain in the IDLE state.

2. If the value of the LI field in the COM SAR_PDU is different than 44, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU

shall be discarded, and the RSM for MID = X shall return to the IDLE state. Any partially received CPCS_PDU for the associated receive process shall be considered to be unusable. Otherwise, the SAR receiver shall continue with step 3.

3. If the value of the Sequence Number field of the COM SAR_PDU is different from the expected value contained in the RxSN counter for MID = X, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall return to the IDLE state. Any partially received CPCS_PDU for the associated receive process shall be considered to be unusable. If the value of the Sequence Number field of the COM SAR_PDU is equal to the expected value contained in the RxSN counter for MID = X, the SAR receiver shall increment the value of the RxSN counter by one (modulo 16).

(R) 11-18 If a SAR_PDU is received with Segment Type = EOM and MID = X, the SAR_PDU shall be processed as follows:

1. If the RSM for MID = X is in the IDLE state, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall remain in the IDLE state.

2. If the value of the LI field in the EOM SAR_PDU is less than 4 or greater than 44, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall return to the IDLE state. Any partially received CPCS_PDU for the associated receive process shall be considered to be unusable. Otherwise, the SAR receiver shall continue with step 3.

3. If the value of the Sequence Number field of the EOM SAR_PDU is different from the expected value contained in the RxSN counter for MID = X, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID = X shall return to the IDLE state. Any partially received CPCS_PDU for the associated receive process shall be considered to be unusable. If the value of the Sequence Number field of the EOM SAR_PDU is equal to the expected value contained in the RxSN counter for MID = X, the SAR receiver shall complete the SAR receive process, return the RSM for MID = X to the IDLE state, and deliver the CPCS_PDU to the CPCS receiver (see Section - "CPCS Receiver Procedures").

(R) 11-19 If a SAR_PDU is received with Segment Type = SSM and MID = X, the SAR_PDU shall be processed as follows:

1. If the RSM for MID = X is in the REASS state, any partially received CPCS_PDU for the associated receive process shall be considered to be unusable.

2. If the value of the LI field in the SSM SAR_PDU is less than 8 or greater than 44, the SAR receiver shall stop processing the SAR_PDU, the SAR_PDU shall be discarded, and the RSM for MID

= X shall return to the IDLE state. Otherwise, the SAR receiver shall continue with step 3.

3. The SAR receiver shall complete the SAR receive process, return the RSM for MID = X to the IDLE state, and deliver the CPCS_PDU to the CPCS receiver (see Section - "CPCS Receiver Procedures").

(R) 11-20 The maximum time that is allowed to elapse between the receipt of a BOM SAR_PDU and the corresponding EOM SAR_PDU shall be specified by the value of the parameter SAR Receive Interval (SRI). An active receive process shall be terminated (i.e., go to the IDLE state) if the elapsed time exceeds the SRI. The value of the SRI is for further study.

By measuring the elapsed time, the SAR receiver can guard against the SAR receive process running indefinitely (e.g., due to loss of the EOM).

(O) 11-2 A SAR receiver should terminate an active receive process if the SAR receiver determines, before the full CPCS_PDU associated with that receive process has been received, that the CPCS_PDU must not be delivered. Reasons that the SAR receiver may determine this include:

- CPCS_PDU or ICIP_CLS_PDU format validation performed prior to reception of the EOM determines that the data unit contains errors; or

- Feature processing, performed prior to the reception of the EOM, determines that the ICIP_CLS_PDU encapsulated within the CPCS_PDU must not be delivered.

11.2.2.3 CPCS_PDU Format

The format of the CPCS_PDU is shown in Figure 11.6 (I.363), along with the lengths of the fields. The CPCS_PDU is created by adding both a CPCS_PDU header and a CPCS_PDU trailer to a variable-length ICIP_CLS_PDU received from the ICIP_CLS Layer. The ICIP_CLS_PDU is the User Information subfield of the CPCS_PDU.

The requirements for the meaning and use of each field of the CPCS_PDU are stated below.

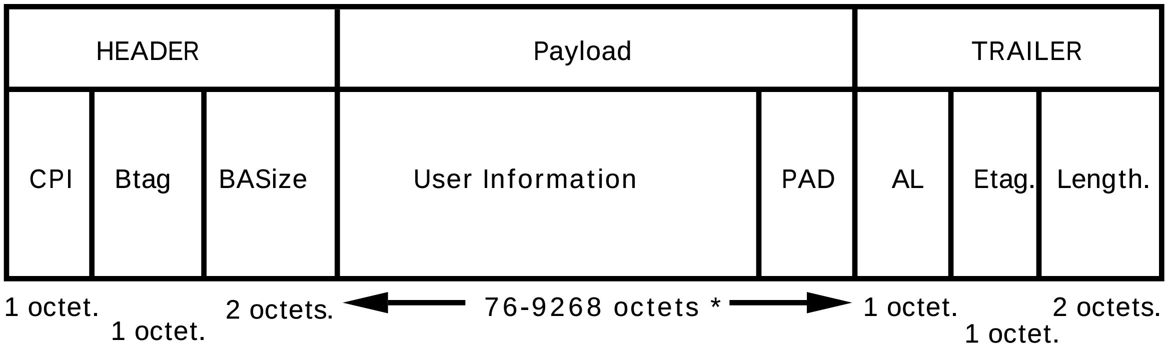
(R) 11-21 The CPCS_PDU shall have the format shown in Figure 11.6 (I.363).

<u>(1) Common Part Indicator (CPI)</u>

This 1-octet field is used to indicate the type of message contained in the CPCS_PDU and defines the counting unit for the values specified in the BASize and Length fields.

(R) 11-22 The 1-octet CPI field shall be encoded with all 0's.

A CPI value of all zeros indicates that the BASize and Length field values are encoded in octets.



CPI = Common Part Indication
Btag = Beginning Tag
BASize = Buffer Allocation Size
AL = Alignment
Etag = End Tag

* Dependent on the ICIP_CLS Layer

Figure 11.6 CPCS_PDU Format (I.363)

(2) Beginning Tag (Btag) and End Tag (Etag)

The 1-octet Btag field in the CPCS_PDU header is used in conjunction with the 1-octet Etag field in the CPCS_PDU trailer to form an association between the Beginning of Message (BOM) SAR_PDU and the End of Message (EOM) SAR_PDU derived from the same CPCS_PDU.

(R) 11-23 The 1-octet Btag field shall contain the same binary encoded value as the Etag field, ranging from 0 through 255.

(3) Buffer Allocation Size (BASize)

(R) 11-24 The 2-octet BASize field shall give the length, in units indicated by the CPI field, of the User Information subfield of the Payload field. The BASize field shall be encoded in binary format.

To support SMDS, the BASize field value is set equal to the length of the User Information subfield of the Payload field. More general AAL Type 3/4 implementations allow the BASize to be set to a value greater than or equal to the length of the User Information subfield of the Payload field[52].

(4) Payload

(R) 11-25 The variable-length Payload field shall be composed of two subfields:

- User Information — This subfield shall contain an ICIP_CLS_PDU.
- PAD — This subfield shall contain the adequate number of octets, from 0 to 3 octets, to ensure that the CPCS_PDU Payload field is 4-octet aligned.

Since all ICIP_CLS_PDUs are 4-octet aligned, the PAD field will be 0 octets in length.

(5) Alignment (AL)

This 1-octet field is used to provide 4-octet alignment of the CPCS_PDU trailer.

(R) 11-26 The 1-octet AL field shall be encoded with all 0's.

(6) Length

(R) 11-27 The 2-octet Length field shall give the length, *in units specified by the CPI field,* of the User Information subfield of the Payload field.

11.2.2.4 Convergence Sublayer Procedures

11.2.2.4.1 CPCS Sender Procedures

(R) 11-28 Upon receipt of an ICIP_CLS_PDU from the ICIP_CLS Layer, a CPCS sender shall create a CPCS_PDU, based on the ICIP_CLS_PDU.

(R) 11-29 Each field in a CPCS_PDU shall be populated as described in Section - "CPCS_PDU Format".

(R) 11-30 The value of the Btag for a CPCS_PDU shall be different than the value used in the previous CPCS_PDU which was sent by the CPCS sender using the same MID value that will be used for the current CPCS_PDU.

(R) 11-31 The CPCS sender shall deliver the CPCS_PDU to the SAR entity, which shall perform the "SAR Sender Procedures" defined earlier.

11.2.2.4.2 CPCS Receiver Procedures

(R) 11-32 Upon receipt of a complete CPCS_PDU from a completed receive process, a CPCS receiver shall check the CPCS_PDU for the following errors:

- Values of the Btag field in the CPCS_PDU header and the Etag field in the CPCS_PDU trailer that are not equal.
- A Length field value that is greater than the number of received CPCS_PDU octets minus 8 (4 octets of CPCS_PDU header and 4 octets of CPCS_PDU trailer).
- A Length field value that is less than the number of received CPCS_PDU octets minus 11 (4 octets of CPCS_PDU header, 4 octets of CPCS_PDU trailer, and 3 octets of possible padding).
- A CPCS_PDU length that is not a multiple of 4 octets.

- A Length field value that is not equal to the BASize field value[30].

If any of the above errors occur, the CPCS_PDU shall be discarded. Discarding a CPCS_PDU is accomplished by discarding one or more of the SAR_PDUs associated with the CPCS_PDU.

(O) 11-3 If the implementation of the CPCS receiver permits, then that CPCS receiver shall, upon receipt of a complete CPCS_PDU from a completed receive process, check the CPCS_PDU for the following errors:

- An invalid CPI field value. (The only valid CPI value currently defined for SMDS is 0.)

- An AL field that is not equal to 0.

CPCS receiver implementations that comply with the CCITT Recommendation I.363 will perform the checks in the Option above. However, the checks are listed as Options to ease the transition from IEEE 802.6 to ATM (since IEEE 802.6-based equipment does not perform the checks).

(R) 11-33 The CPCS Receiver shall deliver the CPCS_PDU User Information to the ICIP_CLS Layer entity, which shall perform the "ICIP_CLS Layer Receiving Procedures" defined later.

The inter-layer transaction in the Requirement above may be modeled by the transfer of one or more CPCS_UNITDATA.signal primitives[52] from the CPCS entity to the ICIP_CLS Layer entity, with the parameters of each CPCS-UNITDATA.signal set as follows:

- Interface Data (ID) contains either a portion of or the entire CPCS_PDU User Information.

- More (M) is set to 0 when the ID parameter contains the end of the CPCS_PDU User Information. (The M parameter is used for Streaming Mode only).

- Maximum Length (ML) is set to the value of the BASize field. The ML parameter is used only on the first CPCS-UNITDATA.signal for a CPCS_PDU. (The ML parameter is used for Streaming Mode only).

- Reception Status (RS) is not used, since the corrupted data delivery option is not used.

11.2.3 ICIP_CLS Layer Specification

This section specifies the ICIP Connectionless Service (ICIP_CLS) Layer. The ICIP_CLS Layer supports functions for the connectionless transfer of variable-length SMDS data units between carrier networks. This layer supports the transfer of end-user data units by encapsulating those data units with header information; the encapsulation technique is consistent with the method defined

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[30] This check enforces the Requirement for the BASize, which sets BASize equal to the length (in octets) of the User Information subfield of the Payload field. The check and the Requirement for the BASize are necessary to allow SMDS supporting interfaces (e.g., B-ICI) based on AAL Type 3/4 to interoperate with those interfaces (e.g., SNI and SMDS ICI)) based on IEEE 802.6. Because of these Requirements, the AAL Type 3/4 for SMDS may be viewed as operating in Message Mode, or in a specific implementation of Streaming Mode.

for the SMDS ICI[49] and broadband connectionless data service on BISDN[53]. Figure 11.7 summarizes the SMDS_PDU formats at the B-ICI, and illustrates the encapsulation by the ICIP_CLS Layer.

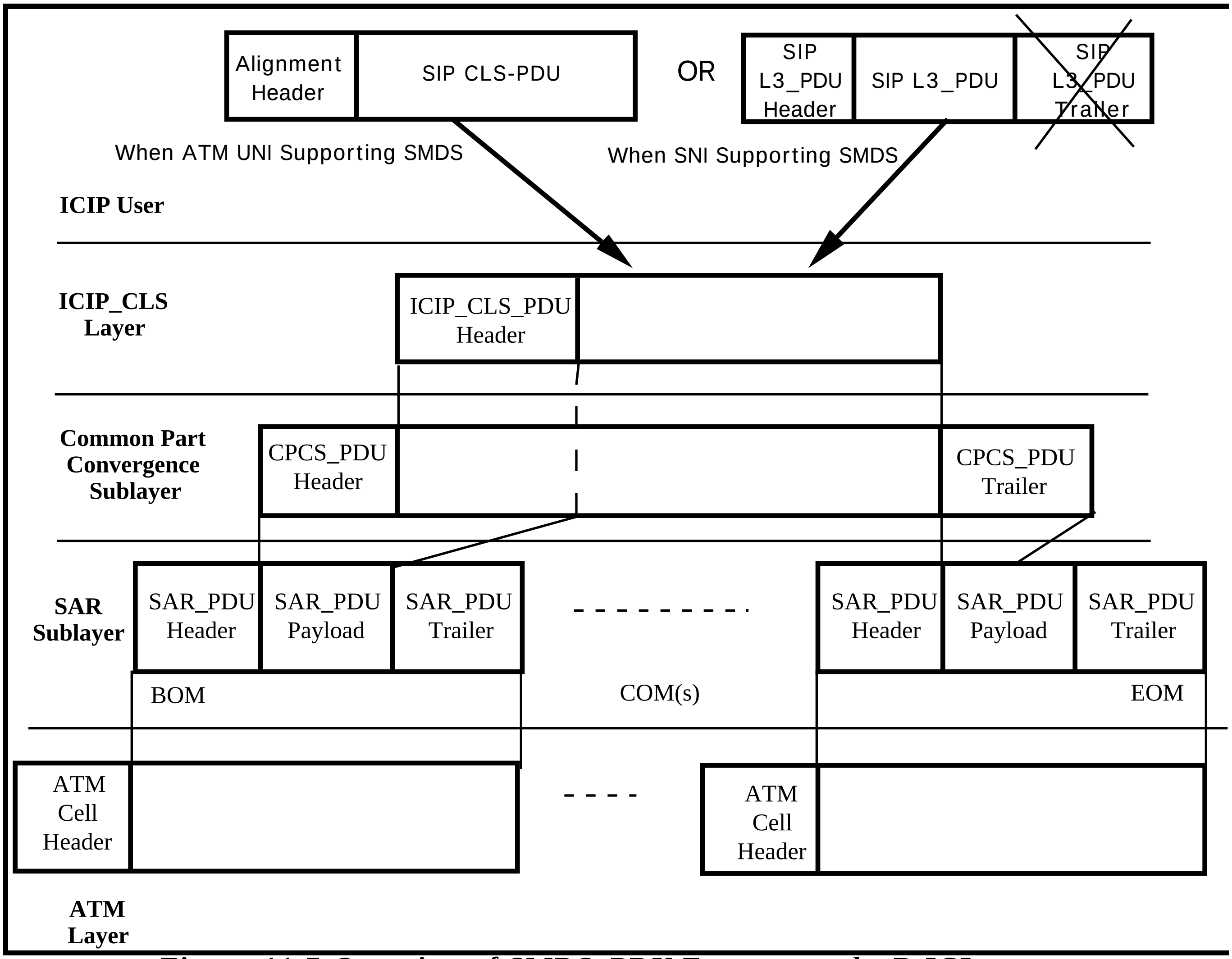


Figure 11.7 Overview of SMDS_PDU Formats at the B-ICI

The ICIP_CLS Layer is a subset of ICIP Level 3[49] (see Figure 11.7) for two reasons:

1. ICIP Level 3 contains protocol elements defined at both the ICIP_CLS Layer and CPCS of the B-ICI protocol architecture.

2. ICIP Level 3 supports specific inter-carrier SMDS arrangements[49]. The ICIP_CLS Layer defined here is consistent with ICIP Level 3. However, it is generalized so that it supports the inter-carrier SMDS arrangements defined in [49], as well as other inter-carrier SMDS arrangements. For example, the ICIP_CLS Layer specification provides address field structure requirements that are consistent with ICIP Level 3; however, requirements on

how to populate the Destination Address and Source Address fields are not given, since these depend on the specific inter-carrier SMDS arrangement[31].

