The ATM Forum

Technical Committee

Circuit Emulation Service

Interoperability Specification

AF-SAA-0032.000

September, 1995

Notice:

Bellcore asserts that its U.S. Patent No 5,260,978 for Synchronous Residual Timestamp (SRTS) Timing Recovery in a Broadband Network may apply to the ATM Adaptation Layer Type 1 (AAL1) ANSI standard (T1.630-1993) referenced in Section 3.4 of this specification.

1 Introduction

There is a user demand for carrying certain types of constant bit rate (CBR) or "circuit" traffic over Asynchronous Transfer Mode (ATM) networks. As ATM is essentially a packet- rather than circuit-oriented transmission technology, it must emulate circuit characteristics in order to provide good support for CBR traffic.

A critical attribute of a Circuit Emulation Service (CES) is that the performance realized over ATM should be comparable to that experienced with the current TDM technology.

1.1 Purpose of Document

This document -- referred to as the Circuit Emulation Service Interoperability Specification (CES-IS) --specifies the ATM Forum's interoperability agreements for supporting CBR traffic over ATM networks that comply with the Forum's other interoperability agreements.

1.2 Scope of Document

The CES-IS specifically covers the following types of CBR service:

1. Structured DS1/E1 Nx64 kbit/s (Fractional DS1/E1) Service
2. Unstructured DS1/E1 (1.544 Mbit/s, 2.048 Mbit/s) Service

The Structured Nx64 and Unstructured services described in this document offer two ways to connect DS1/E1 equipment across emulated circuits carried on an ATM network. The two techniques can be used to solve different kinds of problems:

The Structured DS1/E1 Nx64 service is modelled after a Fractional DS1/E1 circuit, and is useful in the following situations:

1. The Nx64 service can be configured to minimize ATM bandwidth, by only sending the timeslots that are actually needed.
2. The Nx64 service provides clocking to the end-user equipment, so it fits into a fully-synchronous network environment.
3. Because it terminates the Facility Data Link, the Nx64 service can provide accurate link quality monitoring and fault isolation for the DS1/E1 link between the IWF and the end-user equipment

The Unstructured DS1/E1 Service is modelled after an asynchronous DS1/E1 circuit with repeaters. It should be used in the following situations:

1. When non-standard framing is used by the end-user DS1/E1 equipment.
2. When end-to-end communication of the Facility Data Link or Alarm states is important.
3. When timing must be supplied by the end-user DS1/E1 equipment and carried through the network.
4. When simple configuration of the service is important. Unstructured has relatively few configuration options, so configuration requires less detailed knowledge of telco practices.

The scope of the CES-IS is limited to the essential agreements needed to reliably transport these bit rates across ATM networks that comply with the ATM Forum's interoperability agreements. Specifying all the agreements needed to support a full service offering (for example, ATM-based video telephony) is explicitly beyond the scope of this document.

1.3 Structure of Document

Section 1 is an introduction and contains some technical material relating to both types of service. Sections 2 and 3 cover Structured DS1/E1 Nx64 kbit/s and Unstructured Service, respectively. Each of these sections covers the following topics:

1. Service description
2. Service-specific AAL 1 requirements (e.g., clocking and error recovery)
3. AAL user entity requirements (e.g., data coding/formatting, signalling)

Section 4 discusses service-specific ATM Layer requirements (e.g., cell rate and delay requirements), section 5 describes ATM signalling parameters, and section 6 discusses the management of the CES service.

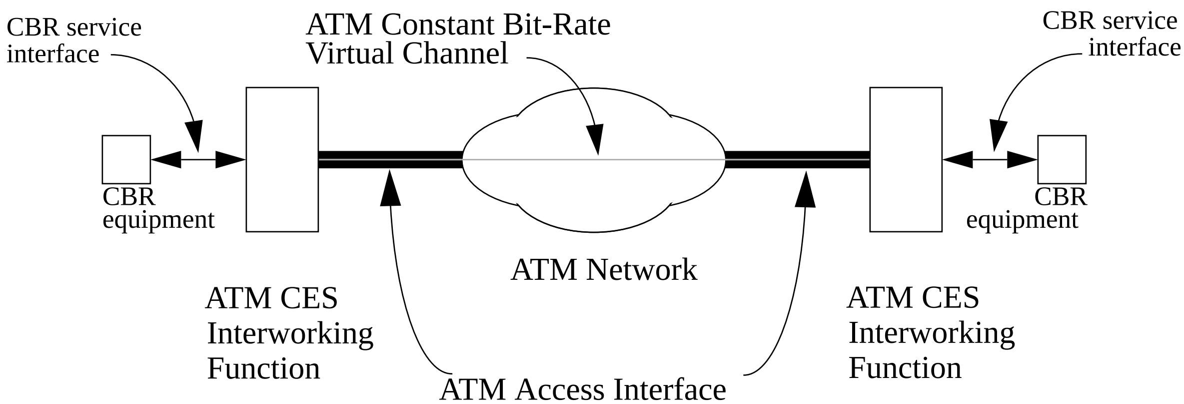
1.4 Terminology

This document uses three levels for indicating the degree of compliance necessary for specific functions, procedures and coding associated with the Circuit Emulation specification:

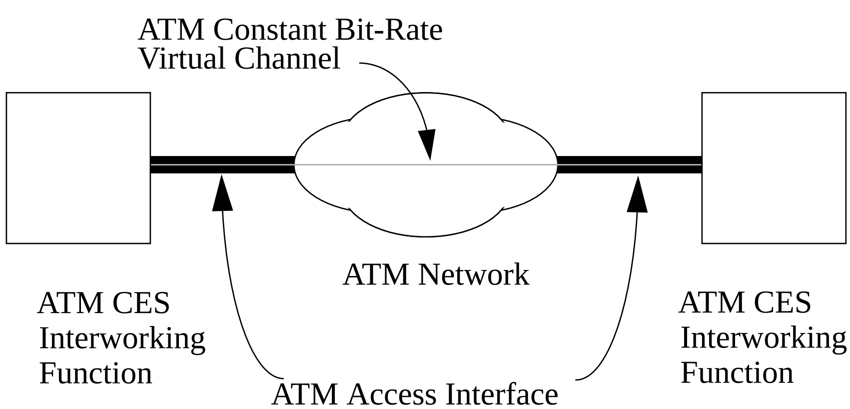
- **Requirement (R)**: Functions, procedures and coding necessary for operational compatibility.
- **Conditional Requirements (CR)**: functions, procedures and coding necessary providing the specified optional function is implemented.
- **Option (O)**: functions, procedures and coding that may be useful, but are not necessary for operational compatibility.

1.5 Reference Model and Terms

Figure 1-1 provides a reference model for circuit emulation services. Figure 1-1a) pictures two ATM Circuit Emulation Service (CES) Interworking Functions (IWFs) connected to an ATM network via physical interfaces defined in the ATM Forum UNI Specification. The CES IWFs are also connected to standard constant bit-rate (CBR) circuits (e.g., DS1 or E1). The job of the two IWFs is to extend the constant bit-rate circuit to which they are connected across the ATM network. They are to do this in a manner that is transparent to the terminals of the CBR circuit. The assumption in the CES-IS is that using AAL 1 over ATM constant bit-rate virtual channels is a simple, general, and effective method of addressing this type of application.



a) CES IWFs with CES-IS-Specified Physical DS1 or E1 Service Interfaces



b) CES IWFs with Unspecified Service Interfaces ("Logical" Service)

Figure 1-1: Circuit Emulation Service Reference Model

Figure 1-1b) shows a similar arrangement, but does not make any external physical interfaces explicit. This is intended to show that CES can be used to provide a "logical" structured or unstructured DS1/E1 service, even if that service is not used to bridge between existing traditional DS1- or E1-based circuits. It is also possible of course that one IWF would interface to a DS1- or E1-based circuit and the other would not.

1.6 References

1.6.1 Normative

UNI 3.1, ATM Forum User-Network Interface (UNI) Specification

B-ICI 1.1, ATM Forum Broadband Intercarrier Interconnect (B-ICI) Specification

ANSI T1.630-1993, B-ISDN ATM Adaptation Layer CBR Services

ANSI T1.627-1993, B-ISDN ATM Layer Functionality and Specification

ITU-T I.356-1993 B-ISDN ATM layer cell transfer performance

ITU-T I.362-1993 B-ISDN ATM adaptation layer (AAL) functional description

ITU-T I.363.X (ITU-T Study Group 13, Report R32) November, 1994, B-ISDN ATM Adaptation Layer (AAL) Specification, Types 1 and 2

ANSI T1.102-1993 Revised - Digital Hierarchy — Electrical Interfaces

ANSI T1.107A-1990, Digital Hierarchy — Formats Specification

ANSI T1.403-1989, Carrier-to-Customer Installation — DS1 Metallic Interface

ANSI T1.408-1990, Integrated Services Digital Network (ISDN) Primary Rate -- Customer Installation Metallic Interfaces Layer 1 Specification

ITU-T G.824-1993, The control of jitter and wander within digital networks which are based on the1544 kbit/s digital hierarchy

Bellcore TR-NWT-000170, Issue 2, January, 1993, Digital Crossconnect System Generic Requirements and Objectives

ITU-T G.702-1988 Digital hierarchy bit rates

ITU-T G.703-1991 Physical/electrical characteristics of hierarchical digital interfaces

ITU-T G.704-1991 Synchronous frame structures used at Primary and secondary hierarchical levels

ITU-T G.709-1993 Synchronous multiplexing structure

ITU-T G.823-1993, The control of jitter and wander within digital networks which are based on the 2048 kbit/s digital hierarchy

IETF Draft RFC1406, Definitions of the Managed Objects for the DS1 and E1 Interface Types

IETF RFC1573, Evolution of Interfaces Group of MIB-II, January 1994.