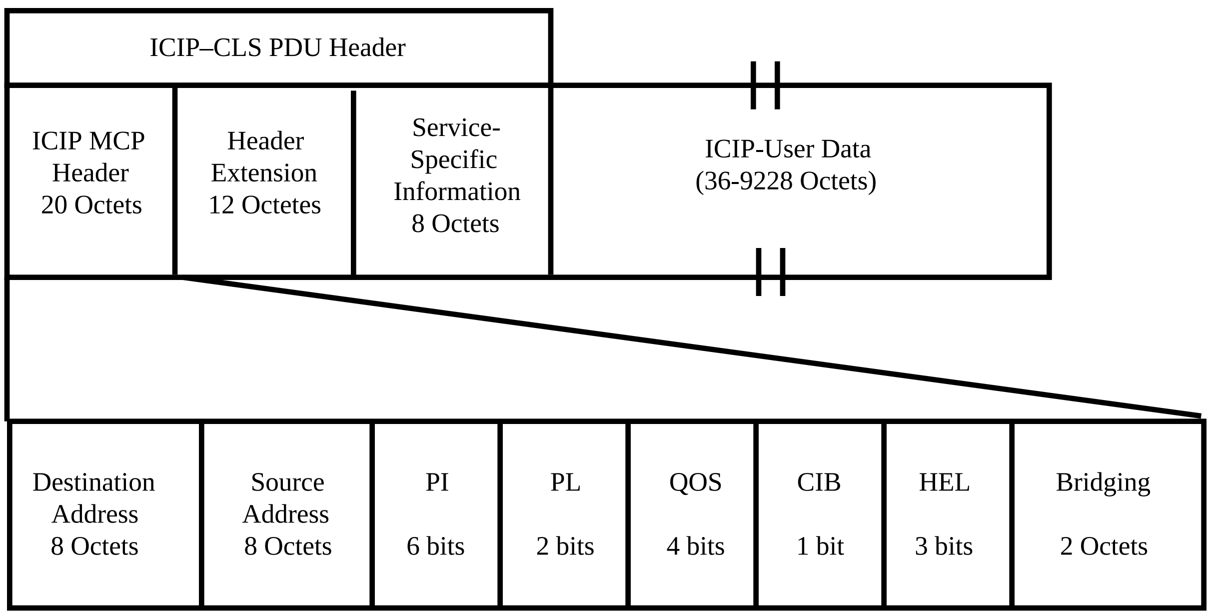
Because the ICIP_CLS Layer is a subset of ICIP Level 3, equipment that conforms to the ICIP Level 3 specification also conforms to the ICIP_CLS Layer protocol defined in this section.

Note: The combined functions of the ICIP_CLS Layer and the CPCS are nearly identical to those of the "ICIP Level 3".

11.2.3.1 ICIP_CLS_PDU Format

Figure 11.8 illustrates the format of the ICIP_CLS_PDU and the lengths of the fields. The requirements for the meaning and use of each field are stated below.

(R) 11-34 The ICIP_CLS_PDU shall use the format shown in Figure 11.8.



CIB = CRC 32 Indicator Bit
HEL = Header Extension Length
MCP = MAC (Medium Access Control) Convergence Protocol
PI = Protocol Identifier
PL = Pad Length
QOS = Quality Of Service

Figure 11.8 ICIP_CLS_PDU Format

31 Requirements specific to XA-SMDS and serving arrangements between LECs within an exchange serving area can be found in [49] and [54].

(1) Destination Address and Source Address

The Destination Address and Source Address fields each have the same format. Each address field has two subfields: Address Type and Address, as shown in Figure 11.9.

(R) 11-35 The Address fields shall each be 8 octets (64 bits) long. The first 4 bits shall identify the Address Type and shall contain the value 1100 for public 60-bit individual addresses and 1110 for public 60-bit group addresses. Other Address Type values are not used.

(R) 11-36 The remaining 60 bits shall identify an address. Addresses that begin with the E.164[55] Country Code "1" shall be followed immediately by an address of 10 decimal digits. Other Country Codes may be used for international service. In this case, the Country Code (from 1 to 3 decimal digits) shall precede the address.

(R) 11-37 The Country Code and address shall be encoded with the Binary-Coded Decimal (BCD) digits of its value, and shall be left-justified within the Address Subfield. To encode the Country Code "1", the four most significant bits of the address shall be set to the binary value 0001. To encode the 10 decimal digit address, the next 40 bits shall be the BCD value of the address. The remaining 16 least-significant bits shall be filled with 1's. For international service, SMDS addresses may use the entire 60 bits of the Address subfield. The least-significant bits which are not used shall be filled with 1's.

Address Type 4 bits	Address 60 bits

Figure 11.9 Address Field Format

(2) Protocol Identification (PI)

For a given ICIP_CLS_PDU, the PI field identifies the user of the services provided by the ICIP_CLS Layer. The users of the ICIP_CLS Layer services are called *ICIP Users*. The service interface between the ICIP_CLS Layer and the ICIP Users may be modeled using the ICIP-UNITDATA.request and ICIP-UNITDATA.indication primitives[52].

(R) 11-38 The 6-bit binary-encoded Protocol Identification (PI) field shall identify the ICIP User. The value of the PI field for all versions of the ICIP shall fall between the decimal values 48 and 63.

In the European environment, at an interoperator domain B-ICI, the sender is responsible for the encoding of the PI field of the PDUs carrying user data with a value that is appropriate for the network directly across the interface. On the basis of bilateral agreement between the operators, the PI field outside the range 48-63 may be used. Currently identified value are in the range 44-47.

(3) Pad Length (PL), Quality of Service (QOS), and CRC32 Indicator Bit (CIB)

The PL field, QOS field, and CIB are present to align the ICIP_CLS_PDU with the ICIP L3_PDU[52].

(R) 11-39 The 2-bit PL field shall be encoded with the binary value 00.

(R) 11-40 The 4-bit QOS field shall be encoded with the binary value 0000.

(R) 11-41 The CIB shall be set to 0.

(4) Header Extension Length (HEL)

(R) 11-42 The 3-bit Header Extension Length (HEL) field shall be encoded with the value 011, indicating a 12-octet Header Extension field.

(5) Bridging

The Bridging field is present to align the ICIP_CLS_PDU with the ICIP L3_PDU[52].

(R) 11-43 When an ICIP_CLS layer entity encapsulates a SIP L3_PDU or a SIP CLS_PDU, it shall fill the 2-octet "Bridging" field with 0.

(R) 11-43a Equipment supporting the distributed database approach defined in ITU Recommendation I.364 shall set the "Bridging" field to 0 when sending an ICIP_CLS packet across a B-ICI for an ATM Forum B-ICI Specification Version 1.1 compliant equipment.

(6) Header Extension

(R) 11-44 The Header Extension field shall be 12 octets long.

(7) Service Specific Information (SSI)

This 8-octet field carries information that is needed to support SMDS on the B-ICI. For the transport of end-user data, three subfields are defined: ICIP Version, Carrier, and Explicit Selection. The remainder is reserved to support future growth, and has the default encoding of all 0's.

(R) 11-45 For the transport of end-user data, the 8-octet Service Specific Information (SSI) field shall be formatted as shown in Figure 11.10.

ICIP Version 1 Octet	Carrier 2 Octets	Explicit Selection 1 bit	Reserved 7 bits	Reserved 4 Octets

Figure 11.10 Service Specific Information Field Format

(R) 11-45a In the European environment, for the transport of end user data, the 8 octet SSI field shall be formatted as shown in Figure 11.10a. The ICI Hop Count Indicator shall be encoded as described in [64] (R) 4-24 and (R) 4-25.

ICIP Version 1 Octet	Carrier 2 Octets	Explicit Selection 1 bit	ICI Hop Count 3 bits	Reserved 4 bits	Reserved 4 Octets

Figure 11.10a European Service Specific Information Field Format

(i) ICIP Version

The ICIP Version field identifies the version of the ICIP_CLS Layer protocol.

(R) 11-46 The 1-octet ICIP Version subfield shall be encoded with the binary value 1, meaning ICIP Version 1[52].

(ii) Carrier and Explicit Selection Subfields

The Carrier and Explicit Selection subfields are reserved for carrier selection purposes. The details of their use are to be defined.

(8) ICIP-User Data

The variable-length ICIP-User Data field carries the information to be transported between peer ICIP Users.

(R) 11-47 For the transport of end user data, the variable length ICIP-User Data field shall contain either:

(a) The end user's SIP L3_PDU without its SIP L3_PDU Trailer (for end user access over an SNI); or

(b) The end user's SIP CLS_PDU, preceded by four octets of Alignment Header (for end user access over an ATM connection supporting SMDS).

The format of the Alignment header requires further study.

11.2.3.2 ICIP_CLS Layer Procedures

This section describes the protocol procedures used for sending and receiving ICIP_CLS_PDUs between peer ICIP_CLS Layer entities.

11.2.3.2.1 Sending Procedures

When an ICIP User provides (in an ICIP-UNITDATA.request primitive[49]) an ICIP_CLS Layer entity with a SIP L3_PDU or SIP CLS_PDU to be transferred, the ICIP_CLS Layer entity encapsulates the SIP L3_PDU or SIP CLS_PDU, without its trailer, within an ICIP_CLS_PDU, as described in the previous section.

(R) 11-48 When sending an ICIP_CLS_PDU, an ICIP_CLS Layer entity shall generate each field as described in Section — "ICIP_CLS_PDU Format".

(R) 11-49 The ICIP_CLS Layer sender shall transfer each created ICIP_CLS_PDU to the CPCS entity, which shall perform the "CPCS Sender Procedures" defined earlier.

The inter-layer transaction in the above Requirement may be modeled by the transfer of one or more CPCS_UNITDATA.invoke primitives[52] from the ICIP_CLS Layer entity to the CPCS entity, with the parameters of each CPCS-UNITDATA.invoke set as follows:

- Interface Data (ID) contains either a portion of or the entire ICIP_CLS_PDU.
- More (M) is set to 0 when the ID parameter contains the end of the CPCS_PDU User Information. (The M parameter is used for Streaming Mode only).
- Maximum Length (ML) is set to the length of the ICIP_CLS_PDU[32]. The ML parameter is used only on the first CPCS-UNITDATA.invoke for a CPCS_PDU. (The ML parameter is used for Streaming Mode only).
- Reception Status (RS) is not used, since the corrupted data delivery option is not used.

11.2.3.2.2 Receiving Procedures

Once an ICIP_CLS Layer entity transmits a PDU to its peer ICIP_CLS Layer entity, the ICIP_CLS Layer receiver performs specific validation procedures and takes action accordingly. For instance, an ICIP_CLS receiver will not deliver an ICIP_CLS_PDU to its destination if an error has occurred. In the following description of the procedures, the phrase, "shall discard the ICIP_CLS_PDU" means that the ICIP_CLS receiver shall take whatever action is necessary to assure that the data is not delivered by the network providing service. The action may be taken when the failure condition is detected, even if the full ICIP_CLS_PDU has not been received.

The rest of this section specifies that action that occurs following the failure. The actions taken by Carrier A and Carrier B are the same. These actions are consistent with the ICIP Level 3 receive checks defined in [52]. If no receive checks fail, the protocol processing at the B-ICI is complete, and the ICIP_CLS Layer entity passes the SIP L3_PDU, without its trailer, (in an ICIP-UNITDATA.indication primitive[52]) to the appropriate ICIP User.

<u>(1) Invalid Address Format</u>

(R) 11-50 If the Destination Address or Source Address formats are incorrect or the Address Type is not a recognized value, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

[32] For Streaming Mode implementations of AAL Type 3/4, this ensures that the CPCS_PDU BASize field is encoded with the length of the CPCS_PDU User Information, as defined in the Requirement for the BASize.

(2) Invalid Protocol Identification

(R) 11-51 If the Protocol Identification field value is not between the decimal values 48 and 63 inclusive, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

In the European environment, on the basis of bilateral agreement, the PI values out of the range 48-63 may be used. Currently identified values are in the range 44-47.

(3) Invalid Pad Length

(R) 11-52 If the Pad Length field does not equal 00, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

(4) Invalid Quality of Service Field

(R) 11-53 If the Quality of Service field does not equal 0000, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

(5) Invalid CRC-32 Indicator Bit

(R) 11-54 If the CRC-32 Indicator Bit does not equal 0, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

(6) Invalid Header Extension Length

(R) 11-55 If the Header Extension Length does not equal 011, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

(7) Invalid Bridging Field

~~**(R) 11-56** If the Bridging field[33] is not filled with 0's, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.~~

(8) Invalid ICIP Version

(R) 11-57 If the value in the ICIP Version subfield is not equal to the binary value 1, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU.

(9) Invalid Reserved Subfield

(R) 11-58 If the Reserved subfield of the Service Specific Information field is not filled with 0's, then the ICIP_CLS receiver shall discard the ICIP_CLS_PDU. This feature can be disabled if the hop count is supported.

(10) Invalid SIP L3-PDU Header Extension

[33] If agreed by the ITU-T, to allow future use of the Bridging Field, the raising of the error condition should be configurable.

(R) 11-59 The ICIP_CLS layer receiver shall verify[34] that the encapsulated SIP L3_PDU or SIP CLS_PDU satisfies following conditions defined in [50]:

- The Version element appears first within the Header Extension.
- For the Version element type, the Element Value is encoded with the binary value "1".
- For the Carrier Selection element type appearing second within the Header Extension field, the value in the Element Length subfield specifies a length of 4, 6, or 8.
- Within the Element Value subfield of a Carrier Selection element appearing second within the Header Extension field, the carrier value is encoded as four decimal, BCD digits.

If any are incorrect, the ICIP_CLS layer receiver shall discard the ICIP_CLS_PDU.

(R) 11-60 If the length of the ICIP_CLS_PDU is not an integral multiple of 4 octets in the range [76, 9268] octets, the ICIP_CLS Layer receiver shall discard the ICIP_CLS_PDU.

If none of the preceding checks fails, the ICIP_CLS Layer entity passes the ICIP-User data to the ICIP User identified in the Protocol Identification field.

11.3 SMDS Traffic Management and Network Performance

This section provides SMDS specific traffic management functions and network performance considerations that are required for a B-ICI.

11.3.1 Traffic Management

Traffic management impacts for SMDS at a B-ICI are considered here. These are the additional information (beyond that required for the carrier-to-carrier traffic contract at a B-ICI) that can increase the efficiency of a carrier's CAC function.

A carrier's CAC function and its engineering of its network portion can generally by facilitated by the availability of additional information beyond that required for the carrier-to-carrier traffic contract at a B-ICI. Additional information that may — subject to bilateral agreement — be exchanged is information on the SMDS Access Classes (for example, an estimate of the number of subscribers in each Access Class) being supported by the B-ICI. If there is any need for clarification, the peak cell rate associated with an SMDS subscriber is to be exchanged.

For this Version of the B-ICI Specification, no further SMDS specific traffic management requirements are considered.

[34] In the European environment, this check is not performed because the content of the SIP Header Extension is not defined.

11.3.2 Network Performance

Network performance parameters for SMDS have been defined[49]. These parameters are generally based on the SMDS Interface Protocol's Level 3 Protocol Data Units (L3_PDUs). No additional SMDS specific performance considerations are included in this Version of the B-ICI Specification.

11.4 SMDS Operations and Maintenance

This section specifies the SMDS operations for the layer above the ATM layer (i.e., the AAL Type 3/4). Operations for layers above the AAL are not discussed in this Version. Section 11.4.1 discusses operations for the AAL Type 3/4, and Section 11.4.2 is a placeholder for SMDS operations for the layers above the AAL Type 3/4 (e.g., ICIP_CLS Layer).

11.4.1 Operations for the AAL Type 3/4

This section specifies performance measurements needed to monitor errors for the AAL Type 3/4.

11.4.1.1 SAR Sublayer

At the SAR sublayer, the following errors may occur:

- Multiplexing IDentification (MID) field value out of range[35].
- Length Indicator (LI) ≠ 44 for a BOM or COM segment.

These indicate problems in the implementation of the protocol. One possible implementation approach is to have only one counter for these two error possibilities, because further diagnosis will be required.

The following errors indicate a transmission or procedural error at the SAR sublevel, such as lost or misinserted cells, and should be counted:

- Incorrect SAR_PDU CRC.
- COM or EOM segment with unexpected Sequence Number.
- BOM/EOM Segment with unexpected MID; i.e., a BOM is received with a currently active MID, or an EOM is received for which a MID is not currently active.
- Number of times an EOM is not received before SAR Receive Interval (SRI) expires.
- Optionally, the number of aborts received (i.e., an EOM is received with Length Indication = 63) may be counted.

11.4.1.2 Common Part Convergence Sublayer (CPCS)

At the CPCS, the following protocol errors may occur:

[35] For example, as stated in Section 11.2.2.1, the allowable MID range for SMDS is [1-1023] in North America and [0, 1023] in Europe. So in the case of North America, a MID value of 0 would be out of range and counted as an error. (The notation [x-y] refers to all values from x to y, including x and y).

- Common Part Indicator (CPI) ≠ 0.
- Alignment Field ≠ 0.

The following procedural or transmission errors may occur at the CPCS:

- Btag ≠ Etag.
- BASize inconsistent with Length field. If the connection is operating in message mode (which is used by SMDS), there is an error if BASize ≠ Length. In streaming mode, there is an error if BASize < Length[36].
- Length of CPCS-PDU not consistent with Length field. Specifically, an error occurs if the length of the CPCS-PDU minus the length specified in the Length field is not in the range [0-3].

(R) 11-61 Network equipment at a B-ICI terminating the AAL Type 3/4 shall measure the SAR and CPCS errors listed in this section.

A typical value for a measurement interval could be 15 minutes, and at least 8 hours of history should be kept. The measurement interval and amount of history data will be established by bilateral agreements between the carriers.

11.4.2 Operations for Layers Above the AAL Type 3/4

Operations for layers above the AAL Type 3/4 will be provided in future Versions of this document.