IETF RFC1407, Definitions of Managed Objects for the DS3/E3 Interface Type, January 1993.

IETF RFC1406, Definitions of Managed Objects for the DS1/E1 Interface Type, January 1993.

IETF RFC1595, Definitions of Managed Objects for the SONET/SDH Interface Type, March 1994.

1.6.2 Informative

ETSI ETS 300 353 B-ISDN ATM adaptation layer (AAL) specification type 1

Bellcore GR-1113-CORE, Issue 1, July, 1994, Asynchronous Transfer Mode (ATM) and ATM Adaptation Layer (AAL) Protocols

Bellcore TA-NWT-001110, Issue 2, August 1993, Broadband ISDN Switching Systems Generic Requirements

Bellcore TA-TSV-001409, Issue 1, November 1993, Generic Requirements for Exchange Access PVC Cell Relay Services.

DTR/NA-52622 Optional aspects of AAL type 1

ANSI T1M1.3/92-005R1

ANSI T1.510-1994, Network Performance Parameters for Dedicated Digital Services — Specifications.

ANSI T1.511-1994, B-ISDN ATM Layer Cell Transfer Performance Parameters.

1.7 ATM Physical Interfaces

An ATM UNI physical interface has two characteristics that are relevant when supporting CES Service:

1. Bandwidth - the ATM interface must provide adequate bandwidth to carry Nx64 or Unstructured traffic after segmentation.
2. Timing - the ATM interface can be used to convey timing traceable to a Primary Reference Source from the ATM network to the CES Interworking Function.

2 Structured DS1/E1 Nx64 Kbit/s Service

A number of applications currently use Nx64 kbit/s services. For example, there are a number of DTE interfaces and video codecs that are capable of operating at Nx64 kbit/s rates for N>1. Within this section, the following conventions apply:

Nx64 Service = All modes of the Structured DS1/E1 Nx64 kbit/s Service.

DS1 Nx64 Service = All modes of Structured DS1/E1 Nx64 kbit/s Service in which the two IWFs involved are emulating DS1-based Nx64 kbit/s service supplied via a DSX-1 interface.

E1 Nx64 Service = All modes of Structured DS1/E1 Nx64 kbit/s Service in which the two IWFs involved are emulating E1-based Nx64 kbit/s service supplied via a G.703 interface.

DS1 Nx64 Basic Service = DS1 Nx64 Service with no support for carrying channel associated signaling (CAS).

E1 Nx64 Basic Service = E1 Nx64 Service with no support for carrying CAS.

DS1 Nx64 Service w/CAS = DS1 Nx64 Service with support for carrying CAS.

E1 Nx64 Service w/CAS = E1 Nx64 Service with support for carrying CAS.

Logical Nx64 Service = All modes of Structured DS1/E1 Nx64 kbit/s Service in which the non-ATM-related functions of the two IWFs involved are left unspecified.

Logical Nx64 Basic Service = Logical Nx64 Service with no support for carrying CAS.

Logical Nx64 Service w/CAS = Logical Nx64 Service with support for carrying CAS.

Figure 2-1 shows the relationships among the members of the Nx64 Services family.

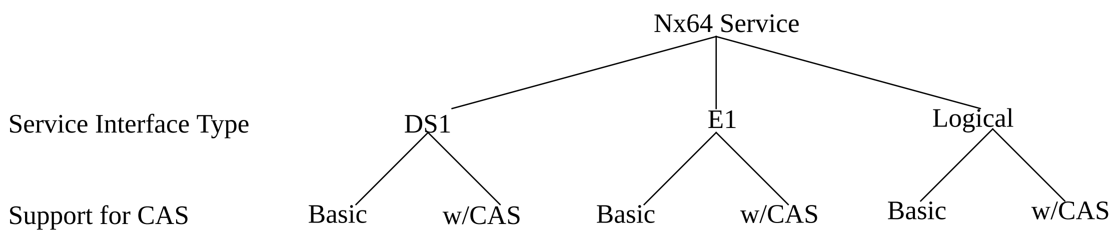


Figure 2-1: Nx64 Service Taxonomy

2.1 Service Description

Nx64 Service is intended to emulate a point-to-point Fractional DS1 or E1 circuit. The service is typically accessed via either 1.544 Mbit/s DSX-1 interfaces or 2.048 Mbit/s G.703 interfaces. For DS1, N of the 24 timeslots available at the DSX-1 interface, where N can be as small as 1 or as large as 24, are carried across the ATM network and reproduced at the output edge. For E1, N can be as small as 1, or as large as 31.

Because the Nx64 Service can be configured to use only a fraction of the timeslots available on the Service Interface, it is possible to allow several independent emulated circuits to share one Service Interface, as shown in Figure 3-1. The capability of allowing several AAL1 Entities to share one Service Interface, where each AAL1 Entity is associated with a different Virtual Channel Connection (VCC), allows for functional emulation of a DS1/DS0 or E1/DS0 Digital Crossconnect Switch.

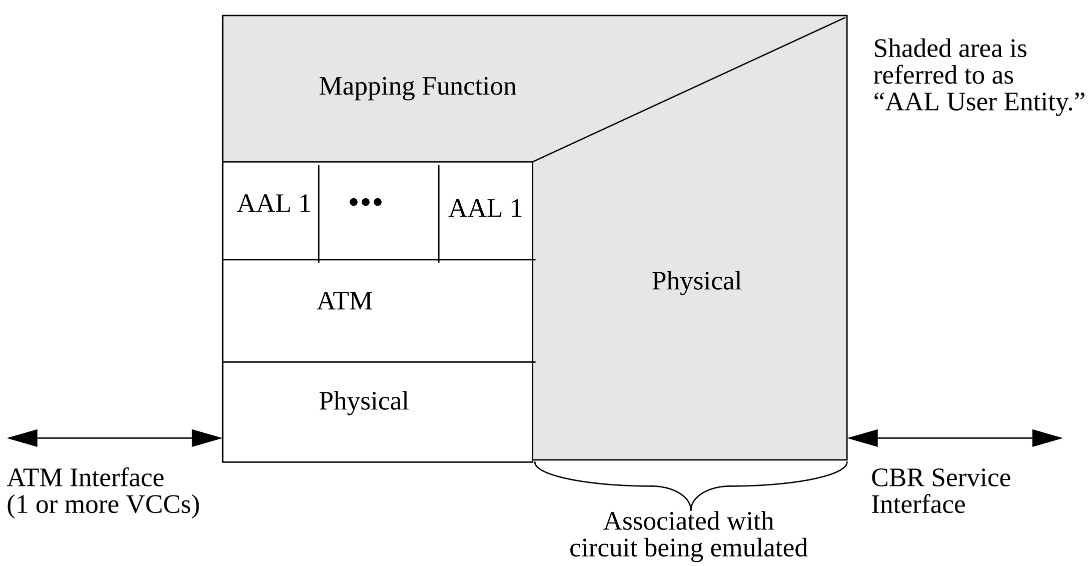


Figure 2-2: DS1/E1 Structured Service Interworking Function—Layering Perspective

In this configuration:

1. The ATM layer is responsible for multiplexing and demultiplexing several VCCs, one to each AAL1 Entity.
2. Each AAL1 Entity is responsible for performing segmentation and reassembly on one VCC.
3. The Timeslot Mapping Function is responsible for assigning the stream input and output from the SAR process to specific time slots in the Service

Figure 2-3 shows an example crossconnect configuration in which two PBXs are connected across an ATM backbone to a Central Office switch. One virtual channel might carry 10 timeslots between one PBX and the Central Office switch; another virtual channel might carry 10 timeslots between the other PBX and the Central Office Switch. At the IWF near the Central Office switch, the two virtual channels are reassembled, and a total of 20 timeslots are carried across the last DS1/E1 link connecting the Central Office switch and its CES IWF. Although the Nx64 Service should be useful in providing a crossconnect service, it is outside the scope of the current CES-IS to specify crossconnect service, such as that defined in Bellcore TR-NWT-000170.

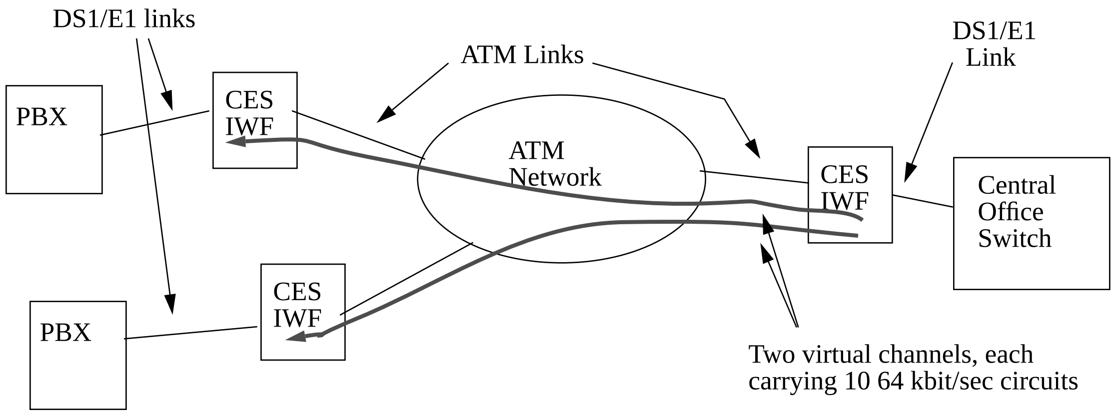


Figure 2-3: Crossconnect Example

(R) A CES IWF providing Nx64 Service shall provide at least one AAL1 Entity.

(O) A CES IWF providing Nx64 Service may provide multiple AAL1 Entities, allowing several Nx64 connections to be multiplexed onto each Service Interface.

2.1.1 Framing

(R) DS1 Nx64 Service shall be capable of interfacing with circuits using Extended Superframe Format.

(O) DS1 Nx64 Service may provide SF framing at a DS1 Service Interface.

(R) E1 Nx64 Service shall be capable of interfacing with circuits using G.704 framing.

2.1.2 Timeslot Assignment

(R) The Nx64 Service shall carry any group of up to 24 (31 for E1) 64 kbit/sec timeslots.

The timeslots assigned to a virtual channel are not required to be contiguous. Timeslots are assigned to a virtual circuit by MIB variables, and it should be noted that the assignment of timeslots is not required to be the same on the input and output ends of the virtual channel. Even though the timeslot assignment on input and output may be different, the CES IWFs must deliver octets at the output in the same order as they were received at the input. The Nx64 service also must maintain 125-µsec frame integrity across a virtual channel. For example, given a 2x64 kbit/s emulated circuit, two octets that are sent into the input IWF's Service Interface in one frame shall be delivered at the output IWF's Service Interface in one frame, and in the same order.

2.1.3 Clocking

(R) An Nx64 Service IWF shall provide a means by which a timesource traceable to a Primary Reference Source (PRS) may be supplied.

(R) For DS1 Service, an IWF Service Interface shall provide 1.544 MHz timing to external DS1 equipment.

(R) For E1 Nx64 Service, an IWF Service Interface shall provide 2.048 MHz timing to external E1 equipment.

Section 2.4 gives more information about clock distribution techniques.

2.1.4 Jitter and Wander

(R) Jitter measured at the output of the IWF Service Interface must meet ANSI T1.403 and G.824 for DS1 circuits.

(R) Wander must meet ANSI T1.403 and G.824 for DS1 circuits.

(R) Jitter measured at the output of the IWF Service Interface must meet G.823 for E1 circuits.

(R) Wander must meet G.823 for E1 circuits.

ANSI T1.403-1989 Section 5.7.5 specifies that wander shall not exceed 28 UI (18 µsec) peak-to-peak in any 24-hour period. Recommendations G.823 and G.824 require that network wander be maintained at less than 10 µsec over any 10 000 second interval (approximately 3 hours).

2.1.5 Facility Data Link

This section applies only to DS1 ESF Nx64 service.

The Facility Data Link associated with the Service Interface is terminated at the ESF/G.704 sublayer in the Interworking Function.

The Facility Data Link is used to carry once-per-second Performance Report Messages as described in T1.403. These messages carry information on numbers of CRCs, framing errors, line code violations and other impairments detected over the last second.

(CR) For DS1, the CES IWF shall terminate the Facility Data Link as specified in ANSI T1.403-1989.

(CR) Performance-related information from T1.403-compliant FDL messages shall be stored in the IWF's MIB, as described in Section 6.

FDL messages which are not Link Management messages as defined in T1.403 maybe ignored by the IWF.

2.1.6 Bit Oriented Messages

This section applies only to DS1 Nx64 service.

(R) For DS1 using ESF, the IWF must terminate Bit Oriented Messages for Yellow Alarms and loopback as described in T1.403.

Loopbacks are handled as described in TR-NWT-000170.

2.1.7 Alarms

Several kinds of alarms can be detected at the point where the Service Interface is received by the IWF. Definition of alarm states is given in T1.403 for DS1, and G.704 for E1.

Some alarm situations require that an alarm condition detected at the point where the Service Interface is received by an IWF (the “Upstream IWF”) be propagated downstream to the IWF responsible for reproducing the bit stream (the “Downstream IWF”).

When alarms are detected by the Upstream IWF, a Trunk Conditioning procedure is used to signal these alarms to downstream DS1/E1 equipment. In this case, the Upstream IWF continues to emit cells at the nominal rate, but sets the DS1/E1 payload to an appropriate code to indicate Idle or Out-of-Service. Additionally, if signalling bits are being carried by the IWF, the Upstream IWF will insert appropriate signalling codes into the DS1/E1 stream before AAL1 segmentation takes place. Trunk conditioning procedures are specified in Bellcore TR-NWT-000170 Issue 2, Section 2.5.

This technique allows DS1/E1 alarm conditions to be transferred through the emulated circuit environment without causing additional ATM Layer errors.

(R) The IWF shall detect Loss of Signal (LOS), AIS or Yellow conditions, loss of frame synch, and loss of multiframe synch and report these conditions via the MIB.

(R) When LOS, Out-of-Frame or AIS occur, the IWF shall apply Trunk Conditioning in the downstream direction. Procedures for Trunk Conditioning are described in Bellcore TR-NWT-000170 Issue 2, Section 2.5. A Remote Alarm Indication (RAI, or 'yellow') shall be delivered in the upstream direction. Figure 2-4 illustrates alarm handling at the Service Interface. The exact maintenance actions required to be performed depend on the application and environment being served.

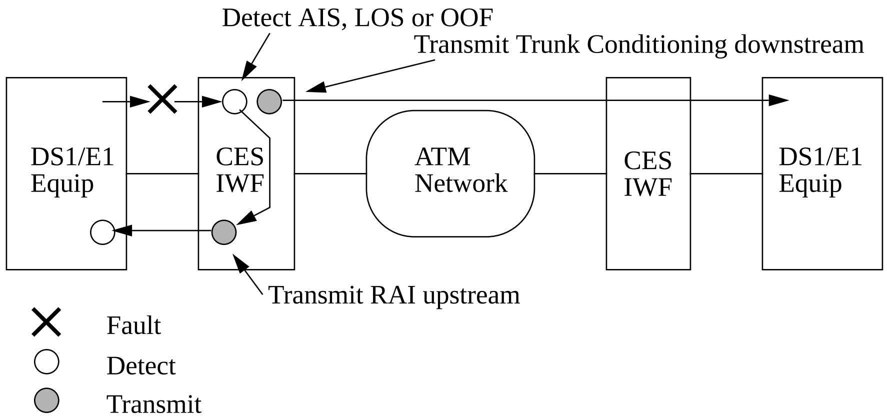


Figure 2-4: Nx64 Service Interface Fault Indication

(R) When RAI is received at the Service Interface, the IWF shall apply trunk conditioning in the downstream direction only.

2.1.8 Signalling Bits

The Nx64 service can support signalling in one of two modes of operation: with Channel Associated Signalling (CAS) or without CAS. Nx64 Service with CAS requires direct recognition and manipulation of the signalling bits by the CES IWF. This mode is necessary to support Nx64 applications requiring DS1 Robbed Bit Signalling or E1 CAS support.

Conversely, non-CAS mode, or Basic Service, requires no direct CAS support by the CES IWF. Basic Service can be used to support Nx64 applications not requiring signalling or those that provide signalling using Common Channel Signalling (e.g., as used in N-ISDN) or provided by other means.

(R) All Nx64 Service IWFs shall provide Basic Service. This mode is compatible with N-ISDN applications, as well as many video codecs.

(O) Nx64 Service IWFs may also provide Nx64 Service with CAS. This mode is required for much existing PBX and voice telephony equipment.