[36] In streaming mode, the originating point of the packet may begin sending the first cells of the CPCS-PDU before it knows how long the CPCS-PDU will be. In this case, the BASize field is encoded to the largest size that the originating point expects to send, so the BASize must be ≥ Length. In message mode, the size of the packet is known when the BASize is encoded, and it must be set = Length.

12. Usage Measurement

Usage measurement is the collection of usage information to support inter-carrier serving arrangements for services supported by the B-ICI. Usage information can be used for such functions as Accounting Management information and Automatic Message Accounting (AMA).

The objective of this section is to identify the usage information necessary to support initial inter-carrier services (i.e., PVC CRS, PVC CES, PVC FRS, SMDS) and SVC services by the B-ICI providing point-to-point ATM connections. This usage information has service-independent (or common) and service-specific aspects. Both aspects are discussed here for usage information collected for the B-ICI. It is expected that the usage measurements capabilities defined in this section for PVC services will also be applicable for the SVC inter-carrier services possibly with some enhancements.

Inter-carrier billing arrangements and charging principles are beyond the scope of this document.

12.1 Usage Measurement Framework

The initial inter-carrier services supported by the B-ICI are: PVC CRS, PVC CES, PVC FRS, and SMDS (carried on ATM PVCs). The usage information generated by the ATM/BISDN must account for both common ATM transport and service-specific functions. Consequently, the ATM/BISDN must be capable of generating both service-independent (common) and service-specific usage information.

Service-independent (common) usage information is generated for inter-carrier ATM PVCs and includes a count of the number of cells transported on an inter-carrier PVC in the ingress and/or egress direction at a recording interface (UNI or B-ICI). The service-independent (common) usage information is defined in Section 12.2.

Service-specific usage information is generated by network nodes that perform service-specific functions. Service-specific usage information is defined for each initial inter-carrier service in Section 12.3.

Service-independent and service-specific B-ICI functions are distributed in the ATM/BISDN network, as illustrated in Figure 12.1 (see also Figure 2.9, ATM Forum B-ICI Specification, Version 1.0, August 1993, for additional details). Service-independent and service-specific usage measurement functions are also distributed. Distributing the usage measurement functions in the ATM/BISDN network is intended to allocate the service-specific functions to the IWF and the Service Layer. This approach is also intended to minimize the impacts on the common B-ICI functions.

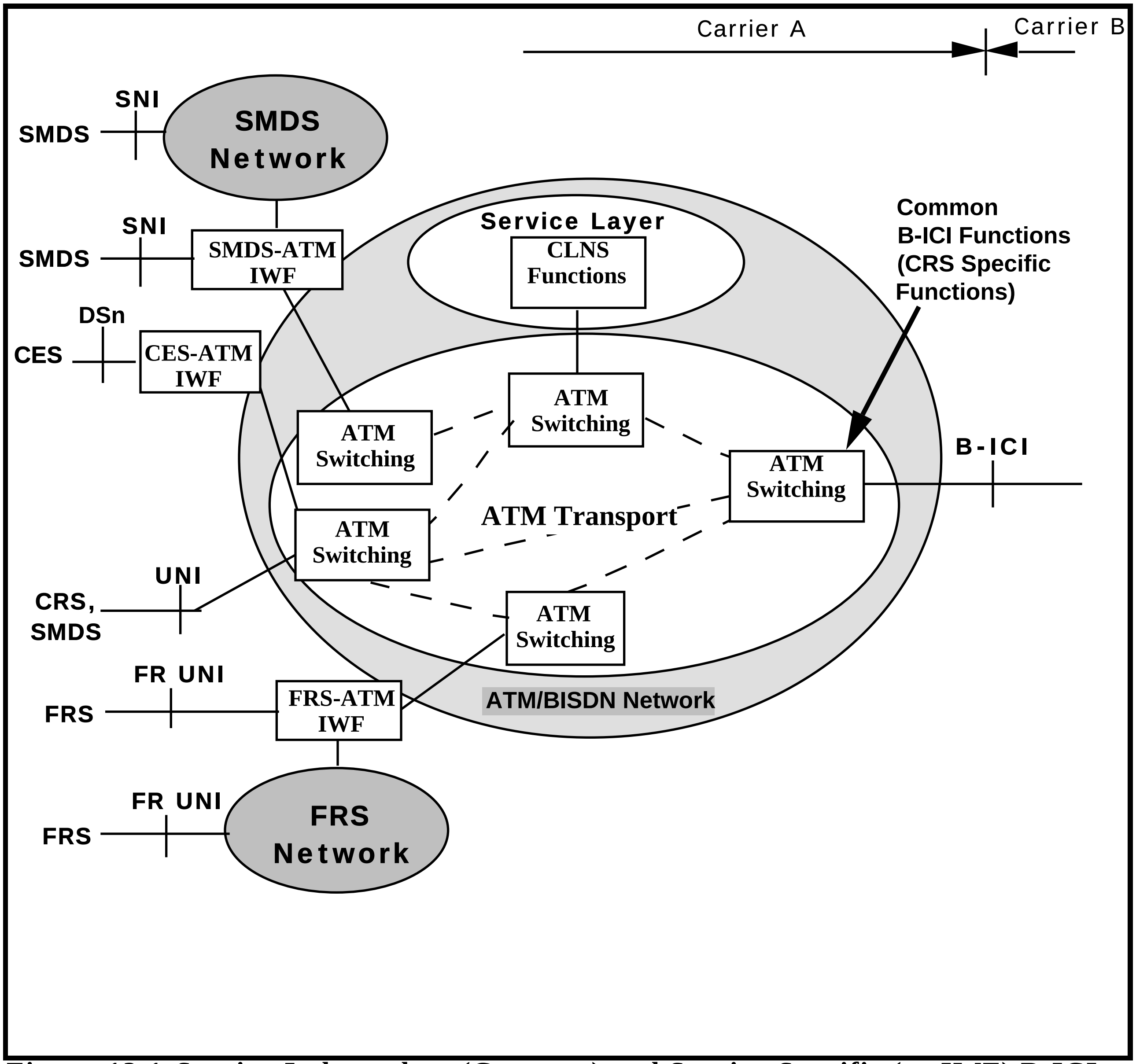


Figure 12.1 Service-Independent (Common) and Service-Specific (or IWF) B-ICI Usage Metering Functions

12.2 PVC Service-Independent Usage Information

This section provides service-independent usage information for Data Generation, Recording Interval, and Data Formatting.

12.2.1 Data Generation

Data generation is the process of determining that usage information is needed for each PVC and producing the necessary data elements. The data generation function is performed by the generation functionality.

Service-independent usage information is generated for inter-carrier PVCs at a recording interface. The recording interface may be a UNI or B-ICI. Usage information is generated at the same level that the PVC is managed at the recording interface. Three example inter-carrier PVC configurations are illustrated in Figure 12.2.

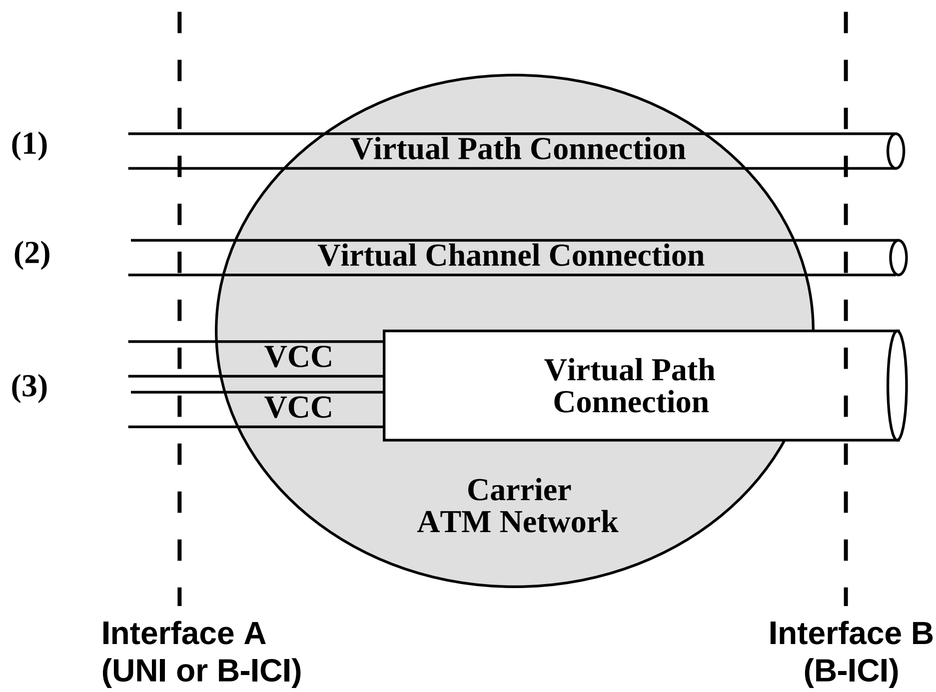


Figure 12.2 Examples of PVC Configurations

For the PVC configurations illustrated in Figure 12.2, the designation Virtual Path Connection (VPC) signifies that policing and shaping functions are performed at the VPC level. The designation Virtual Channel Connection (VCC) signifies that policing and shaping functions are performed at the VCC level. For Configuration (1), usage information is generated at the VPC level for both Interface A and Interface B. For Configuration (2), usage information is generated at the VCC level for both Interface A and Interface B. For Configuration (3), usage information is generated at the VCC level for Interface A and at the VPC level for Interface B. Configuration (3) assumes that the Carrier ATM Network “aggregates,” “bundles,” or “multiplexes” VCCs from multiple end users into a single VPC at the B-ICI.

If a specific service requires VCC level usage information at a B-ICI, then that service should use a VCC, or a group of VCCs, across a B-ICI. If a service requires VPC level usage information at a B-ICI, then that service should use a VPC across a B-ICI.

If a service does not require either VCC or VPC level usage information at a B-ICI, then from a usage measurement perspective it is irrelevant whether the service uses a VPC or a VCC across a B-ICI. It is not required to gather VCC level usage information at a B-ICI for VCCs that have been bundled into a VPC and cross the B-ICI as a VPC.

The above discussion is summarized in the Table 12.1 below.

Table 12.1 Usage Information and Connection Across a B-ICI

Desired Usage Information	Connection Across a B-ICI	
	VCC	VPC
VCC Level Only	X	
VPC Level Only		X
None	X	X
VCC and VPC Level	Not Required	Not Required

The following data generation requirements apply to a PVC at a recording interface (UNI or B-ICI). A PVC at a recording interface has two cell flows: ingress and egress. Generating Ingress Usage Information and Egress Usage Information can be activated or deactivated separately by the carrier for each PVC at a recording interface.

(R) 12-1 The generation functionality shall enable the carrier to set, via an operations interface, the Ingress Usage Information generation parameter for each PVC at a recording interface for each recording interval. The allowable values shall be active and inactive. The default value shall be active.

If the Ingress Usage Information generation parameter is set as active, then the generation functionality shall generate Ingress Usage Information for the PVC at the recording interface during the recording interval.

If the Ingress Usage Information generation parameter is set as inactive, then the generation functionality shall ensure that Ingress Usage Information is not generated for the PVC at the recording interface during the recording interval.

The Ingress Usage Information includes the data elements defined in Section 12.2.1.1, and the Ingress Total Cells and Ingress High Priority Cells defined in Section 12.2.1.2.

(R) 12-2 The generation functionality shall enable the carrier to set, via an operations interface, the Egress Usage Information generation parameter for each PVC at a recording interface for each recording interval. The allowable values shall be active and inactive. The default value shall be active.

If the Egress Usage Information generation parameter is set as active, then the generation functionality shall generate Egress Usage Information for the PVC at the recording interface during the recording interval.

If the Egress Usage Information generation parameter is set as inactive, then the generation functionality shall ensure that Egress Usage Information is not generated for the PVC at the recording interface during the recording interval.

The Egress Usage Information includes the data elements defined in Section 12.2.2.1, and the Egress Total Cells and Egress High Priority Cells defined in Section 12.2.1.3.

Requirements on the generation functionality to report that Ingress Usage Information generation or Egress Usage Information generation is inactive may be provided in the future.

12.2.1.1 Identifying the PVC at a Recording Interface

The data generation point for an inter-carrier PVC is the recording interface (the B-ICI and/or UNI). One data element is necessary to identify the recording interface.

(R) 12-3 The generation functionality shall enable the carrier to set, via an operations interface, an identifier for each recording interface (either UNI or B-ICI). The same recording interface identifier is used for all PVCs carried over the recording interface. The Recording Interface shall be identified by a 15 decimal digit number.

(R) 12-4 The generation functionality shall identify each PVC at a recording interface by the Recording Connection Identifier as follows:

- For PVCs configured as Virtual Path Connections (VPCs) at the recording interface (either UNI or B-ICI), the Recording Connection Identifier is the Virtual Path Identifier at the recording interface.
- For PVCs configured as Virtual Channel Connections (VCCs) at the recording interface (either UNI or B-ICI), the Recording Connection Identifier is the Virtual Path Identifier and the Virtual Channel Identifier at the recording interface.

The Carrier Identifier is used to identify the interconnected carrier associated with the PVC at a recording interface.

(R) 12-5 The generation functionality shall enable the carrier to set, via an operations interface, a Carrier Identifier for each B-ICI and for each inter-carrier PVC at the UNI. The Carrier Identifier shall be a 5 decimal digit number.

The Type of Service is used to identify the inter-carrier service provided by the inter-carrier PVC.

(R) 12-6 The generation functionality shall enable the carrier to set, via an operations interface, a Type of Service Supported for each PVC at the B-ICI, and at the UNI. Valid values for the Type of Service Supported at the B-ICI are PVC CRS, PVC CES, PVC FRS, and SMDS.

A summary of parameters and their status at the UNI and B-ICI are provided in Table 12.1.

> **(R) 12-7** The generation functionality shall indicate to the formatting functionality any usage information generated for PVCs that support transit inter-carrier service.

A transit inter-carrier service is provided if the PVC is supported between two B-ICIs. Additional parameters for transit inter-carrier services may apply.

Table 12.2 Parameters and Values at the Interface

Parameter	Settable at the UNI		Settable at the B-ICI	
	Per PVC	Per UNI	Per PVC	Per B-ICI
Recording Interface		X		X
Carrier Identifier	X			X
Type of Service	X		X	

12.2.1.2 Ingress Cell Counts

For the ingress cell counts, a *Measurable Ingress Cell* is defined as any assigned cell received by the ATM switch across the ingress interface (either UNI or B-ICI) that is *not* discarded by Cell Validation Procedures, Network Parameter Control (NPC) procedures, or Usage Parameter Control (UPC) procedures.

> **(R) 12-8** For a PVC at a recording interface for which Ingress Usage Information generation is active, the generation functionality shall count all Measurable Ingress Cells during the recording interval. This count is referred to as Ingress Total Cells.

> **(R) 12-9** For a PVC at a recording interface for which Ingress Usage Information generation is active, the generation functionality shall count all Measurable Ingress Cells with CLP = 0 during the recording interval. This count is referred to as Ingress High Priority Cells.

Note that for VPI = 0, usage information may be generated separately for each VCC.

12.2.1.3 Egress Cell Counts

For the egress cell counts, a *Measurable Egress Cell* is defined as any assigned cell transported by the ATM switch across the egress interface (either UNI or B-ICI). If an ATM switch employs egress shaping at an interface, then any cells lost or discarded by the egress shaping process are not measurable. Measurable egress cells do not include unassigned cells added to the user cell stream.

(R) 12-10 For a PVC at the recording interface for which Egress Usage Information generation is active, the generation functionality shall count all Measurable Egress Cells during the recording interval. This count is referred to as Egress Total Cells.

(R) 12-11 For a PVC at the recording interface for which Egress Usage Information generation is active, the generation functionality shall count all measurable egress cells with CLP = 0 during the recording interval. This count is referred to as Egress High Priority Cells.

Note that for VPI = 0, usage information may be generated separately for each VCC.

12.2.2 Recording Interval

The service-independent (common) usage information is collected during carrier-defined recording intervals. During a recording interval, usage information is collected for each PVC at the recording interface for which usage information generation is active. At the end of each recording interval, the usage information is sent to the formatting functionality. Recording intervals normally begin and end at scheduled times. Procedures for scheduled closings are described in Section 12.2.2.1. Recording intervals may close at unscheduled times for many reasons, including system failure and reaching memory exhaustion or counter overflow thresholds. Procedures for unscheduled closings are described in Section 12.2.2.2.

To illustrate recording intervals, assume that the recording intervals for an ATM switch are hourly (e.g., from midnight to 0:59:59.9, from 1:00:00.0 to 1:59:59.9, etc.). For a PVC at the recording interface, usage information is generated and sent to the formatting functionality for each hourly interval (i.e., 24 separate instances of usage information are forwarded to the formatting functionality). The interval elapsed time of each is one hour.

(R) 12-12 To support recording intervals, the generation functionality shall have access to a duration timer and a date and time-of-day clock that conform to **(R)-89** to **(R)-103** in Section 8.2 of TR-NWT-000508, *Automatic Message Accounting (AMA)* (A Module of LSSGR, FR-NWT-000064).

The requirements in Section 8.2 of TR-NWT-000508 are in use today to support a wide variety of telecommunications services, including Plain Old Telephone Service (POTS), exchange access services, narrowband ISDN, and Public Packet Switched Network (PPSN). The requirements and supporting text in Section 8.2 of TR-NWT-000508 describe procedures to meet the timing accuracy standards for existing telecommunication services. The existing timing accuracy standards are as follows:

- The accuracy objective for the Interval Start Time and Interval Start Date is ± 5 seconds.
- The Interval Elapsed Time should not be overstated.
- The accuracy objective for the Interval Elapsed Time should be + 0 seconds to - 0.5 seconds.

The applicability of the above timing accuracy standard to ATM technology is under study.

(R) 12-13 The generation functionality shall provide recording intervals that have an interval start date, an interval start time, and an interval elapsed time as defined below.

- The *interval start date* and *interval start time* shall contain the date and time of day that the recording interval begins.

- The *interval elapsed time* shall contain the length of the recording interval.

The interval start time shall be recordable in hours, minutes, seconds, and tenths of seconds. The interval elapsed time shall be recordable in minutes, seconds, and tenths of seconds.

(R) 12-14 The generation functionality shall ensure that recording intervals cover all time during a day and that the intervals do not overlap. A recording interval shall include its interval start time and exclude the interval start time of the next recording interval.

For example, if one recording interval starts at 2:00 AM with an interval elapsed time of 60 minutes, it begins at 2:00:00.0 and ends at 2:59:59.9, inclusive. The next recording interval starts at 3:00 AM.

Recording intervals cannot overlap days because a carrier needs to be able to determine the number of usage measurements generated for a given day.

(R) 12-15 The generation functionality shall ensure that the first recording interval of a given day begins at 0:00:00.0.

To support a wide variety of inter-carrier service arrangements, the recording intervals are settable by the carrier via an operations interface.

(R) 12-16 Except for the first recording interval, the generation functionality shall be settable for each ATM switch, via an operations interface, so that a carrier can set the start time of each recording interval for a given day.

The interval start time shall be settable in 15-minute increments.

(R) 12-17 The generation functionality shall be settable for each ATM switch via an operations interface so that a carrier can set the interval elapsed time of each recording interval for a given day.

The interval elapsed time shall be settable in 1-hour increments. The minimum interval elapsed time shall be 1-hour and the maximum shall be 24 hours. The default interval elapsed time shall be 1 hour. The recording interval elapsed time is set independently for different intervals."

Note that for unscheduled closings (as described in Section 12.2.2.2), interval elapsed times will probably not be a multiple of 15 minutes and the next interval start time, if necessary, will probably not fall on a quarter hour.
Although the above hourly recording intervals are sufficient for many needs, more granular counts are necessary for specific applications.

(R) 12-17a The generation functionality shall be settable so that the carrier can specify 15-minute recording intervals for a limited number of simultaneous ATM PVCs.

12.2.2.1 Scheduled Closings

Normally, usage information is assembled at the scheduled closing for each recording interval. The scheduled closing for a recording interval is at the end of the scheduled interval elapsed time. For instance, if the interval start time is 2:00:00.0 and the scheduled interval elapsed time is 60 minutes, the scheduled closing is 2:59:59.9. At the scheduled closing, the usage information is sent to the formatting functionality.

(R) 12-17b The generation functionality shall assemble a usage record and forward it to the formatting functionality only if one or more of the cell counts in it has a non-zero value.

The above requirement specifically applies to assembled usage records. It does not apply to cell counts that are transferred between functions or systems prior to the assembly of a usage record. Whether such transfers include zero cell counts is beyond the scope of this specification.

(R) 12-18 At the scheduled closing of each recording interval, the generation functionality shall assemble the usage information collected for each PVC at the recording interface and send it to the formatting functionality.

The usage information collected for each PVC at its recording interface are:

- Recording Interface
- Recording Connection Identifier
- Carrier Identifier
- Type of Service Supported
- Ingress Total Cells (if collected)
- Ingress High Priority Cells (if collected)
- Egress Total Cells (if collected)
- Egress High Priority Cells (if collected)
- Interval Start Date
- Interval Start Time
- Interval Elapsed Time

Forwarding usage information to the formatting functionality is under study.

12.2.2.2 Unscheduled Closings

Abnormal recording intervals occur when the interval does not begin at a scheduled start time or does not end at the scheduled closing. Requirements on the generation functionality associated with abnormal recording intervals are described below.

It is likely that the usage measurement functionality will not be initially put into service (i.e., the ATM switch put into live service) exactly at the start of a scheduled recording interval. The date and time at which the usage measurement functionality is put into service are referred to as the *initial in-service date* and *time.*

(R) 12-19 When the usage measurement functionality is first put into service, the generation functionality shall create a recording interval with an interval start date and time equal to the initial in-service date and time.

The interval elapsed time of this recording interval shall include all time up to, but not including, the interval start time of the next scheduled recording interval.

The generation functionality shall indicate this occurrence to the formatting functionality.

For example, if the usage measurement functionality is put into service at 10:05 AM and the next scheduled recording interval starts at 11:00 AM, a recording interval is created with an interval start time of 10:05:00.0 and an interval elapsed time of 55:00.0.

In some instances, the generation functionality closes the recording interval before its scheduled closing. This is referred to as an *unscheduled closing*. Unscheduled closings can occur when memory is near exhaustion or after a system failure. Two types of unscheduled closings may occur: (1) those that affect the usage information for all PVCs at the recording interface, or (2) those that affect the usage information associated with only one or a subset of PVCs at the recording interface.

In both cases, the treatment is to end the recording interval for the affected PVC at the recording interface and to start a new recording interval for the affected PVCs. This treatment helps replenish memory if it is near exhaustion and indicates that counts for the interval may be in error.

(R) 12-20 The generation functionality shall perform an unscheduled closing of a recording interval associated with a PVC at the recording interface in any of the following situations:

1. When memory usage by the usage measurement functionality reaches the Usage Measurement Memory Exhaustion Threshold which implies unscheduled closings for recording intervals for all PVCs at the recording interface.

2. When any counter associated with a PVC at the recording interface reaches the usage information Cell Count Overflow Threshold which implies an unscheduled closing only for the recording interval associated with that PVC at the recording interface.

3. When the usage measurement functionality is restored after a failure which implies unscheduled closings for recording intervals for all PVCs at the recording interface.

Note that if a single count for a PVC at the recording interface reaches the Cell Count Overflow Threshold (situation #2 in the (R) 12-20 above), the unscheduled closing applies to all counts that are being generated for that PVC at the recording interface. For example, if both the Ingress Total Cells and Ingress High Priority Cells are being collected for the PVC and the Ingress Total Cells reaches the Cell Count Overflow Threshold, both counts are assembled and sent to the formatting functionality.

(R) 12-21 When the generation functionality determines that an unscheduled closing will occur for a recording interval, it shall:

- Change the interval elapsed time to the elapsed time between the original interval start time and the time at which the unscheduled closing occurs.
- Assemble the usage information for all affected PVCs at the recording interface.
- Send assembled usage information to the formatting functionality.
- Indicate the reason for the unscheduled closing to the formatting functionality.

(R) 12-22 After an unscheduled closing, the generation functionality shall create a new recording interval for the affected PVCs at the recording interface.

The interval start date and time of the new recording interval shall be the date and time of the unscheduled closing of the original recording interval.

The interval elapsed time of the new recording interval shall be the elapsed time between the time that the unscheduled closing of the original recording occurred and the start time of the next scheduled recording interval.

Unscheduled closing of a recording interval should not result in the loss of recorded data.

Since usage information created for the new recording interval described in the above requirement results from an unscheduled closing, it is not associated with a scheduled recording interval. The usage information indicates that the recording interval is abnormal.

(R) 12-23 The generation functionality shall indicate to the formatting functionality that it created a new recording interval after an unscheduled closing and before the next scheduled recording interval.

12.2.3 Data Formatting

Data formatting is the process of formatting the usage information into a format that can be processed by the carrier operations systems. Data formatting is performed by the formatting functionality. The usage measurement format is carrier-specific and beyond the scope of this document. An example format is Bellcore AMA Format (BAF), which is used by Local Exchange Carriers for current telecommunications services.

12.2.4 Usage Information Integrity

The usage information defined in this section is intended to support connecting inter-carrier serving arrangements for PVC services. Traditionally, these serving arrangements are based on the availability of high integrity usage information.

Integrity standards address the accuracy of the usage information and the reliability and quality of the software and hardware that support the usage metering functions. Accuracy standards may include limits on the amount of usage information misproduced (e.g., with the wrong parameters or with incorrect counts). Reliability and quality standards may include limits on the amount of usage information that is lost in the event of equipment failure and guidelines for making back-ups of the usage information.

Integrity standards for usage information are assumed to be company-specific and beyond the scope of this specification.

Note: On the issue of service-independent usage information for OAM cells, at present, no need is seen for generating separate service-independent usage information for OAM cells transported on ATM PVCs.

> **(R) 12-23a** A single failure or error for any component that supports the generation functionality shall not cause a loss of usage measurement data (including cell counts) that are 15 minutes old or more.

The above requirement is based on the guiding principle that the loss of usage measurement data be minimized. Additional carrier-specific requirements related to the loss of partial or complete usage records may also apply.

12.3 PVC Service-Specific Usage Information

12.3.1 PVC Inter-Carrier CRS

The usage information for CRS will include service-independent (common) usage information. The service-independent (common) usage information data elements include:

- Recording Interface
- Recording Connection Identifier
- Carrier Identifier
- Type of Service Supported (which is always equal to PVC CRS)
- Ingress Total Cells
- Ingress High Priority Cells
- Egress Total Cells
- Egress High Priority Cells
- Interval Start Date
- Interval Start Time
- Interval Elapsed Time

The above data elements and the following additional data elements are included in the PVC CRS specific usage information.

The Remote Interface represents the interface to the carrier network for the PVC. As shown in Figure 12.3, when the usage information is generated at the B-ICI, the B-ICI is the Recording Interface and the UNI is the Remote Interface. Alternatively, the usage information could be generated at the UNI. In such case, the UNI is the Recording Interface and the B-ICI is the Remote Interface.

(R) 12-24 The generation functionality shall enable the carrier to set, via an operations interface, a Remote Interface for each PVC at the recording interface (either UNI or B-ICI). The Remote Interface shall be identified by a 15 decimal digit number.

The Remote Connection Identifier is intended to be the VPI (for PVCs configured as Virtual Path Connections at the remote interface) or the VPI/VCI (for PVCs configured as Virtual Channel Connections at the remote interface) of the PVC.

(R) 12-25 The generation functionality shall enable the carrier to set, via an operations interface, a Remote Connection Identifier for each PVC at the recording interface (either UNI or B-ICI).

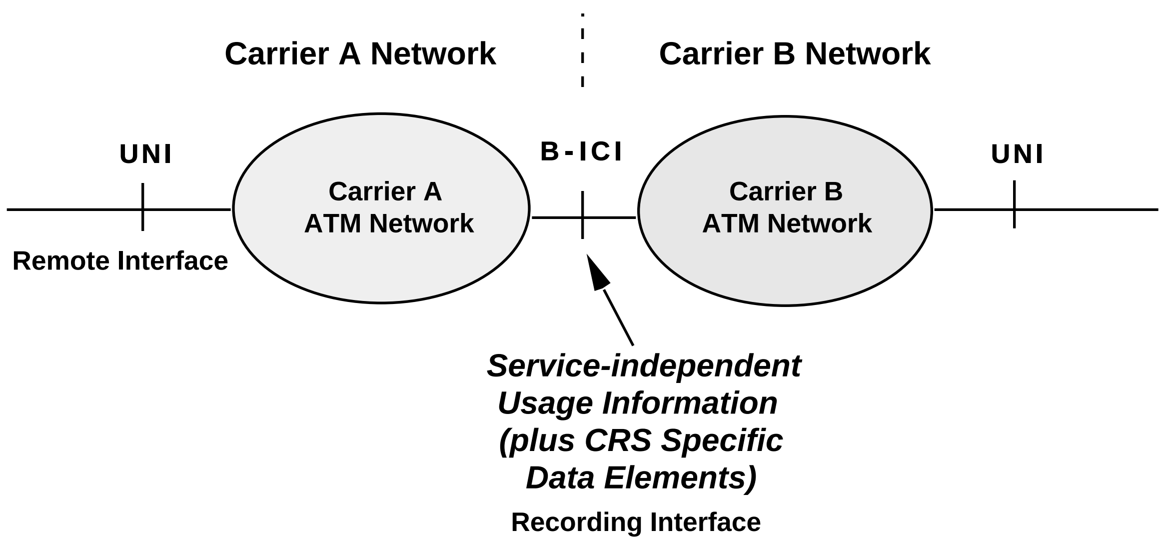


Figure 12.3 CRS Specific Usage Measurements

Usage information for point-to-multipoint CRS PVCs - Any additional data elements needed for point-to-multipoint CRS PVCs are for further study. This issue is expected to be addressed in the next Version of this Specification.

12.3.2 PVC Inter-Carrier CES

Circuit Emulation Service (CES) provides support for transporting Constant Bit Rate (CBR) signals using ATM technology. An example of this service is DS1 or DS3 circuit emulation. For usage metering purposes, CES is being provided by a carrier network if it performs the CES-ATM

Inter-Working Function (IWF) as illustrated in Figure 12.4.[37] In this Figure, Carrier A is providing CES.[38]

As illustrated in Figure 12.4, service-independent usage information may be generated by equipment supporting the B-ICI for any PVC that transports CES. This usage information (as defined in Section 12.2), may include ingress and egress counts of cells transported on the PVC. The service-independent usage information will indicate that the Type of Service Supported is "CES."

Currently, usage information is not generated for DS1 or DS3 Circuit Emulation Service. Consequently, no usage measurement capabilities are proposed at this time for the CES-ATM IWF.

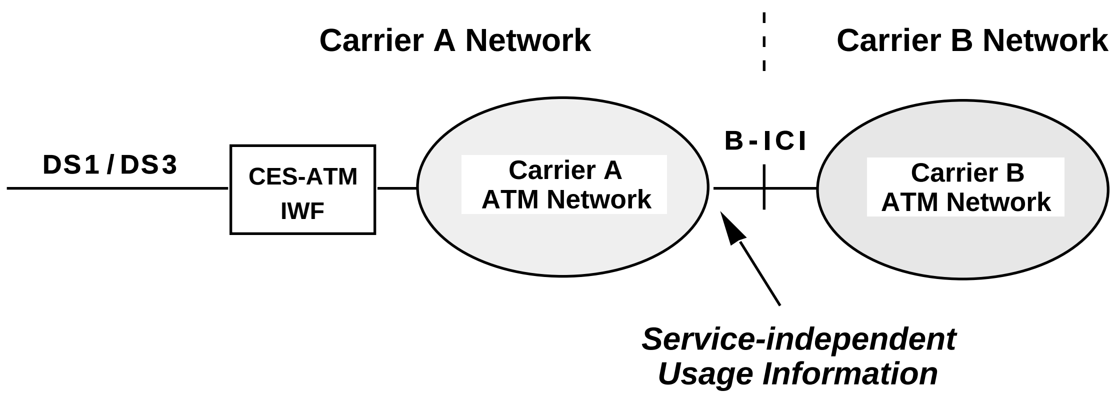


Figure 12.4 CES Specific Usage Measurements

An optional future capability of the CES-ATM IWF is to generate CES specific usage information. The need for such usage information is for further study.

12.3.3 PVC Inter-Carrier FRS

Inter-carrier PVC Frame Relay Service (FRS) is a connection-oriented data transport service that provides for the bi-directional transfer of variable-length packets for LAN interconnection and terminal-host applications. For usage metering purposes, PVC FRS is provided by a carrier network if it performs the FRS-ATM Inter-Working Function (IWF) as illustrated in Figure 12.5. In this Figure, Carrier A is providing PVC FRS. This section assumes one-to-one connection multiplexing, i.e., each frame relay logical connection (DLCI) is mapped to a single ATM VCC. Multiplexing is performed at the ATM layer using VPI/VCI.

As illustrated in Figure 12.5, service-independent usage information may be generated by equipment supporting the B-ICI for an ATM PVC that supports FRS. This usage information (as defined in Section 12.2) may include ingress and egress counts of cells transported on the ATM PVC. The service-independent usage information will indicate that the Type of Service Supported

[37] If a carrier network does not provide the CES-ATM IWF, then the usage metering approach defined in Section 12.3.1 for PVC Cell Relay Service (CRS) applies to the PVC.

[38] Carrier B is also providing CES if it also performs the CES-ATM IWF (e.g., at a user interface).

is “PVC FRS.” Additionally, the usage information generated by equipment supporting the B-ICI for an ATM PVC that supports FRS must include the following FRS specific data element.

(R) 12-26 The generation functionality shall enable the carrier to set, via an operations interface, a Frame Relay Interface Identifier for each ATM PVC that supports PVC FRS at the B-ICI. The Frame Relay Interface Identifier shall be 15 decimal digits to represent the FR-UNI.