2.1.9 Service Performance Characteristics

This section describes the minimal service performance characteristics required by Nx64 Service.

2.1.9.1 End-to-End Delay

End-to-end delay requirements are application-specific. End-to-end delay requirements are beyond the scope of this specification.

2.1.9.2 Error Ratios

Bit Error Ratio (BER) is the ratio of the number of bit errors to the total number of bits transmitted in a given time interval. There are no specific bit-error ratio requirements for Nx64 service other than those implied by the errored second and severely-errored second requirements that follow. (Source: ANSI T1.510-1994, *Network Performance Parameters for Dedicated Digital Services — Specifications*.)

Service performance is also measured in terms of Errored Seconds (ES) and Severely Errored Seconds (SES). Performance objectives for Errored Seconds and Severely Errored Seconds are given in ANSI T1.510-1994 for DS1, and in G.826 for E1.

2.1.10 Electrical

(R) The DS1 Nx64 Service shall provide a DSX-1 interface with B8ZS coding.

(O) The DS1 Nx64 Service may also provide AMI coding as an option.

The Service Interface may use a connector such as the RJ48C or RJ48M, as specified in T1.403.

(R) The E1 Nx64 Service shall provide a G.703 interface using HDB3 line coding. G.703 allows both 75 ohm and 120 ohm interfaces for E1.

The E1 Service Interface may use a connector such as ISO8877 for the 120 ohm interface, and a 75 ohm BNC connector, as described in IECSC46D, for the 75 ohm interface.

2.2 AAL 1 Requirements

2.2.1 Data Transfer Service Type

(R) The Nx64 Service shall use the Structured Data Transfer (SDT) mode as defined in I.363.X.

ANSI document T1.630 and Bellcore GR-1113-CORE also contain descriptions of AAL1 Structured Data Transfer mode.

2.2.2 Cell Utilization

A significant source of delay in the Nx64 Service is the “cell payload assembly delay”, or the amount of time it takes to collect enough data to fill a cell. This period of time can be reduced by sending cells that are only partially full, rather than waiting for a full 46- or 47-byte payload before sending each cell. This reduces delay at the expense of a higher cell rate. Partial cell fill is an optional feature of a CES IWF; if available, the number of bytes to be sent in each cell can be set when the virtual channel is established, either through configuration for PVCs, or by ATM UNI 3.1 signalling for SVCs.

(R) The Nx64 Service Interworking Function shall be capable of sending cells without dummy octets.

(O) The Nx64 Service may reduce cell payload assembly delay by introducing dummy octets to complete the cell payload, as outlined in ITU I.363.X, November 1994.

It should be noted that the cell padding technique described in I.363.X requires a fixed number of payload (i.e., Service Interface) octets per cell, resulting in a variable number of pad bytes per cell, depending on the presence of the AAL1 Structure Pointer.

When padding is used with Structured Data Transfer, it should be noted that I.363.X requires that the structure pointer span both payload and pad bytes. For example, a structure pointer with the value 46 always indicates the first octet of the second cell in a pair, no matter how much padding might be present in each cell.

2.3 AAL User Entity Requirements

2.3.1 Cell Coding

AAL1 as specified in ITU-T document I.363.X has the capability to delineate repetitive, fixed-size “blocks” of data, each block being an integral number of octets in size. This capability is used in the Nx64 service to carry N DS0 timeslots, organized into blocks.

For a block size of one octet, corresponding to a single DS0 stream (i.e. N=1) with Basic Service, AAL1 provides block delineation merely by aligning each AAL user octet with an ATM cell payload octet.

For a block size greater than one octet, AAL1 uses a pointer mechanism to indicate the start of a structure block. The pointer is inserted at the first opportunity in a cycle of eight cells, or in cell number six of the cycle.

The layout of the Nx64 service data within the structure blocks—or cell coding—varies with the type of Nx64 Service being supported, as described below.

Logical Nx64 Service may use any of the coding approaches described below.

Note: the need for a common method to transport CAS signaling transitions for DS1, E1, and voice compression is for further study.

2.3.1.1 Cell Coding for DS1 and E1 Nx64 Basic Service

To encode Nx64 into AAL1 SDT without carrying signalling bits, a block is created by collecting N octets — one from each of the N timeslots to be carried — and grouping them in sequence. See Figure 2-5 for an example which shows the block structure for Nx64 where N=3. The block size for Nx64 Basic mode is always N octets.

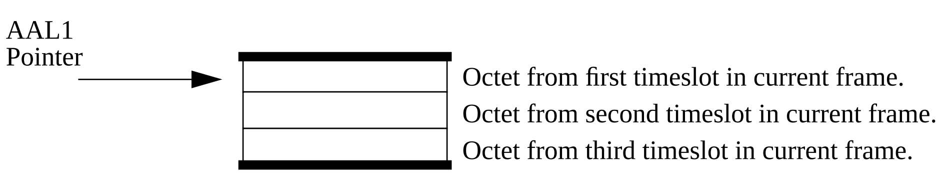


Figure 2-5: Example Singleframe Structure Format for 3x64 kbit/s

(R) DS1 and E1 Nx64 Basic Service shall encode Nx64 Service data in an AAL1 Structure of size ‘N’

2.3.1.2 Cell Coding for DS1 and E1 Nx64 with CAS

Circuits which carry the ABCD signalling bits end-to-end may also be emulated with the CES IWF, if the CAS mode option is provided.

A special AAL1 structure format is used to carry emulated circuits with CAS. In this format, the AAL1 block is divided into two sections, the first of which carries the Nx64 payload, the second of which carries signalling bits that are associated with the payload.

In CAS Mode, the payload part of the structure is one multiframe in length. For Nx64 DS1 with ESF framing, this portion of the AAL1 structure is N times 24 in length. For Nx64 E1 using G.704 framing, the payload portion of the AAL1 structure, called the Payload Substructure, is N times 16 octets in length. In each case, the first octet in the AAL1 structure is from the first of the N timeslots in the first frame of a multiframe.

The second portion of the AAL1 structure, called the Signalling Substructure, contains the signalling bits that are associated with the multiframe. The ABCD signalling bits associated with each time slot are packed two sets to an octet and placed at the end of the AAL1 structure. If N is odd, the last octet will contain only four signalling bits and four zero pad bits.

The AAL1 Structure Pointer is used to indicate the first octet of the Payload Substructure.

An example of the AAL1 structure for Nx64 circuits with CAS is shown in Figure 2-6. In this example, N is set to three, so each AAL1 block contains payload from three timeslots, plus the three sets of signalling bits present in one multiframe..

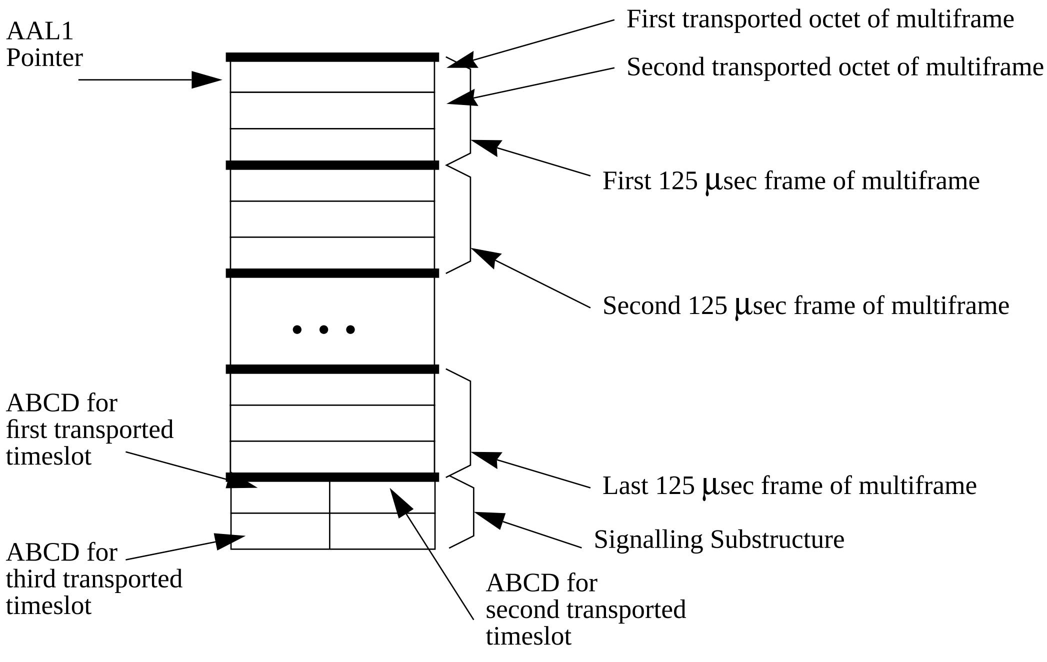


Figure 2-6: Example Multiframe Structure for 3x64 kbit/s DS1 or E1 with CAS

Packing of the signalling bits is done by using bits 8..5 of the first octet for the first set of signalling bits, bits 4..1 of the first octet for the second set of signalling bits, and so on. Bits 4..1 of the last octet of the Signalling Substructure will be unused and shall be set to zero if the VCC is configured to carry an odd number of timeslots. Figure 2-7 shows the assignment of bits to the signalling substructure.

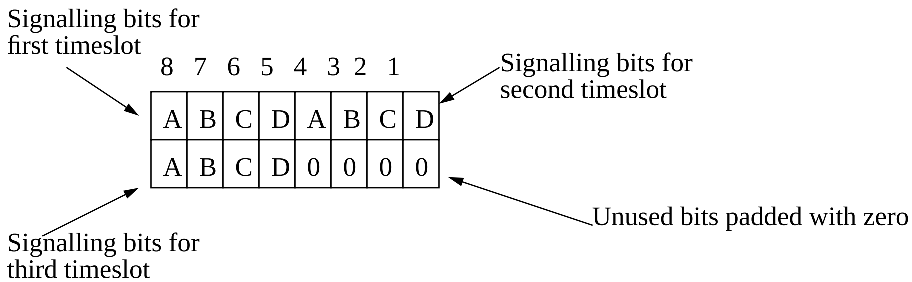


Figure 2-7: Example DS1/ESF and E1 Signalling Substructure

DS1 with Superframe Format (SF) can also be carried with a CES IWF. For SF format, the AAL1 structure is made the same size as the equivalent ESF structure by sending two SF multiframes together in one AAL1 block, instead of one multiframe as is done in ESF framing. For SF format, the signalling octets at the end of the AAL1 structure contain AB signalling bits from the two SF multiframes in the structure. Figure 2-7 shows the signalling substructure detail for an example circuit of N=3. In this example, signalling bits AB are from the first SF multiframe in the AAL1 structure, while bits A'B' are from the second SF multiframe.

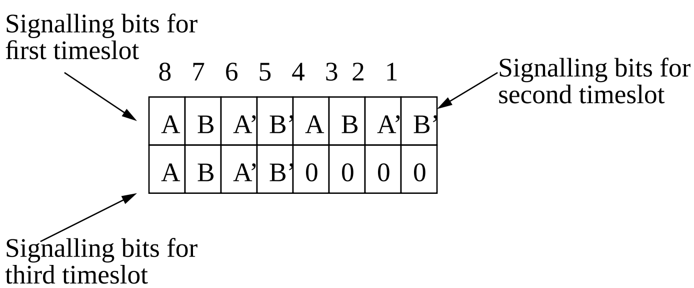


Figure 2-8: Example DS1/SF Signalling Substructure

Table 2-1 gives the size of the AAL1 structure in octets for a few different values of N. The parameter N gives the number of 64 kbit/s timeslots derived from a single access line to be transmitted over one VCC. A value of N = 1 corresponds to a single 64 kbit/s circuit; N = 6 corresponds to 384 kbit/s; N =30 corresponds to the full E1 payload of 1.920 Mbit/s.

	Structure Size in Octets			
Framing	N = 1	N = 6	N = 24	N = 30
DS1/ESF	25	147	588	n/a
DS1/SF	25	147	588	n/a

Table 2-1: Sample AAL1 Structure Sizes for Nx64 Service with CAS

Framing	Structure Size in Octets			
	N = 1	N = 6	N = 24	N = 30
E1	17	99	396	495

Table 2-1: Sample AAL1 Structure Sizes for Nx64 Service with CAS

It should be noted, that in the case of DS1 with CAS, the ABCD bits may be present in the Payload Substructure in addition to being in the Signalling Substructure. In both circumstances of both normal operation, and also alarm conditions such as trunk conditioning, valid signalling must be sent in the Signalling substructure.

(CR) If CAS mode operation is enabled, the Downstream IWF may only obtain ABCD signalling bits from the signalling substructure.

2.3.2 Bit Ordering

Bits from the DS1 or E1 Nx64 Service Interface are packed into ATM cells using the ordering shown in Figure 2-9. Note that G.704 and T1.403 designate the most significant bit as 'bit 1', while ATM cells as defined in T1.627 number the least significant bit as 'bit 1'. In both cases, however, the most significant bit is transmitted first.

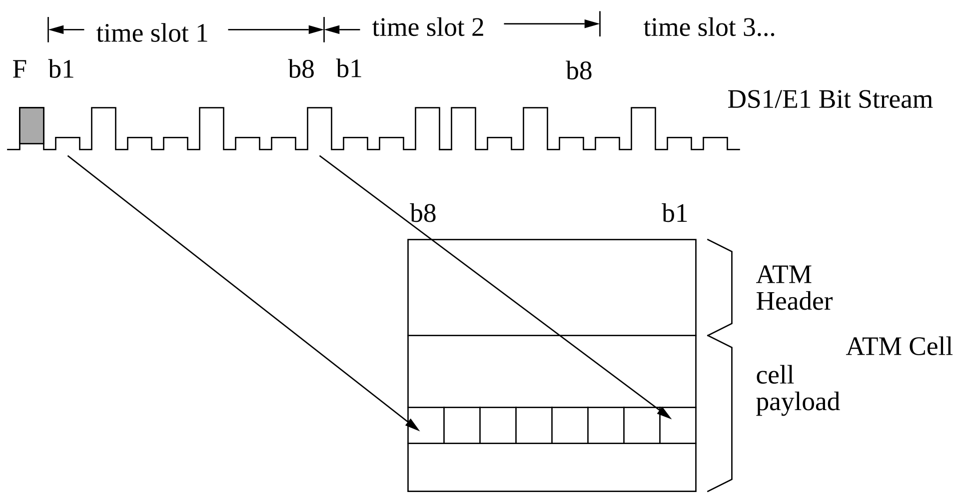


Figure 2-9: DS1/E1 vs ATM Bit Ordering

2.3.3 Loss/Error Response

The IWF will contain a function that reassembles a sequence of AAL1 cells into streams of octets for transmission by the DS1/E1 Service Interface. This reassembly function must cope with a variety of errors and impairments, including lost cells, late cells and misinserted cells.

2.3.3.1 Lost and Misinserted Cells

The reassembly unit may detect lost and misinserted cells by processing sequence numbers in the AAL1 headers.

(R) If cell loss is detected, dummy cells consisting of 46 or 47 octets shall be inserted when bit count integrity can be maintained. The content of the inserted octets is implementation-dependent.

Depending on implementation, there will be a point at which too many cells will have been lost to maintain bit count integrity; at this point, the AAL1 receiver may have to locate the next AAL1 Structure Pointer to re-acquire framing.

(O) Misinserted cells are expected to be rare. The reassembly unit may maintain bit count integrity where possible by dropping cells that the AAL1 header processor detects as misinserted.

2.3.3.2 Buffer Overflow/Underflow

The reassembly function will require a buffer in which the reassembled cell stream is stored before it is transmitted out the Service Interface. The size of this buffer will be implementation dependent, but it must be large enough to accommodate expected CDV, while small enough to not introduce excessive delay in the emulated circuit. This buffer will be subject to overflow or underflow if slight clocking differences exist between the node at which segmentation takes place, and the node at which reassembly takes place. Buffer underflow may also result from unexpectedly large CDV.

(R) The Nx64 Service IWF shall perform controlled frame slips if the reassembly buffer encounters an overflow or underflow (i.e., “starvation”) condition. The data inserted in case of underflow is implementation-dependent.

Under some circumstances, such as a failure in the ATM network carrying the emulated Nx64 circuit, the flow of cells to the reassembly unit will stop for an extended period. This condition shall be signalled to the external equipment attached to the Service Interface by Trunk Conditioning, as illustrated in Figure 2-10.

(R) After an integration period, a persistent buffer starvation condition shall trigger Trunk Conditioning, as specified in Bellcore TR-NWT-000170.

The length of the integration period has not yet been specified by ITU-T, ANSI and/or ETSI. Pending specification, implementors are advised to use a 2.5 +/- 0.5 second integration period, in a manner analogous to that used to integrate Loss of Signal to declare red alarm state.