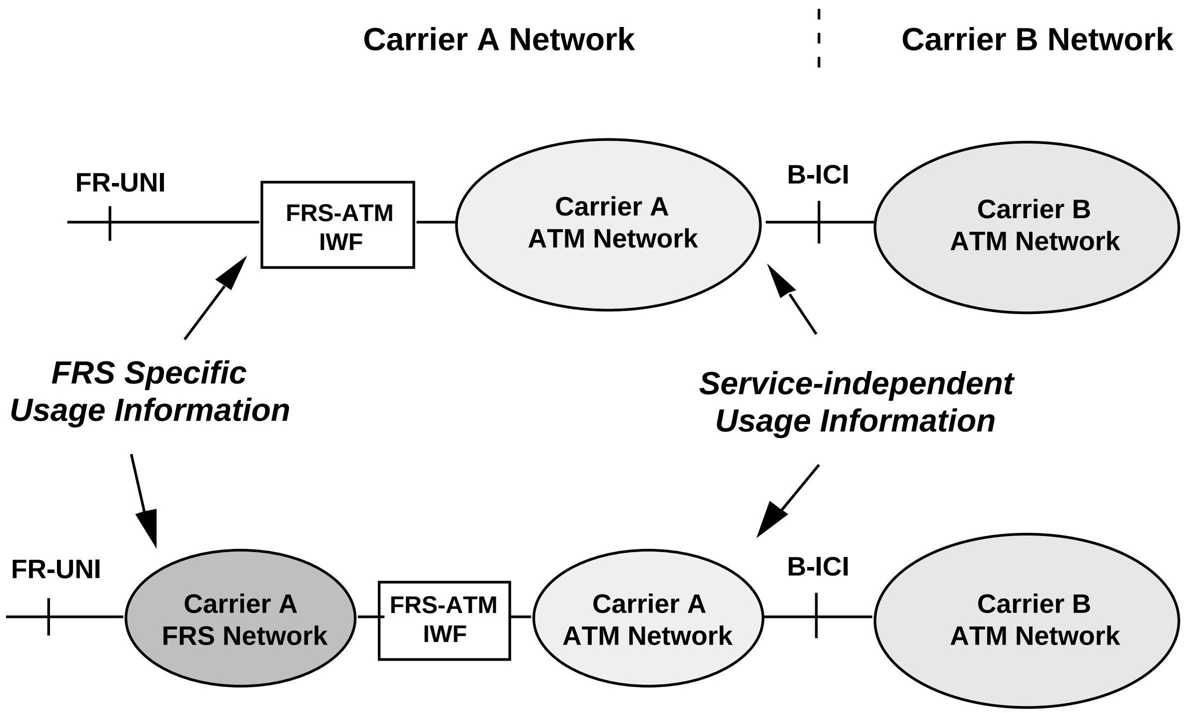


Figure 12.5 Inter-carrier PVC FRS

For FRS PVCs supported by a FR-UNI connected to a carrier FRS network, it is assumed that the FRS switching equipment in the FRS network generates the FRS specific usage information at the FR-UNI. The FRS specific usage information is defined in TR-TSV-001370[65]. For these FRS PVCs, the FRS-ATM IWF is assumed to generate no usage information.

For FRS PVCs supported by a FR-UNI directly connected to the FRS-ATM IWF, it is assumed that the FRS-ATM IWF generates the FRS specific usage information defined in the following requirements. These requirements (except for the capability to activate or deactivate usage measurement generation) are summarized from TR-TSV-001370[65].

FRS specific usage information may be generated by the FRS-ATM IWF for each FRS PVC. The generation functionality may be activated or deactivated by the carrier via an operations interface for each FRS PVC for each recording interval.

(R) 12-27 The generation functionality shall enable the carrier to set, via an operations interface, the FRS Usage Information Generation parameter for each FRS PVC supported by the FRS-ATM IWF for each recording interval. The allowable values shall be active and inactive. The default value shall be active.

If the FRS Usage Information Generation is set as active, then the generation functionality shall generate the FRS specific usage information for the FRS PVC during the recording interval.

If the FRS Usage Information Generation is set as inactive, then the generation functionality shall ensure the FRS specific usage information is not generated for the FRS PVC during the recording interval.

The FRS specific usage information is defined in the following requirements, which are summarized from TR-TSV-001370[65]. This usage information is generated during recording intervals. These intervals have the same characteristics as the recording intervals defined in Section 12.2.2 for the service-independent usage information. The generation functionality is assumed to be part of the FRS-ATM IWF.

For inter-carrier PVC FRS, the FRS-ATM IWF measures the amount of end-user data transported on each PVC in the ATM to FRS direction during a recording interval. End-user data include only the information payload of the frame. The headers and trailers are not considered end-user data by the usage measurement functionality. The amount of end-user data is measured in terms of *Measurement Units*. The Measurement Unit is a fixed-length unit determined jointly by the carrier and FRS-ATM IWF supplier. Example units include octets and cells.

(R) 12-28 The generation functionality shall provide fixed-length Measurement Units to measure the end-user data.

(R) 12-29 During the recording interval, the generation functionality shall accumulate the number of Measurement Units of user data transported from the FRS-ATM IWF across the destination interface (FR-UNI) for each FRS PVC on the interface. The user data shall be all data in the information payload of a frame. This count is referred to as the *Received Count*.

Note that the Received Count is an egress count of the amount of user data transported in the ATM to FRS direction to a FR-UNI (i.e., received by the user). It includes both discard-eligible (DE = 1) and discard-ineligible (DE = 0) user data.

Each Received Count is identified by the following data elements:

- **Destination Interface Identifier:** A 16 decimal digit number that identifies the destination interface. This identifier is provisioned for each FR-UNI. All Received Counts at a given interface are identified by the same Destination Interface Identifier.
- **Destination DLCI:** The Data Link Connection Identifier (at the destination interface) of the FRS PVC for which the Received Count is being generated. This DLCI is used to distinguish between Received Counts generated for the same destination interface. For the FRS specific usage information generated by the FRS-ATM IWF, the destination interface is the FR-UNI.
- **Source Interface Identifier:** A 16 decimal digit number that identifies the source interface of the PVC for which the Received Count is being generated. This identifier is provisioned separately for each FRS PVC. For the FRS specific usage information generated by the FRS-ATM IWF, the source interface is the B-ICI.

These data elements are illustrated in Figure 12.6.

It is assumed that FR-UNIs are identified by 16 decimal digit numbers to facilitate processing of the usage information by applications.

(R) 12-30 For the FRS specific usage information generated by the FRS-ATM IWF, the Destination Interface Identifier shall be the 16 decimal digit memory-administrable numeric address that is associated with the terminated FR-UNI path for which the Received Count is being generated.

(R) 12-31 The generation functionality shall enable the carrier to set, via an operations interface, a 16 decimal digit numeric Source Interface Identifier for each Received Count.

Note that the PVC FRS usage information defined in TR-TSV-001370[65] also includes the source DLCI for the FRS PVC. For the usage information generated at the FRS-ATM IWF, the source interface is the multi-service B-ICI. Consequently, the source DLCI is not needed.

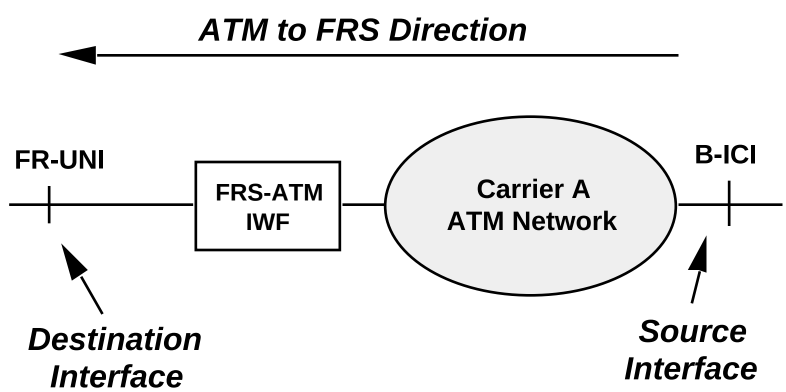


Figure 12.6 FRS Specific Usage Measurements

At the end of a recording interval, the usage information is assembled and forwarded to the formatting functionality.

(R) 12-32 At the end of the recording interval, the generation functionality shall assemble usage information for each Received Count that contains the following data elements:

- Interval Start Date
- Interval Start Time
- Interval Elapsed time
- Source Interface Identifier
- Destination Interface Identifier
- DLCI (at the Destination Interface) of the FRS PVC for which the Received Count is being generated
- Measurement Unit
- Received Count.

Data formatting requirements related to the FRS specific usage information are company-specific and beyond the scope of this specification.

12.3.4 SMDS

SMDS is a public packet-switched service that provides for the transfer of variable length data units at high speeds, without the need for call establishment procedures. To support SMDS, a carrier may provide processing at several different levels. These levels range from point-to-point traffic transport between carriers to full processing and routing of SMDS packets (e.g., ICIP_CLS PDUs) based on their packet level addresses. A functional network architecture in support of inter-carrier SMDS is illustrated in Figure 12.7. In this Figure, Carrier A is providing Exchange Access SMDS (XA-SMDS) to Carrier B.

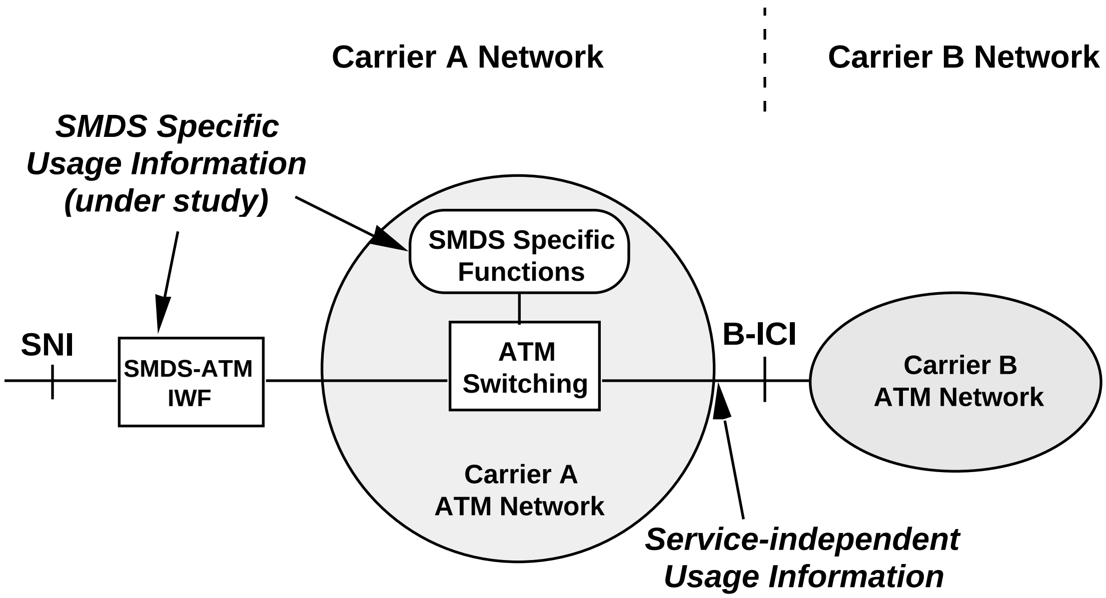


Figure 12.7 SMDS Specific Usage Measurements

As illustrated in Figure 12.7, service-independent usage information may be generated by equipment supporting the B-ICI for any PVC that transports SMDS traffic. This usage information (as defined in Section 12.2) may include ingress and egress counts of cells transported on the PVC. The service-independent usage information will indicate that the Type of Service Supported is "SMDS."

SMDS specific usage information may be generated by the SMDS-ATM IWF or SMDS Specific Functionality. SMDS usage information is defined in TR-TSV-001060 for the SMDS ICI. The SMDS specific usage information is generated for SMDS Level 3 Protocol Data Units (L3_PDUs) transported between an SMDS Source Address and SMDS Destination Address. It is generated at the last point of SMDS protocol processing within the carrier network (for a service-specific platform, this point is the egress interface). The usage information includes a count of the number of L3_PDUs and L2_PDUs transported by the carrier network from the source to destination during an aggregation interval. For XA-SMDS, the usage information also includes the Network Identification and the ICI Transmission Path Set to identify the interconnected carrier. Two additional data elements, the Condition Code and SNI Identifier, are used to measure partially-transmitted L3_PDUs and group addressed L3_PDUs.

SMDS specific usage information for inter-carrier SMDS supported by the B-ICI is under study. This includes usage measurements for both cases, SMDS-ATM IWF and the SMDS network interconnected to SMDS-ATM IWF.

12.4 SVC Service-Independent Usage Information

In Section 7, Figure 7.6 illustrates an example of the reference configuration for B-ICIs supporting SVC service. As illustrated below in Figure 12.8, this example configuration contains one Originating Carrier, one or more Transit Carriers, and one Terminating Carrier.

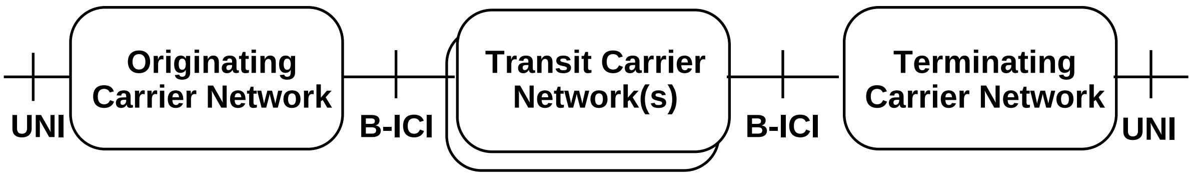


Figure 12.8 Example Reference Configuration

In order to support Inter Carrier SVC services, each carrier will need to provide usage measurement capabilities.

12.4.1 Originating Carrier Network

This section proposes usage measurement capabilities that apply to the Originating Carrier Network. The following requirements apply to an Originating Carrier Network for Point-to-Point Inter Carrier Switched Virtual Connections (SVCs).

(R) 12-33 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Calling Party associated with the SVC. The Calling Party is the Address Digits from the Calling Party Number parameter from the IAM associated with the SVC, plus the AESA for Calling Party parameter, if present.

(R) 12-33a In North American Networks, for Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Charge Number associated with the SVC. The Charge Number is the Address Digits from the Charge Number parameter (when present) from the IAM associated with the SVC.

(R) 12-33b For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Default Address associated with the SVC. This requirement applies when usage information is generated by the Originating ATM Switch in the Originating Carrier Network.

(R) 12-34 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Terminating Address for the SVC. The Terminating Address is the Address Digits from the Called Party Number Parameter from the IAM associated with the SVC, plus the AESA for Called Party parameter, if present.

(R) 12-35 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the following subfields in the Broadband Bearer Capability Parameter from the IAM associated with the SVC:

- Bearer Class,
- Traffic Type,
- Timing Requirements,
- Susceptibility to Clipping, and
- User Plane Connection Configuration.

(R) 12-36 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the QOS Class Forward and QOS Class Backward subfields (when present) in the Quality of Service Parameter from the IAM associated with the SVC.

(R) 12-37 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the following indicators from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Best Effort Indication,
- Tagging Forward, and
- Tagging Backward.

(R) 12-38 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the following traffic parameters from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Forward Peak Cell Rate (CLP = 0+1)
- Forward Peak Cell Rate (CLP = 0)
- Forward Sustainable Cell Rate (CLP = 0+1)
- Forward Sustainable Cell Rate (CLP = 0)
- Forward Maximum Burst Size (CLP = 0+1)
- Forward Maximum Burst Size (CLP = 0)

(R) 12-39 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the following traffic parameters from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Backward Peak Cell Rate (CLP = 0+1)
- Backward Peak Cell Rate (CLP = 0)
- Backward Sustainable Cell Rate (CLP = 0+1)
- Backward Sustainable Cell Rate (CLP = 0)
- Backward Maximum Burst Size (CLP = 0+1)
- Backward Maximum Burst Size (CLP = 0)

(R) 12-40 In North American networks, for Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording Originating Line Information Parameter (OLIP) from the IAM associated with the SVC (when present).

(R) 12-41 In North American networks, for Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Carrier Identification Code corresponding to the Transit Carrier Network from the Transit Network Selection Parameter from the IAM associated with the SVC.

Note that if multiple Transit Carrier Networks transport the inter carrier SVC, more than one Transit Carrier Identifiers may be needed. This issue is for further study.

(R) 12-42 In North American networks, for Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Outgoing Facility Identifier for the SVC.

The Outgoing Facility Identifier for the SVC includes the Signaling Point Code of the Intermediate ATM Switch in the Transit Carrier Network and the VPCI which transports the ATM SVC between the Originating and Transit Carrier Networks.

At the Originating ATM Switch in the Originating Carrier Network, the Outgoing Facility Identifier is recorded from the EXM associated with the SVC. At the Intermediate ATM Switch in the Originating Carrier Network, the Outgoing Facility Identifier is determined by the ATM Switch from internal processes.

(R) 12-43 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the duration of the ATM SVC.

The duration may be described by a start date, start time, and elapsed time. The elapsed time represents the amount of time between a defined start time and the disconnect of the SVC. Two start times are relevant for Inter Carrier SVCs: Carrier Connect Time and Connect Time. The Carrier Connect Time is the time that the SVC is recognized by the originating network as connected to the transit network. The Connect Time is the time that the SVC is recognized by the originating network as connected end-to-end between the calling and called party.

(R) 12-44 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording cell counts as needed.

See Section 12 of the B-ICI Specification, Version 1.1 for a description of cell counting functionality for ATM Permanent Virtual Connections (PVCs). This functionality may be used to generate cell counts for ATM SVCs.