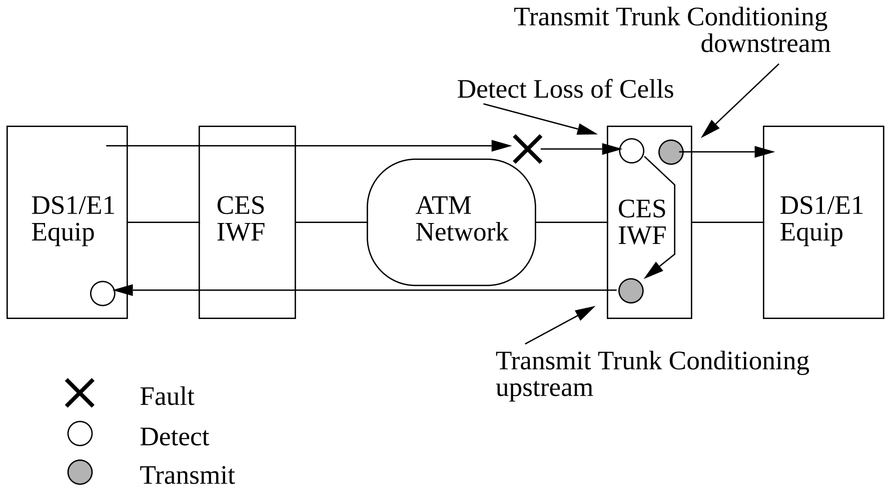


Figure 2-10: Virtual Channel Fault Indication

Although not required as part of this specification, implementors may wish to consult Bellcore GR-1113-CORE and ETSI ETS 300 353 Annex D for advice on the handling of various fault conditions.

2.4 Clock Distribution Guidelines

As stated in Section 2.1.3, IWFs must provide a means by which a timesource traceable to a Primary Reference Source (PRS) may be supplied. For DS1 and E1 Nx64 Service, the IWF must provide timing at the DS1/E1 Service Interface.

While the technique by which that clock is provided at the Service Interface is beyond the scope of this specification, here are some possible techniques:

1. A PRS-traceable source is used to time the physical layers supporting ATM links between the IWF and the ATM network. Timing might be introduced to the ATM network via a Central Office Clock connection on one or more ATM switches. Each CES IWF receives timing from its ATM interface.

2. The physical links accessing an ATM network might be synchronized to a PRS as above, but the timing might be introduced to the ATM network via a DS1/E1 interface.

3. The access physical links of the ATM network might not be synchronized at all, in which case PRS-traceable timing must be externally supplied to every CES IWF Service Interface.

4. In some private network applications involving circuit emulation, it may be sufficient to distribute a common clock to all CES IWF nodes, but not require that the common clock be traceable to a Stratum 1 oscillator.

In all cases, Service Interfaces are expected to be timed from a single, common clock, or one or more PRSs. Service Interface timing is not carried across the network via SRTS, or through the use of Adaptive clock recovery. All Nx64 emulated circuits are carried with AAL1 Synchronous mode, as described in T1.630.

Information on the distribution of network timing may be found in Bellcore document TR-NWT-001244, “Clocks for the Synchronized Network: Common Generic Criteria”.

3 DS1/E1 Unstructured Service

A large number of applications utilize DS1 and E1 interfaces today, either utilizing the entire bandwidth, or through use of DS0 multiplexing performed in end systems. Within this section, the following conventions apply:

Unstructured Service = All modes of the unstructured DS1/E1 Unstructured Service.

DS1 Unstructured Service = Unstructured Service at a bit rate of 1.544 Mb/s in which the two IWFs involved are emulating a DS1 circuit supplied via a DSX-1 interface.

E1 Unstructured Service = Unstructured Service in which the two IWFs involved are emulating an E1 circuit supplied via a G.703 interface.

DS1 Logical Unstructured Service = Unstructured Service at a bit rate of 1.544 Mb/s in which the non-ATM-related functions of the two IWFs involved are left unspecified.

E1 Logical Unstructured Service = Unstructured Service at a bit rate of 2.048 Mb/s in which the non-ATM-related functions of the two IWFs involved are left unspecified.

3.1 Service Description

DS1/E1 Unstructured CBR service is intended to emulate a point-to-point DS1 or E1 circuit. The service is accessed via either a 1.544 Mbit/s DSX-1 interface or a 2.048 Mbit/s G.703 interface. The service is defined as a “clear channel pipe”, carrying any arbitrary 1.544 Mbit/s (2.048 Mbit/s for E1) data stream.

The DS1/E1 Unstructured Service also provides an optional feature that allows performance monitoring of the link if SF, ESF or G.704 framing is used.

Figure 3-1 shows the DS1/E1 Unstructured Service from a layering perspective. For this service, the CES interworking function has two physical layers, one for the CBR circuit to be emulated and one for ATM. Linking the CBR physical layer with the AAL1 layer is a “mapping function”. In Unstructured service, the mapping function simply maps every bit between the AAL1 layer and the 1.544 or 2.048 Mbit/s Service Interface. From an ATM perspective, everything shaded in the diagram represents an “AAL User Entity,” and that is how we refer to the shaded portions in the CES-IS. For the “logical” versions of the Circuit Emulation Services, the CES-IS leaves the non-ATM portions identified in the figure (i.e., the CBR Physical layer and CBR Service Interface) unspecified.

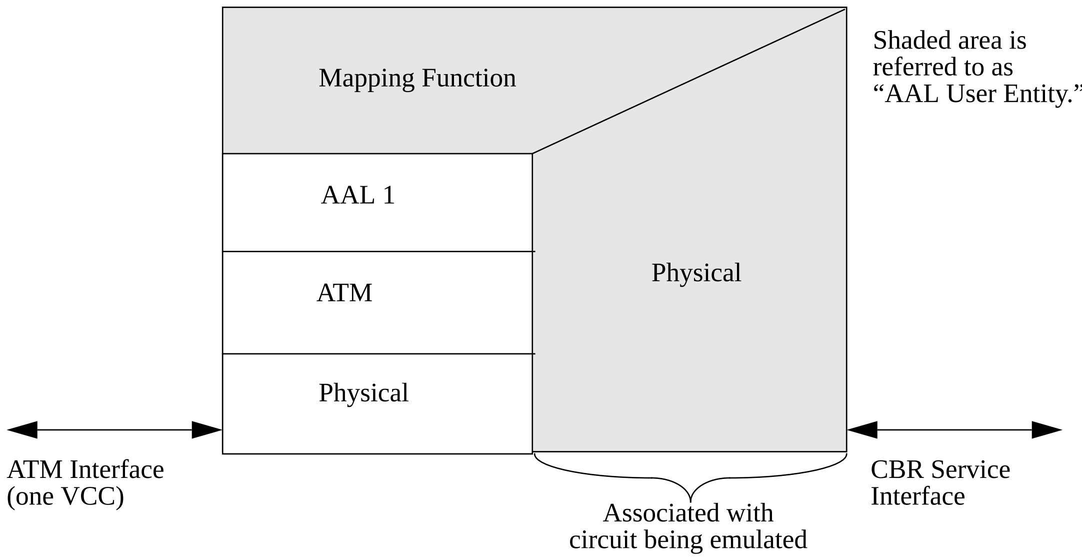


Figure 3-1: DS1/E1 Unstructured Service Interworking Function—Layering Perspective

3.1.1 Framing

(R) The DS1/E1 Unstructured Service carries any arbitrary 1.544 Mbit/s (2.048 Mbit/s for E1) data stream.

(O) Optionally, the Unstructured service may include a performance monitoring function that will decode SF, ESF or G.704 framing. The functions required to support this option are: collection of performance statistics, and detection of frame-based alarms and messages. There must be a configuration option to disable the performance monitor for use with unframed signals.

3.1.2 Clocking

The DS1/E1 Unstructured Service has two modes for timing user equipment attached to the Service Interface:

1. Synchronous Mode, in which timing is supplied to attached DS1/E1 equipment via the IWF Service Interface, and may be tracable to a Primary Reference Source.
2. Asynchronous Mode, in which timing is supplied by attached equipment and carried through the ATM network.

(R) A CES IWF must implement at least one of the two clocking modes for DS1/E1 Unstructured Service, and may offer both modes. Two Interworking Functions must be configured for the same clocking mode in order to interoperate.

(CR) If Asynchronous Mode is used, timing supplied by user equipment shall be within +/- 130 ppm for DS1 (as specified in T1.403-1989), and +/- 50 ppm for E1 (as specified in G.703).

3.1.3 Jitter and Wander

Jitter and Wander may be present at the output of the emulated circuit, introduced by imperfections in clock recovery at the output of the CES IWF. For circuits using the Asynchronous timing mode, there are two techniques for recovering clock -- SRTS and Adaptive (see Section 3.4). While the two techniques can produce equal jitter performance, they may differ in the amount of wander present at the output of the IWF.

(R) Jitter measured at the output of the IWF Service Interface shall meet ANSI T1.403 and G.824 for DS1 circuits with any clocking mode.

(R) Jitter measured at the output of the IWF Service Interface shall meet G.823 for E1 circuits with any clocking mode.

(CR) If Synchronous clocking or Asynchronous clocking with SRTS clock recovery is used, wander must meet ANSI T1.403 and G.824 for DS1 circuits.

(CR) If Synchronous clocking or Asynchronous clocking with SRTS clock recovery is used, wander must meet G.823 for E1 circuits.

ANSI T1.403-1989 Section 5.7.5 specifies that wander shall not exceed 28 UI (18 µsec) peak-to-peak in any 24-hour period. Recommendations G.823 and G.824 suggest that network wander be maintained at less than 10 µsec over any 10 000 second interval (approximately 3 hours).

If the Asynchronous clocking mode is used with Adaptive clock recovery, the resulting wander will depend on the CDV characteristics of the ATM network used to interconnect Interworking Functions, and might not meet recommendations specified in T1.403, G.823 or G.824.

Note: for circuit emulation service, ITU-T Recommendation I.363 and ANSI T1.630 specify the SRTS method of timing recovery to guarantee/meet performance requirements (jitter and wander) of G.823 and G.824. If either IWF connects to DS1 or E1 equipment in the public network, the Public Network Operator may require that SRTS be used.

3.1.4 Facility Data Link

The Unstructured Circuit Emulation Service will carry any signal that meets the bit rate requirement specified in Section 3.1.2, without regard to framing. In the particular case of DS1 circuits using ESF framing, a Facility Data Link (FDL) may be present in the signal. If this is the case, the CES IWF is allowed to monitor the FDL, but must not change messages carried by the FDL, or insert new FDL messages.

(R) The Facility Data Link associated with the Service Interface, if present, shall not be modified by the Unstructured Service Interface.

(CR) If the optional performance monitoring feature is enabled, the Interworking Function shall monitor Performance Report Messages as described in T1.403. The collected statistics shall be stored in the MIB, as described in Section 6.

3.1.5 Alarms

(R) For DS1 and E1 Unstructured Service, all alarms received at the input of the Service Interface are carried through to the output Service Interface without modification.

(R) The IWF shall detect Loss of Signal at the IWF Service Interface. Upon detection of LOS, the segmenting IWF shall send cells containing all-ones, effectively propagating an unframed AIS signal. This situation is illustrated in Figure 2-4.

(CR) If the optional performance monitoring feature is provided for the DS1 or E1 Unstructured Service, the CES Interworking Function shall monitor the alarm status of the Service Interface. Alarm status shall be reflected in the MIB.

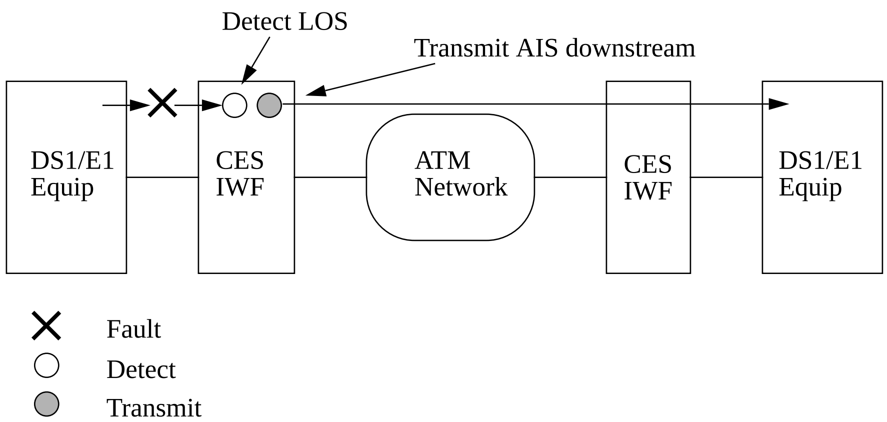


Figure 3-2: Unstructured Service Interface Fault Indication

3.1.6 Service Performance Characteristics

This section describes the minimal service performance characteristics required by the Unstructured Service.

3.1.6.1 End-to-End Delay

End-to-end delay requirements are application-specific. End-to-end delay requirements are beyond the scope of this specification.

3.1.6.2 Error Ratios

BER is the ratio of the number of bit errors to the total number of bits transmitted in a given time interval. There are no specific bit-error ratio requirements for DS1/E1 CBR service other than those implied by the errored second and severely-errored second requirements that follow. (Source: ANSI T1.510-1994, *Network Performance Parameters for Dedicated Digital Services — Specifications*.)

Service performance is also measured in terms of Errored Seconds (ES) and Severely Errored Seconds (SES). Performance objectives for Errored Seconds and Severely Errored Seconds are given in ANSI T1.510-1994.

3.1.7 Electrical

(R) For the DS1 Unstructured Service, the Service Interface will provide a DSX-1 interface with B8ZS coding.

(O) For the DS1 Unstructured Service, AMI coding may be provided as an option.

The Service Interface may use a connector such as the RJ48C or RJ48M, as specified in T1.403.

(R) For the E1 Unstructured Service, the Service Interface will provide a G.703 interface using HDB3 line coding. G.703 allows both 75 ohm and 120 ohm interfaces for E1

The E1 Service Interface may use a connector such as ISO8877 for the 120 ohm interface, and a 75 ohm BNC connector, as described in IECSC46D, for the 75 ohm interface.

3.2 AAL 1 Requirements

3.2.1 Data Transfer Service Type

(R) The Unstructured service shall use the Unstructured Data Transfer (UDT) mode as defined in T1.630 and I.363.

3.2.2 Cell Utilization

(R) In accordance with ANSI T1.630, the IWF shall fill the entire 47-octet cell payload with DS1/E1 data.

3.3 AAL User Entity Requirements

3.3.1 Cell Coding

Unstructured Data Transfer does not rely on any particular data format. Bits received from the service interface are packed into cells without regard to framing. Note that no particular alignment between octets in DS1 or E1 frames and octets in an ATM cell can be assumed with Unstructured Data Transfer.

However, correct bit ordering must be used. Considering the 376 contiguous bits that will be packed into the SDU, the first bit received on the DS1/E1 line is placed in the MSB of the first octet of the SDU, and placement proceeds in order until the last bit is placed in the LSB of the 47^{th} octet of the SDU.

3.3.2 Loss/Error Response

The IWF should attempt to maintain “bit count integrity”; i.e., the number of DS1/E1 bits coming into the segmenting IWF providing the Unstructured service should equal the number of DS1/E1 bits leaving the reassembling IWF whenever possible. Failure to maintain bit count integrity will probably cause end-user equipment to suffer a reframe event.

3.3.2.1 Lost and Misinserted Cells

The reassembly unit may detect lost and misinserted cells by processing sequence numbers in the AAL1 headers.

(R) If lost cells are detected, dummy cells consisting of 47 octets of all ones shall be inserted when bit count integrity can be maintained. Depending on implementation, there will be a point at which too many cells will have been lost to maintain bit count integrity.

(O) The reassembly unit may maintain bit count integrity where possible by dropping cells that the AAL1 header processor detects as misinserted.

3.3.2.2 Buffer Overflow/Underflow

The reassembly function will require a buffer in which the reassembled cell stream is stored before it is transmitted out the Service Interface. The size of this buffer will be implementation dependent, but it must be large enough to accommodate expected CDV, while small enough to not introduce excessive delay in the emulated circuit. This buffer will be subject to overflow or underflow if slight clocking differences exist between the node at which segmentation takes place, and the node at which reassembly takes place. Buffer underflow may also result from unexpectedly large CDV.

(R) The IWF shall insert an all-ones pattern if the reassembly buffer encounters an underflow (i.e., “starvation”) condition. This condition may result in a reframe event for DS1/E1 equipment using the Unstructured service.

Under some circumstances, such as a failure in the ATM network carrying the emulated circuit, the flow of cells to the reassembly unit will stop for an extended period. The Loss-of-Cells condition should be signalled to the downstream external equipment attached to the Service Interface by sending the all-ones AIS pattern, as illustrated in Figure 2-10.

(R) After an integration period, a persistent buffer starvation condition shall trigger a Loss-of-Cells fault indication, resulting in downstream AIS.

The length of the integration period has not yet been specified by ITU-T, ANSI and/or ETSI. Pending specification, implementors are advised to use a 2.5 +/- 0.5 second integration period, in a manner analogous to that used to integrate Loss of Signal to declare red alarm state.

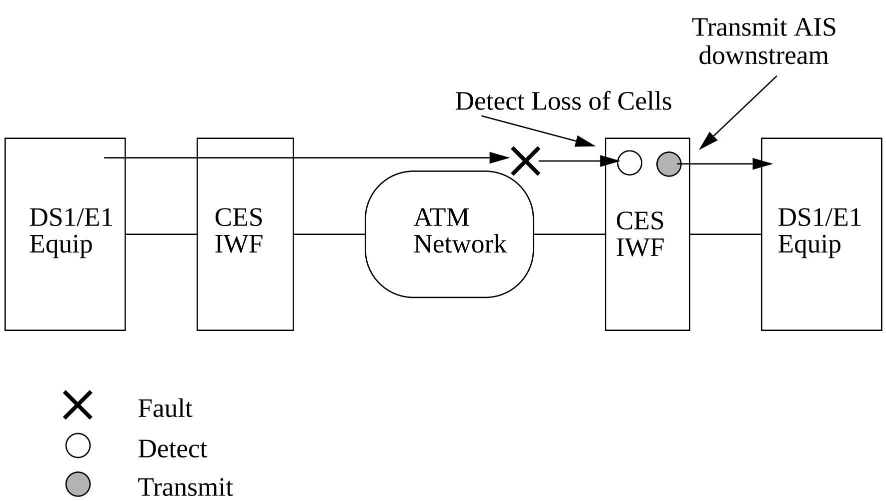


Figure 3-3: Virtual Channel Fault Indication

The reassembly buffer can also suffer an overflow condition due to a clocking error. In this case, the IWF shall drop a number of bits from the reassembled stream. The number of bits dropped at each buffer overflow event is implementation dependent. A buffer overflow is likely to result in a reframe event for DS1/E1 equipment using the Unstructured service.