(R) 12-45 For Inter Carrier SVCs, the Originating Carrier Network shall be capable of recording the Cause Value subfield from the Cause Indicators Parameter from the RELEASE or RELEASE COMPLETE messages associated with the SVC.

The potential usage measurement recording locations in the Originating Carrier Network are illustrated in Figure 12.9.

In this figure, note that the Charge Number Parameter and OLIP might not be included in the usage information. The Charge Number Parameter is included in the usage information only if the Charge Number Parameter is present in the IAM associated with the SVC. The OLIP is included in the usage information only if OLIP is present in the IAM associated with the SVC.

The Charge Number, OLIP, and Carrier Identification Code are indicated by (*) because the Charge Number parameter, OLIP, and TNS parameters apply to North American networks only.

The Quality of Service (QOS) Parameter is indicated by (**) because the current Version of BISUP does not support this Parameter.

The objective is that all usage information generated by the Originating Carrier Network for an Inter Carrier SVC be assembled as a single usage record and made available to the formatting functionality. Procedures to assemble usage information from the Originating and Intermediate ATM Switches require further study.

Procedures to control the generation of usage information for Inter Carrier SVCs require further study.

Additional carrier-specific data elements may also be included in the usage information.

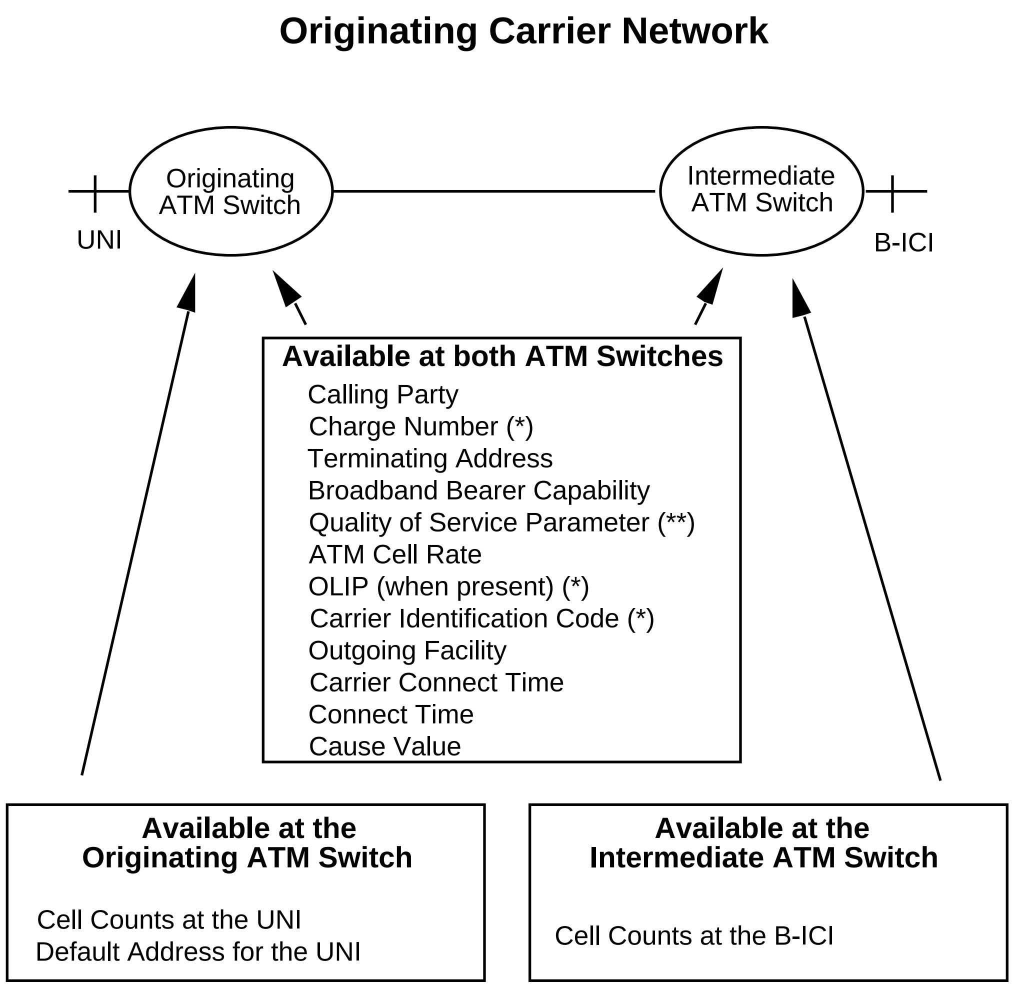


Figure 12.9 Originating Carrier Network Usage Information

12.4.2 Terminating Carrier Network

This section proposes usage measurement capabilities that apply to the Terminating Carrier Network. The following requirements apply to a Terminating Carrier Network for Point-to-Point Inter Carrier Switched Virtual Connections (SVCs).

(R) 12-46 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Calling Party associated with the SVC. The Calling Party is the Address Digits from the Calling Party Number parameter (when present) from the IAM associated with the SVC, plus the AESA for Calling Party, if present.

(R) 12-46a In North American Networks, for Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Charge Number associated with the SVC. The Charge Number is the Address Digits from the Charge Number parameter (when present) from the IAM associated with the SVC.

Note that Charge Number Parameter and/or Calling Party Number might not be provided to the Terminating Carrier Network. The above requirements apply only if these Parameters are included in the IAM provided to the Terminating Carrier Network.

(R) 12-47 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Terminating Address for the SVC. The Terminating Address is the Address Digits from the Called Party Number parameter from the IAM associated with the SVC, plus the AESA for Called Party parameter, if present.

(R) 12-48 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the following subfields in the Broadband Bearer Capability Parameter from the IAM associated with the SVC:

- Bearer Class,
- Traffic Type,
- Timing Requirements,

- Susceptibility to Clipping, and
- User Plane Connection Configuration.

(R) 12-49 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the QoS Class Forward and QoS Class Backward subfields (when present) in the Quality of Service Parameter from the IAM associated with the SVC.

(R) 12-50 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the following indicators from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Best Effort Indication,
- Tagging Forward, and
- Tagging Backward.

(R) 12-51 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the following traffic parameters from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Forward Peak Cell Rate (CLP = 0+1)
- Forward Peak Cell Rate (CLP = 0)
- Forward Sustainable Cell Rate (CLP = 0+1)
- Forward Sustainable Cell Rate (CLP = 0)
- Forward Maximum Burst Size (CLP = 0+1)
- Forward Maximum Burst Size (CLP = 0)

(R) 12-52 For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the following traffic parameters from the corresponding subfields (when present) in the ATM Cell Rate Parameter from the IAM associated with the SVC:

- Backward Peak Cell Rate (CLP = 0+1)
- Backward Peak Cell Rate (CLP = 0)
- Backward Sustainable Cell Rate (CLP = 0+1)
- Backward Sustainable Cell Rate (CLP = 0)
- Backward Maximum Burst Size (CLP = 0+1)
- Backward Maximum Burst Size (CLP = 0)

(R) 12-53 In North American networks, for Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording Originating Line Information Parameter (OLIP) from the IAM associated with the SVC (when present).

Note that the Originating Line Information Parameter (OLIP) might not be provided to the Terminating Carrier Network. The above requirement applies only if this Parameter is included in the IAM provided to the Terminating Carrier Network.

(R) 12-54 In North American networks, for Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Carrier Identification Code corresponding to the Transit Carrier Network.

Note that if multiple Transit Carrier Networks transport the inter carrier SVC, more than one Transit Carrier Identifiers may be needed. This issue is for further study.

At the Intermediate ATM Switch in the Terminating Carrier Network, the Carrier Identification Code is associated with the B-ICI. Determining the Carrier Identification Code at the Terminating ATM Switch in the Terminating Carrier Network requires further study.

> **(R) 12-55** In North American networks, for Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Incoming Facility Identifier for the SVC.

The Incoming Facility Identifier for the SVC includes the Signaling Point Code of the Intermediate ATM Switch in the Transit Carrier Network and the VPCI which transports the ATM SVC between the Transit and Terminating Carrier Networks.

At the Intermediate ATM Switch in the Terminating Carrier Network, the Incoming Facility Identifier is determined by the ATM Switch from internal processes. Determining the Incoming Facility Identifier at the Terminating ATM Switch in the Terminating Carrier Network requires further study.

> **(R) 12-56** For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the duration of the ATM SVC.

The duration may be described by a start date, start time, and elapsed time. The elapsed time represents the amount of time between a defined start time and the disconnect of the SVC. Two start times are relevant for Inter Carrier SVCs: Carrier Connect Time and Connect Time. The Carrier Connect Time is the time that the SVC is recognized by the terminating network as connected to the transit network. The Connect Time is the time that the SVC is recognized by the terminating network as connected end-to-end between the calling and called party.

> **(R) 12-57** For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording cell counts as needed.

See Section 12 of the B-ICI Specification, Version 1.1 for a description of cell counting functionality for ATM Permanent Virtual Connections (PVCs). This functionality may be used to generate cell counts for ATM SVCs.

> **(R) 12-58** For Inter Carrier SVCs, the Terminating Carrier Network shall be capable of recording the Cause Value subfield from the Cause Indicators Parameter from the RELEASE or RELEASE COMPLETE messages associated with the SVC.

The potential usage measurement recording locations in the Terminating Carrier Network are illustrated in Figure 12.10.

In this figure, note that three data elements might not be available in the Terminating Carrier Network. These data elements are the Charge Number, Calling Party, and OLIP.

The Charge Number and OLIP are indicated by (*) because the Charge Number Parameter and OLIP apply to North American networks only.

The Quality of Service Parameter is indicated by (**) because the current version of BISUP does not support this parameter.

The objective is that all usage information generated by the Terminating Carrier Network for an Inter Carrier SVC be assembled as a single usage record and made available to the formatting functionality. Procedures to assemble usage information from the Terminating and Intermediate ATM Switches require further study.

Procedures to control the generation of usage information for Inter Carrier SVCs require further study.

Additional carrier-specific data elements may also be included in the usage information.

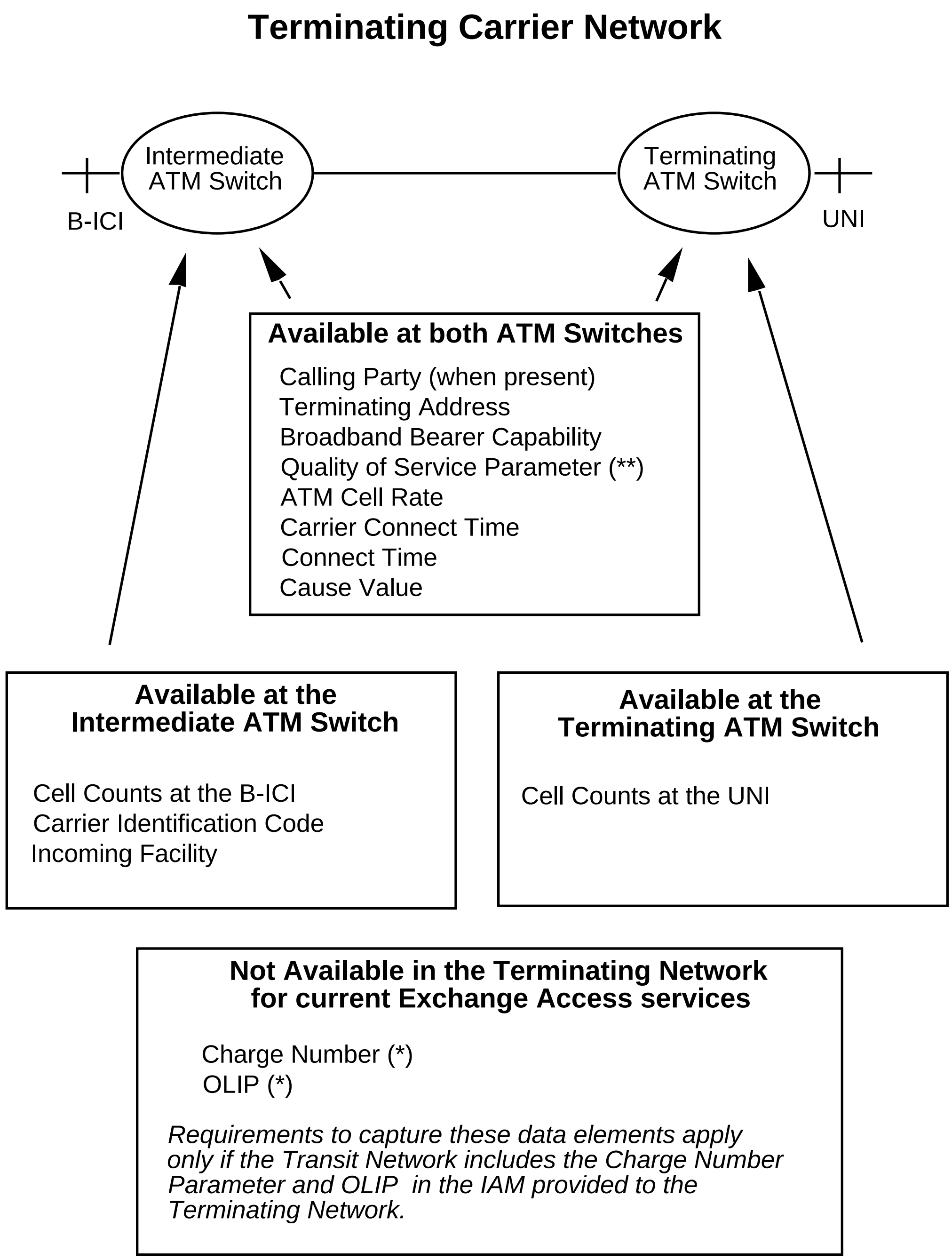


Figure 12.10 Terminating Carrier Network Usage Information

12.4.3 Point-to-Multipoint SVCs

The usage measurement capabilities for inter network SVCs are specified for the Originating Carrier Network in Section 12.4.1 and for the Terminating Carrier Network in Section 12.4.2. These capabilities also apply to Point-to-Multipoint SVCs. An example Point-to-Multipoint SVC is illustrated in Figure 12.11.

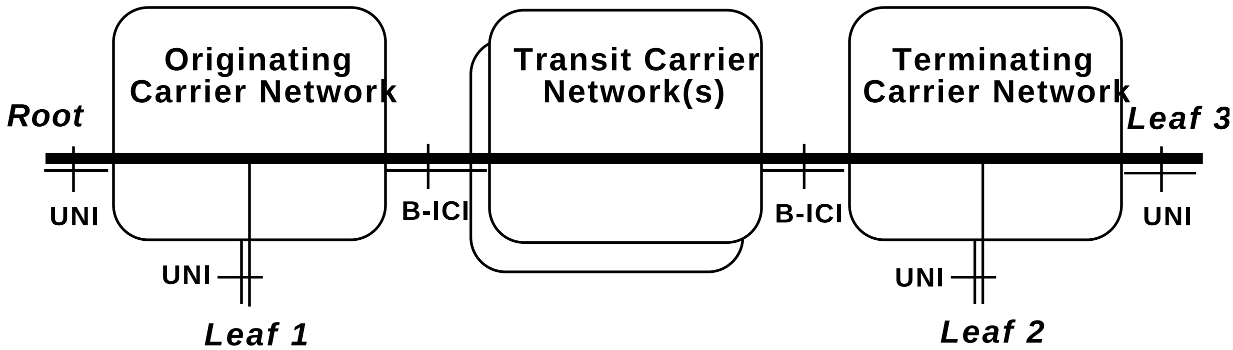


Figure 12.11 Point-to-Multipoint SVC

This Point-to-Multipoint SVC includes one root and three leaves. For usage measurement purposes, this Point-to-Multipoint SVC provides three *communication paths*. A communication path is defined between the root and a leaf. The three communication paths provided by the above Point-to-Multipoint SVC are as follows:

- a communication path from the Root to Leaf 1
- a communication path from the Root to Leaf 2
- a communication path from the Root to Leaf 3

Note that these communication paths share connection links at different points within the networks. For instance, all three communication paths use the same user plane connection link (i.e., the same VPCI/VCI) at the UNI between the Root and the Originating Carrier Network.

Usage information is collected for each communication path. The ATM switches are capable of recording the specified usage measurement data elements for the communication paths they support. These data elements should indicate that the communications path is part of a Point-to-Multipoint SVC. For instance, the User Plane Connection Configuration in the Broadband Bearer Capability Parameter from the IAM should indicate "Point-to-Multipoint". The usage information generated for the above Point-to-Multipoint SVC is illustrated in Figures 12.12 and 12.13.

Figure 12.12 illustrates the Originating Carrier Network.

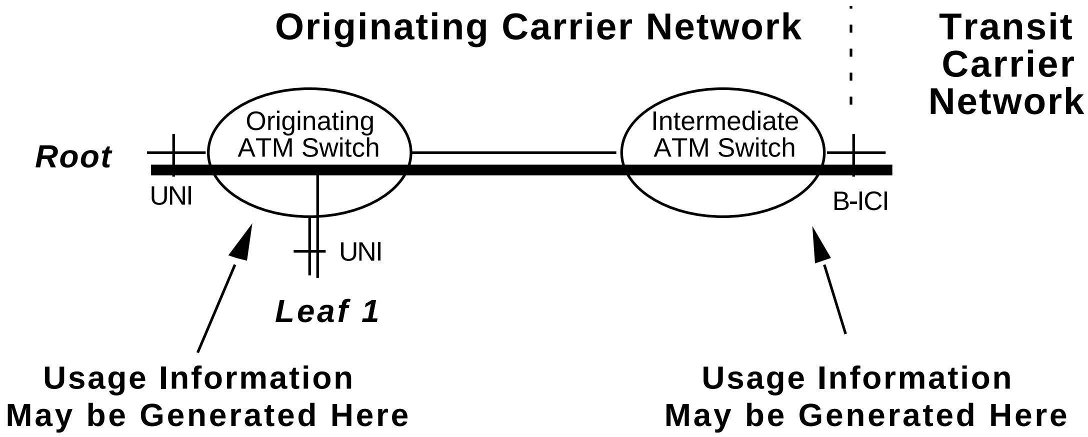


Figure 12.12 Point-to-Multipoint SVC in the Originating Carrier Network

Figure 12.13 illustrates the Terminating Carrier Network.

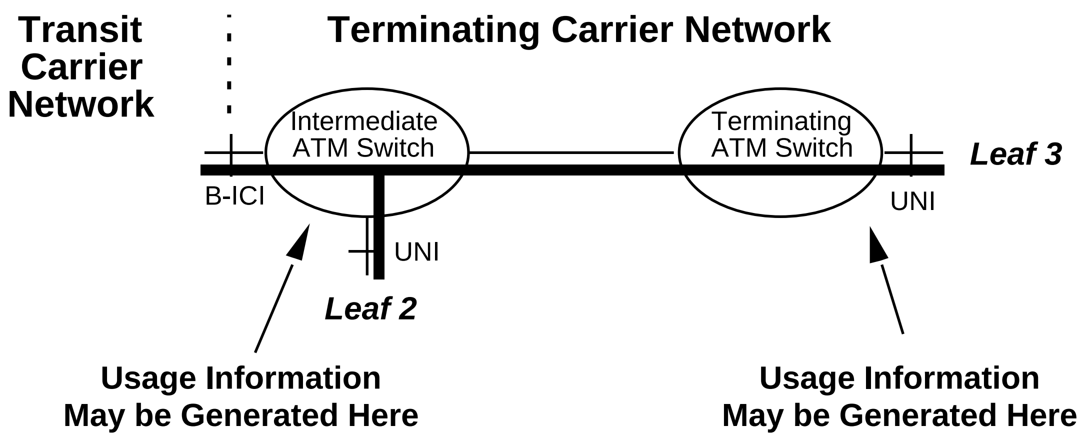


Figure 12.13 Point-to-Multipoint SVC in the Terminating Carrier Network

As illustrated in these figures, each network is capable of generating usage information for the listed communication paths.

Originating ATM Switch in the Originating Carrier Network:

- the communication path from the Root to Leaf 1
- the communication path from the Root to Leaf 2
- the communication path from the Root to Leaf 3

Intermediate ATM Switch in the Originating Carrier Network:

- the communication path from the Root to Leaf 2

- the communication path from the Root to Leaf 3

Intermediate ATM Switch in the Terminating Carrier Network:

- the communication path from the Root to Leaf 2
- the communication path from the Root to Leaf 3

Terminating ATM Switch in the Terminating Carrier Network:

- the communication path from the Root to Leaf 3

The usage information generated for the communication paths will have many common data elements. For instance, the following usage measurement data elements are the same for all communication paths provided by the Point-to-Multipoint SVC:

- Broadband Bearer Capability
- Quality of Service Class (when present)
- ATM Cell Rate Parameters

The following usage measurement data elements may vary (i.e., may be different for each communication path provided by the Point-to-Multipoint SVC):

- Calling Party (when present)
- Terminating Address
- Cause Value
- Carrier Identification Code
- Facility Identifiers (Incoming and Outgoing)
- OLIP (when present)
- Charge Number (when present)
- Connect Time
- Carrier Connect Time
- Cell Counts

The usage measurement data elements collected for the Point-to-Multipoint SVC may be formatted as one or more usage records by each ATM switch that generates usage measurement data. Data formatting is beyond the scope of this specification.

ACRONYMS

AAL	ATM Adaptation Layer
ACM	Address Complete Message
AESA	ATM End System Address
Ai	Signaling ID Assigned by Switch A
AIS	Alarm Indication Signal
ANI	Automatic Number Identification
ANM	Answer Message
ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
BBC	Broadband Bearer Capability
BCOB	Broadband Connection Oriented Bearer
BECN	Backward Explicit Congestion Notification
BHLI	Broadband High Layer Information
Bi	Signaling ID assigned by Switch B
B-ICI	BISDN Inter Carrier Interface
BISDN	Broadband Integrated Services Digital Network
BLA	Blocking Acknowledgment Message
BLLI	Broadband Low Layer Information
BLO	Blocking Message
BSS	Broadband Switching System
CAC	Connection Admission Control
CBDS	Connectionless Broadband Data Service
CBR	Constant Bit Rate
CCE	Consistency Check End Message
CCEA	Consistency Check End Acknowledge Message
CCITT	International Telephone and Telegraph Consultative Committee
CCR	Consistency Check Request Message
CCRA	Consistency Check Request Acknowledge Message
CdPN	Called Party Number
CDV	Cell Delay Variation
CES	Circuit Emulation Service
CFN	Confusion Message
CgPN	Calling Party Number
CIP	Carrier Identification Parameter
CLNS	Connection-Less Network Service
CLSF	Connection-Less Service Function
CLP	Cell Loss Priority
CPCS	Common Part Convergence Sublayer
CPE	Customer Premises Equipment
CPG	Call Progress Message
CRC	Cyclic Redundancy Check
CRS	Cell Relay Service
CSI	Carrier Selection Information
CS-2	Capability Set 2
CS-2.1	Capability Set 2, Step 1
DCC	Data Country Code
DCLI	Destination Connection Link Identifier
DE	Discard Eligibility
DLCI	Data Link Connection Identifier
DSID	Destination Signaling Identifier

EA	Address Extension
EFCI	Explicit Forward Congestion Indication
ESIG	European SMDS Interest Group
ETSI	European Telecommunications Standards Institute
EXM	Exit Message
FEBE	Far End Block Error
FECN	Forward Explicit Congestion Notification
FERF	Far End Receive Failure
FRS	Frame Relay Service
HEC	Header Error Control
IAA	IAM Acknowledgment Message
IAM	Initial Address Message
IAR	IAM Reject Message
ICD	International Code Designator
ICI	Inter Carrier Interface
ICIP	Inter Carrier Interface Protocol
ICIP_CLS	ICIP Connectionless Service
IE	Information Element
IEC	Inter Exchange Carrier
ILEC	Independent Local Exchange Carrier
INC	International Carrier
ITU	International Telecommunication Union
IWF	Inter-Working Function
LEC	Local Exchange Carrier
MF	Mapping Function
NNI	Network Node Interface
NPC	Network Parameter Control
PCR	Peak Cell Rate
PDH	Pleisiochronous Digital Hierarchy
PLCP	Physical Layer Convergence Procedure
OCLI	Origination Connection Link Identifier
OFI	Outgoing Facility Identifier
OLI	Originating Line Information
OSID	Origination Signaling Identifier
PMD	Physical Medium Dependent
PVC	Permanent Virtual Connection
QoS	Quality of Service
RAM	Reset Acknowledgment Message
RDI	Remote Defect Indicator
REL	Release Message
RLC	Release Complete Message
RSM	Reset Message
SAAL	Signaling ATM Adaptation Layer
SCR	Sustained Cell Rate
SDH	Synchronous Digital Hierarchy
SID	Signaling Identifier
SIG	SMDS Interest Group
SMDS	Switched Multi-megabit Data Service
SNI	Subscriber Network Interface
SONET	Synchronous Optical NETwork
SPE	Synchronous Payload Envelope
SSCF	Service Specific Coordination Function

SSCOP	Service Specific Connection Oriented Protocol
SSCS	Service Specific Convergence Sublayer
STS	Synchronous Transport Signal
SVC	Switched Virtual Connection
TNS	Transit Network Selection
UBA	Unblocking Acknowledgment Message
UBL	Unblocking Message
UDT	Unstructured Data Transfer
UNI	User Network Interface
UPA	User Part Available Message
UPT	User Part Test Message
VBR	Variable Bit Rate
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VPC	Virtual Path Connection
VPCI	Virtual Path Connection Identifier

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APPENDIX A - Initial Guidelines for FRS Traffic Characterization at the B-ICI

The FR traffic parameters can be used to determine approximately equivalent ATM traffic parameters as described below. Note that this description only provides the guidelines to characterize FR traffic in terms of ATM traffic conformance parameters; it does not specify ATM traffic conformance parameters that FR traffic must conform to. These guidelines are based on the traffic conformance parameters and functions described in the ATM Forum UNI Specification, 1993.

Note: The current text in this Appendix is expected to be revised if and when any updated version of the Traffic Management specification is available.

A.1 1-To-1 Mapping

The following methods can be used to characterize FR traffic in terms of ATM traffic conformance parameters for 1-to-1 mapping.

A.1.1 Method 1

This method characterizes FR traffic using 3 Generic Cell Rate Algorithms (GCRAs) as described in Example 2a in Appendix B of the ATM Forum UNI Specification, 1993.

For frames with 'n' user information bytes:

$$PCR_{0+1} = \frac{AR}{8}\left[OHA(n)\right]$$

$$SCR_0 = \frac{CIR}{8}\left[OHB(n)\right]$$

$$MBS_0 \approx \left[\frac{Bc}{8}\left(\frac{1}{1-\frac{CIR}{AR}}\right) + 1\right]\left[OHB(n)\right]$$

$$SCR_1 = \frac{EIR}{8}\left[OHB(n)\right]$$

$$MBS_1 \approx \left[\frac{Be}{8}\left(\frac{1}{1-\frac{EIR}{AR}}\right) + 1\right]\left[OHB(n)\right]$$

Where:

n = Number of user information octets in a frame

AR = Access Line Rate (bits/sec)

CIR = Committed Information Rate, $\frac{Bc}{T}$, (bits/sec)

EIR = Excess Information Rate, $\frac{Be}{T}$, (bits/sec)

CIR + EIR $\leq$ AR

Bc = Committed Burst size (bits)

Be = Excess Burst Size (bits)

T = Measurement Interval (sec)

PCR = Peak Cell Rate (cells/sec)

SCR = Sustained Cell Rate (cells/sec)

MBS = Maximum Burst Size (cells)

CDVT = Cell Delay Variation Tolerance (sec)

$\lceil X \rceil$ = Stands for the smallest integer greater than or equal to X

$$OHA(n) = \left[\frac{\left\lceil \frac{n+h1+h2}{48} \right\rceil}{n+h1+h3} \right]$$ = Overhead Factor for Access Rate (cells/byte)

h1 = Frame Relay Header Size (octets), 2-octet, 3-octet, or 4-octet headers

h2 = AAL Type 5 PDU Trailer Size (8 octets)

h3 = Frame Relay High-Level Data Link Control (HDLC) overhead of CRC-16 and Flags (4 octets)

$$OHB(n) = \left[\frac{\left\lceil \frac{n+h1+h2}{48} \right\rceil}{n} \right]$$ = Overhead Factor for Committed/Excess Rate (cells/byte)

Subscript 0+1, 0, or 1 applied to PCR, SCR, CDV, or MBS implies the parameter value for CLP = 0+1 cell stream, CLP = 0 cell stream, and CLP =1 cell stream, respectively.

In the above equations, (n+h1+h2) is the total size of an AAL Type 5 PDU containing the FR-SSCS-PDU corresponding to the n-octet frame. The overhead of FR-SSCS-PDU is h1 octets, the overhead of an AAL Type 5 PDU is h2 octets.

Note: At the IWF, in FR to ATM direction, a CDVT that includes the delay variation introduced by the IWF and the FR network needs to be specified. At the B-ICI, in FR to ATM direction, a CDVT that includes the delay variation introduced by the FR network, by the IWF, and by the ATM network segment between the IWF and the B-ICI needs to be specified. For example, CDVT value equal to $\frac{1}{PCR_{0+1}}$ may be appropriate for some networks. The $CDVT_{0+1}$ value should be negotiated for a bilateral agreement between the carriers.

For a typical connection (FR PVC) with variable size frames, networks can calculate PCR, CDV, SCR, and MBS using a typical frame size, using a mean frame size, or using the worst case scenario. If these values are expected to be used for traffic policing, then the worst case values should be used.

This choice and the resulting values of ATM traffic parameters that characterize the FR traffic should be decided by a bilateral agreement between the carriers.

Some examples for PCR_{0+1} and SCR_0 for 2 octet Frame Relay header are:

n = 1: $PCR_{0+1} = \frac{AR}{8}(1/7)$; $SCR_0 = \frac{CIR}{8}(1/1)$

n = 38: $PCR_{0+1} = \frac{AR}{8}(1/44)$; $SCR_0 = \frac{CIR}{8}(1/38)$

n = 8188: $PCR_{0+1} = \frac{AR}{8}(171/8194)$; $SCR_0 = \frac{CIR}{8}(171/8188)$

n -> ∞: $PCR_{0+1} = \frac{AR}{8}(1/48)$; $SCR_0 = \frac{CIR}{8}(1/48)$

The factor OHB(n) represents the overhead of FR-SSCS and a AAL Type 5 Common Part (CP). Let us call this factor the "overhead factor". The overhead can be viewed to consist of two components:

(a) Fixed overhead of (h1+h2) bytes per frame.

(b) Variable overhead of 0 to 47 bytes per frame.

If frame length distribution is uniform or exponential, the component (b) of the overhead has a mean value of $23.5 \approx 24$ bytes per frame.

A.1.2 Method 2

This method characterizes the FR traffic using 2 GCRAs, as described in Example 2b in Appendix B of the ATM Forum UNI Specification, 1993.

Two options are described here to characterize FR traffic using the GCRA configuration of Example 2b in Appendix B of the ATM Forum UNI Specification, 1993.

Option 1:

$$PCR_{0+1} = \frac{AR}{8} \left[OHA\ (n) \right]$$

$$SCR_0 = \frac{CIR}{8} \left[OHB\ (n) \right]$$

$$MBS_0 \approx \left[\frac{Bc}{8} \left(\frac{1}{1 - \frac{CIR}{AR}} \right) + 1 \right] \left[OHB\ (n) \right]$$

This method does not provide a direct characterization of Be or EIR. The allowed EIR can be derived using the difference between the AR and the CIR, both expressed in cells per second.

$$\text{Allowed EIR} = \frac{8\left[PCR_{0+1} - SCR_0 \right]}{OHB(n)} = \frac{AR}{8} \left[\frac{n}{n+h1+h2} \right] - \frac{CIR}{8}$$

$$\text{Allowed Be} \approx \infty$$

If originally negotiated FR EIR (i.e., Be/T) is the same as the "Allowed EIR" above, then this Method is equivalent to Method 1.

Note: At the IWF, in FR to ATM direction, a CDVT that includes the delay variation introduced by the IWF and the FR network needs to be specified. At the B-ICI, in FR to ATM direction, a CDVT that includes the delay variation introduced by the FR network, by the IWF, and by the ATM network segment between the IWF and the B-ICI needs to be specified. For example, CDVT value equal to $\frac{1}{PCR_{0+1}}$ may be appropriate for some networks. The $CDVT_{0+1}$ value should be negotiated for a bilateral agreement between the carriers.

For a typical connection (FR PVC) with variable size frames, networks can calculate PCR, CDV, SCR, and MBS using a typical frame size, using a mean frame size, or using the worst case scenario. If these values are expected to be used for traffic policing, then the worst case values should be used.

This choice and the resulting values of ATM traffic parameters that characterize the FR traffic should be decided by a bilateral agreement between the carriers.

Option 2:

$$PCR_{0+1} = \left[\frac{CIR + EIR}{8} \right] \left[OHB(n) \right]$$

$$SCR_0 = \frac{CIR}{8} \left[OHB(n) \right]$$

$$MBS_0 \approx \left[\frac{Bc}{8} \left(\frac{1}{1 - \frac{CIR}{AR}} \right) + 1 \right] [OHB\ (n)]$$

This method does not provide a characterization of AR.

Notes:

1. This method implies that FR traffic is shaped to achieve a PCR_{0+1} of [CIR + EIR] [OHB(n)]/8.

2. It is possible to view [CIR + EIR] [OHB(n)]/8 as SCR_{0+1} rather than PCR_{0+1}; and choose MBS_{0+1} to be:

$$\left[\frac{Bc + Be}{8} \right] \left[\left(\frac{1}{1 - \frac{CIR+EIR}{AR}} \right) + 1 \right] [OHB\ (n)]$$

   In this case, an alternative method, again using 2 GCRAs could be defined. The configuration of these 2 GCRAs is similar to the GCRA configuration in Example 2b in Annex A of the ATM Forum UNI Specification, 1993; with the difference that the GCRA in relation to PCR_{0+1} is replaced by GCRA in relation to SCR_{0+1}.

3. At the IWF, in FR to ATM direction, a CDVT that includes the delay variation introduced by the IWF and the FR network needs to be specified. At the B-ICI, in FR to ATM direction, a CDVT that includes the delay variation introduced by the FR network, by the IWF, and by the ATM network segment between the IWF and the B-ICI needs to be specified. For example, CDVT value equal to $\frac{1}{PCR_{0+1}}$ may be appropriate for some networks. The $CDVT_{0+1}$ value should be negotiated for a bilateral agreement between the carriers.

For a typical connection (FR PVC) with variable size frames, networks can calculate PCR_{0+1}, $CDVT_{0+1}$, SCR_0, and MBS_0, using a typical frame size, using a mean frame size, or using the worst case scenario. If these values are expected to be used for traffic policing, then the worst case values should be used.

This choice and the resulting values of ATM traffic parameters that characterize the FR traffic should be decided by a bilateral agreement between the carriers.

The choice of Method 1 or Method 2, or a value of PCR_{0+1} between the values given by Method 1 and Method 2 should also be determined by a bilateral agreement between the carriers.

A.2 N-to-1 Mapping

For N-to-1 mapping, the following methods can be used to characterize FR traffic in terms of ATM traffic conformance parameters.

A.2.1 Method 1

This method is suitable only when the number of DLCIs multiplexed in a VCC is large. This method is based on the assumption that statistical multiplexing of traffic from several DLCIs will yield a smooth traffic that can be characterize by the PCR.

$$PCR_{0+1} \approx \sum_{\text{All DLCIs}} \left[\frac{CIR + EIR}{8} \right] \left[OHB(n) \right]$$

A smaller value of PCR_{0+1} can be negotiated between the carriers for a bilateral agreement. If all DLCIs mapped in a VCC are not expected to simultaneously transmit (receive) at [CIR + EIR], it is reasonable to use a PCR_{0+1} value smaller than that obtained from the above equation.

The determination of CDVT involves the same considerations as those for 1-to-1 mapping.

A.2.2 Method 2

This method provides characterization of N-to-1 mapped FR traffic in terms of PCR and SCR.

This method does not assume the traffic smoothing effect of statistical multiplexing, and accommodates the worst case.

$$PCR_{0+1} = \sum_{\text{All Interfaces}} \frac{AR}{8} \left[OHA(n) \right]$$

$$= \sum_{\text{All Interfaces}} \left[PCR_{0+1} \text{ Calculated as per 1-to-1 Mapping Method 1} \right]$$

$$SCR_0 = \sum_{\text{All DLCIs}} \frac{CIR}{8} \left[OHB(n) \right]$$

$$= \sum_{\text{All DLCIs}} \left[SCR_0 \text{ Calculated as per 1-to-1 Mapping Method 1} \right]$$

$$MBS_0 \approx \sum_{\text{All DLCIs}} \left[\frac{Bc}{8} \left(\frac{1}{1 - \frac{CIR}{AR}} \right) + 1 \right] \left[OHB\ (n) \right]$$

$$\approx \sum_{\text{All DLCIs}} \left[MBS_0 \text{ Calculated as per 1-to-1 Mapping Method 1} \right]$$

SCR_1 and MBS_1 can similarly be determined.

The determination of CDVT involves the same considerations as those for 1-to-1 mapping.

For typical connections (FR PVCs) with variable size frames, networks can calculate PCR_{0+1}, $CDVT_{0+1}$, SCR_0, SCR_1, MBS_0, and MBS_1, using a typical frame size, using a mean frame size, or using the worst case scenario. If these values are expected to be used for traffic policing, then the worst case values should be used.

This choice and the resulting values of ATM traffic parameters that characterize the FR traffic should be decided by bilateral agreement between the carriers.

APPENDIX B - Mandatory/Optional Status of BISUP Parameters

In the following table, each parameter is identified as being Mandatory (M), Optional (O), or Not Applicable (no entry) for each message. Message acronyms (e.g., IAM) are spelled out in full in the Acronyms list.

Table B-1 Parameters of Each Message (Part 1)

Parameter	Mandatory/Optional							
	ACM	ANM	BLA	BLO	CCE	CCEA	CCR	CCRA
AAL parameters		O						
Additional ATM cell rate								
AESA for called party								
AESA for calling party								
ATM cell rate								
Automatic congestion level								
Broadband bearer capability								
Broadband high layer information								
Broadband low layer information		O						
Called party's indicators	M							
Called party number								
Called party subaddress								
Calling party number								
Calling party subaddress								
Calling party's category								
Carrier identification code								
Cause indicators								
Carrier selection information								
Charge number								
Connection element identifier								
Consistency check result information						M		
Destination connection link identifier								
Destination signaling identifier	M	M	M		M	M		M
Leaf party type								
Originating line information								
Origination connection link identifier								
Origination signaling identifier				M			M	M
Outgoing facility identifier								
Quality of service								
Resource identifier				M			M	
Transit network selection								

Table B-1 Parameters of Each Message (Part 2)

Parameter	Mandatory/Optional							
	CFN	CPG	EXM	IAA	IAM	IAR	RAM	REL
AAL parameters					O			
Additional ATM cell rate					O			
AESA for called party					O			
AESA for calling party					O			
ATM cell rate					M			
Automatic congestion level						O		O
Broadband bearer capability					M			
Broadband high layer information					O			
Broadband low layer information					O			
Called party's indicators		O						
Called party number					M			
Called party subaddress					O			
Calling party number					O			
Calling party subaddress					O			
Calling party's category					M			
Carrier identification code					O			
Cause indicators	M					M		M
Carrier selection information					O			
Charge number					O			
Connection element identifier				O	O			
Consistency check result information								
Destination connection link identifier					Note1			Note3
Destination signaling identifier	M	M	M	M		M	M	M
Leaf party type					Note4			
Originating line information					O			
Origination connection link identifier				Note2	Note2			
Origination signaling identifier				M	M			
Outgoing facility identifier			O					O
Quality of service					M			
Resource identifier								
Transit network selection					O			
Originating ISC point code					O			

Note 1 - (IAM) This parameter is mandatory for the addition of a new leaf to an existing connection. It is not applicable for point-to-point calls.

Note 2 - (IAM & IAA) This parameter is mandatory for the establishment of a new connection link in a point-to-multipoint call. It is not applicable for point-to-point calls.

Note 3 - (REL) This parameter is mandatory for the en-bloc release of call/connection requested by the root party in a point-to-multipoint call. It is not applicable for point-to-point calls.

Note 4 - (IAM) This parameter is mandatory for point-to-multipoint calls. It is not applicable for point-to-point calls.

Table B-1 Parameters of Each Message (Part 3)

Parameter	Mandatory/Optional			
	RLC	RSM	UBA	UBL
AAL parameters				
Additional ATM cell rate				
AESA for called party				
AESA for calling party				
ATM cell rate				
Automatic congestion level				
Broadband bearer capability				
Broadband high layer information				
Broadband low layer information				
Called party's indicators				
Called party number				
Called party subaddress				
Calling party number				
Calling party subaddress				
Calling party's category				
Carrier identification code				
Cause indicators	O			
Carrier selection information				
Charge number				
Connection element identifier				
Consistency check result information				
Destination connection link identifier				
Destination signaling identifier	M		M	
Leaf party type				
Originating line information				
Origination connection link identifier				
Origination signaling identifier		M		M
Outgoing facility identifier				
Quality of service				
Resource identifier		M		M
Transit network selection				

APPENDIX C - Illustration of Use of VPCI

C.1 Introduction

This Appendix identifies issues surrounding the use of the VPCI in signaling for SVC call setup within Permanent Virtual Path Connections. A sample problem which raised the issues is captured in Figure C1:

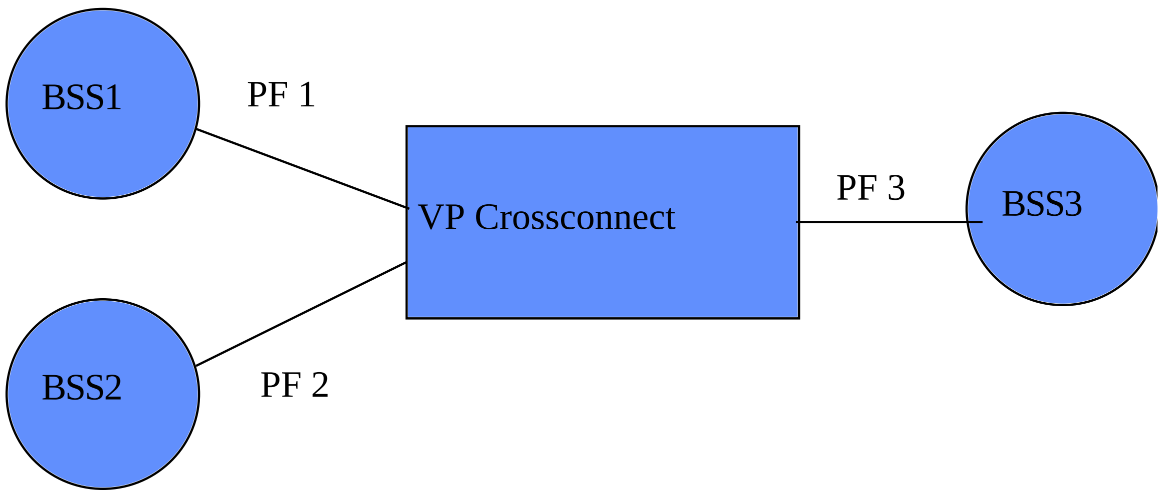

Figure C1 Merging Physical Facilities onto a Single Facility

Note: PF # refers to Physical Facility #.

If BSS1 has a Virtual Path Connection (VPC) over PF 1 and PF 3 to BSS3, and BSS2 has a VPC over PF 2 and PF 3 to BSS3, are the VPs merged over PF 3 into a single VP? Also, how is signaling for setting up SVCs handled? If the signaling channel is VPI 0, VCI 5 for both PF 1 and PF 2, are they merged in some way onto VPI 0, VCI 5 on PF 3? The answers can be found in the ATM Forum UNI 3.1, B-ICI Version 2.0 specifications (Section 7.8), and Bellcore's GR-1417-CORE, "Broadband Switching System SS7 Requirements Using BISUP SS7 and ATM Protocols for Broadband".

C.2 B-ISUP Signaling Links

There is some misconception in the industry that the signaling channel for a virtual path is always carried over VPCI 0, VCI 5. In fact, B-ICI signaling uses "signaling links" which can be carried in any VPCI. VCI 5 is reserved for signaling links, and each signaling link shall use this VCI value. While each VPC shall be able to support a signaling link, the BSS is not required to have a signaling link for each VPC since a signaling link can be used to transport signaling messages associated with multiple VPCs.

The set of signaling links that directly interconnect two signaling points constitute a "signaling link set". All signaling links in a signaling link set must operate at the same speed.

For the question posed above, signaling from BSS1 and BSS2 is not merged, but is kept in distinct signaling link sets.

Routing of SS7 messages is performed by the MTP layer. Routing of signaling messages involves selecting an outgoing signaling link from the signaling link set that will efficiently deliver a signaling message to its proper destination node.

Additional requirements regarding transport of MTP level 3 user messages, support of Message Sequencing procedures, and support of Load Sharing procedures are found in GR-1417-CORE.

Finally, merging VPs into a single VP is not allowed. VPs must be set up on a per switch pair basis (see Figure C2).

C.3 Definition and Use of VPCI/VCI

When a BSS sets up a call to another BSS through a Virtual Path, it is necessary that the Virtual Path be identified by the same value at both BSSs. Since an ATM VP can pass through an ATM VP Crossconnect and the VP Crossconnect can perform a translation of the VPIs, it is necessary to define another value, called a Virtual Path Connection Identifier (VPCI), which is unambiguous and identical at both ends of a Virtual Path Connection, i.e., is unique for each pair of BSSs (see B-ICI Version 2.0, Section 7.12). If no VP Crossconnect exists between the BSSs, then the VPI and the VPCI can be the same.

Between the two BSSs each BSS is responsible for assigning bandwidth and the VPI/VCIs for about half of the VPCIs. For every VPCI it shall be defined which BSS controls the VPCI (i.e., is the assigning switch). The default mechanism calls for the BSS with the higher signaling point code to be the assigning switch for all even numbered VPCI values, and the other BSS be the assigning switch for all odd numbered VPCI values.

For an outgoing call/connection, a BSS shall first attempt to use a VPCI which it controls. If it has a VPCI that satisfies the CAC requirements, the BSS sends an Initial Address Message (IAM) over a signaling channel in the signaling link set. The IAM will contain the Connection Element Identifier (CEI) parameter which, in turn, contains the VPCI/VCI values to be used. If the BSS does not have a VPCI which it controls that satisfies the CAC requirements for the call or has run out of VPCI/VCIs, then the BSS sends the IAM without the CEI parameter. In this case, the far end BSS will be expected to assign a VPCI/VCI from the set of VPCIs it controls.

The VPCI subfield (octets 1 and 2) of the CEI shall contain the VPCI code expressed in pure binary. Bit 8 of octet 1 is most significant and Bit 1 of octet 2 is least significant. The VCI subfield (octets 3 and 4) shall contain the VCI code expressed in pure binary. Bit 8 of octet 3 is most significant and bit 1 of octet 4 is least significant.

VCI values 0 to 31 are reserved by the ITU-T and shall not be assigned. (Refer to Section 2.5.2 of GR-1113-CORE for the usage of VCI values in this reserved range.)

These concepts are illustrated in Figure C2.

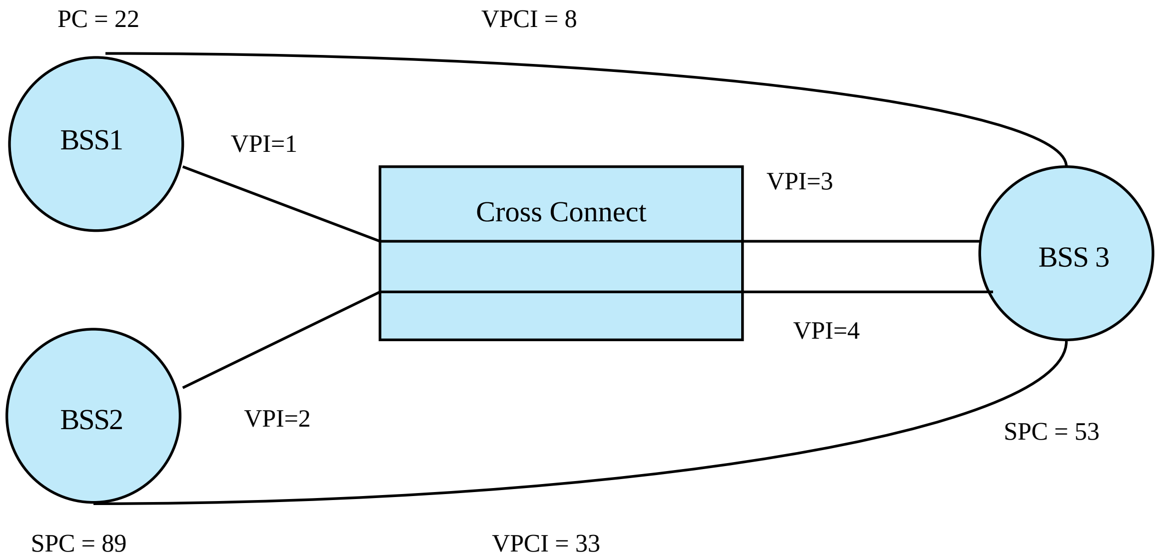

Figure C2 Illustration of VPCIs

In this figure, BSS1 has a physical facility to the VP Crossconnect; this facility contains a virtual path with VPI = 1. In the VP Crossconnect, the cells in this virtual path will have their VPI translated to VPI = 3 before being sent to BSS3. Also, BSS2 has a physical facility to the VP Crossconnect; this facility contains a virtual path with VPI = 2. In the VP Crossconnect, cells with this VPI are translated to VPI = 4 before being sent to BSS3 in the same physical facility that carries cells with VPI = 3.

In order to set up calls, VPCI 8 is assigned for the VPC using VPI 1 and VPI 3 between BSS1 and BSS3, and VPCI 33 is assigned for the VPC using VPI 2 and VPI 4 between BSS2 and BSS3. Note that in order to have unambiguous VPCIs, the facility that carries VPCI 8 between the cross-connect and BSS3 cannot also have a VPCI 8 as part of a VPC between BSS2 and BSS3. Similarly for VPCI 33.

Using the default procedure, the assigning switch for VPCI 8 is BSS3 (since the Signaling Point Code for BSS3 is higher than that for BSS1 and the VPCI is even). The assigning switch for VPCI 33 is also BSS3 (since the Signaling Point Code for BSS3 is smaller than that for BSS2 and the VPCI is odd). In both cases, the non-assigning switch does not assign but requests the assigning switch to assign both VPCI/VCI and bandwidth. For example, in the above figure if BSS2 wants to make a VCC to BSS3 but has no VPCI/VCIs available which it controls, it would send an IAM to BSS3 over a signaling link in the signaling link set; this IAM would not contain a CEI parameter. BSS3 would then assign a VCI in a VPCI which it controls (say VPCI 33, assuming sufficient bandwidth for the CAC) and return the VPCI/VCI (in the CEI) in an IAM Acknowledge message (IAA).