(R) The IWF shall drop an implementation-dependent number of bits in case of a buffer overflow.

Although not required as part of this specification, implementors may wish to consult Bellcore GR-1113-CORE and ETSI ETS 300 353 Annex D for advice on the handling of various fault conditions.

3.4 Clock Recovery

The Unstructured service may carry asynchronous DS1 or E1 circuits. In this situation, the input Service clock frequency must be recovered at the output IWF. There are two techniques for recovering this clock, Synchronous Residual Time Stamp (SRTS) and Adaptive. Either technique may be used, although SRTS gives better control over wander introduced into the emulated circuit.

The SRTS clock recovery technique requires a network-wide reference clock; information on the distribution of network timing may be found in Bellcore document TR-NWT-001244, “Clocks for the Synchronized Network: Common Generic Criteria”.

3.4.1 SRTS

The SRTS technique measures the Service Clock input frequency against a network-wide synchronization signal that must be present in the IWF, and sends difference signals, called Residual Time Stamps, in the AAL1 header to the reassembly IWF. At the output IWF, the differences can be combined with the network-wide synchronization signal, to re-create the input Service clock.

(CR) If SRTS is provided, it shall be used as specified in T1.630 and I.363.

(CR) The *network derived clock frequency* (f_{ox}) used in the SRTS algorithm shall be 2.43 MHz for both DS1 and E1 circuit emulation.

3.4.2 Adaptive

The adaptive technique does not require a network-wide synchronization signal to regenerate the input Service clock at the output IWF.

A variety of techniques could be used to implement Adaptive clock recovery. For example, the depth of the reassembly buffer in the output IWF could be monitored:

1. When the buffer depth is too great or tends to increase with time, the frequency of the Service clock could be increased to cause the buffer to drain more quickly.
2. When the buffer contains fewer than the configured number of bits, the Service clock could be slowed to cause the buffer to drain less quickly.

Wander may be introduced by the Adaptive clock recovery technique if there is a low-frequency component to the Cell Delay Variation inserted by the ATM network carrying cells from the input to output IWF.

4 ATM Virtual Channel Requirements

The subsections that follow specify traffic parameters and tolerances as defined in A.6 of the UNI 3.1 Specification.

The requirements described in this section must be met by the ATM network that provides an end-to-end ATM connection, i.e., from the input ATM Interface to the output ATM Interface in Figure 4-1.

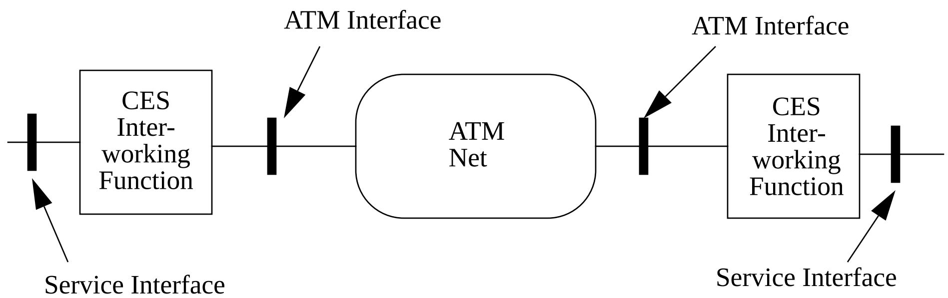


Figure 4-1: Reference Network Configuration

(R) Quality of Service Class 1 for circuit emulation from the ATM Forum UNI Specification Version 3.1 Appendix A shall be used.

4.1 Traffic Parameters and Tolerances

Traffic policing may be performed on cells generated by the CES Interworking Function and transported by the ATM network.

The CDV Tolerance parameter of the UPC should take into account any cell delay variation caused by the introduction of OAM cells. The CDV Tolerance should also account for any CDV that occurs in the intervening multiplexing and switching devices between the Interworking Function and the UPC device.

In the context of this specification, CDV Tolerance is considered a network option, and is currently not subject to standardization.

The following sections give the Peak Cell Rate (PCR) for various versions of the CES Interworking Function.

In all cases, if the OAM traffic is to be included in the PCR per UNI section 3.6.3.2.3.7, then the OAM traffic parameter cells needs to be added to the above or specified separately.

4.1.1 Unstructured DS1 Cell Rate

(R) The PCR on CLP=0+1 required for AAL1 transport of 1544 kbit/s user data is 4107 cells per second.

The calculation of the PCR is based on the following formula:

$$4107 \text{ cells/second} > \frac{1.544 \times 10^{6} \text{ bits/second}}{47 \text{ AAL1 octets/cell} \times 8 \text{ bits/octet}}$$

4.1.2 Unstructured E1 Cell Rate

(R) The PCR on CLP=0+1 required for AAL1 transport of 2048 kbit/s user data is 5447 cells per second.

The calculation of the PCR is based on the following formula:

$$5447 \text{ cells/second} > \frac{2.048 \times 10^{6} \text{ bits/second}}{47 \text{ AAL1 octets/cell} \times 8 \text{ bits/octet}}$$

4.1.3 Structured Nx64 Service Cell Rate

4.1.3.1 Basic Service

(R) If partial cell fill is not used, the PCR on CLP=0+1 required for AAL1 transport of Nx64 Basic Service is $\lceil (8000 \times N)/46.875 \rceil$ cells per second (where $\lceil x \rceil$ means "smallest integer greater than or equal to x"). If partial cell fill is used, the PCR is $\lceil (8000 \times N)/K \rceil$, where K is the number of AAL-user octets filled per cell.

Both of these are derived by dividing the required user octet-rate by the number of user octets carried per cell.

4.1.3.2 DS1/E1 Service w/CAS

(R) The PCR on CLP=0+1 required for AAL1 transport of E1 Nx64 Service w/CAS is:

1. No partial cell fill, N even:

   $$\lceil 8000 \times [N \times 33/32] / 46.875 \rceil$$

2. No partial cell fill, N odd:

   $$\lceil 8000 \times [(1 + N \times 33) / (N \times 32)] / 46.875 \rceil$$

3. Partial cell fill, N even, K the number of AAL1-user octets filled:

   $$\lceil 8000 \times [N \times 33/32] / K \rceil$$

4. Partial cell fill, N odd, K the number of AAL1-user octets filled:

   $$\lceil 8000 \times [(1 + N \times 33) / (N \times 32)] / K \rceil$$

(R) The PCR on CLP=0+1 required for AAL1 transport of DS1 Nx64 Service w/CAS is:

1. No partial cell fill, N even:

   $$\lceil 8000 \times [N \times 49/48] / 46.875 \rceil$$

2. No partial cell fill, N odd:

$$\lceil 8000 \times [(1 + N \times 49) / (N \times 48)] / 46.875 \rceil$$

3. Partial cell fill, N even, K the number of AAL1-user octets filled:

$$\lceil 8000 \times [N \times 49 / 48] / K \rceil$$

4. Partial cell fill, N odd, K the number of AAL1-user octets filled:

$$\lceil 8000 \times [(1 + N \times 49) / (N \times 48)] / K \rceil$$

These rates are derived by dividing the effective user octet-rate (including block overhead) by the number of user octets carried per cell.

Because all of the signalling bits are grouped together at the end of the AAL1 structure, virtual channels supporting DS1 and E1 Nx64 Service with CAS will suffer some jitter in cell emission time. For example, an IWF carrying an Nx64 E1 circuit with N=30 and CAS enabled will, on average, emit about 10.5 cells spaced by 191.8 μsec, followed by a cell carrying CAS bits after a gap of only 130 μsec. This jitter in cell emission time must be accommodated by peak-rate traffic policers.

4.2 ATM Virtual Channel Payload Type and CLP

Sections 3.3 and 3.4 of the UNI 3.1 document specify that, in addition to Virtual Circuit and Virtual Path fields, the ATM cell header contains the Cell Loss Priority bit and the three-bit Payload Type Identifier field.

4.2.1 Cell Loss Priority (CLP)

(R) At the sender, this bit shall be set to “0”. At the receiver, this bit shall be ignored.

4.2.2 Payload Type Identifier

(R) All cells carrying emulated circuit data shall be sent with the Payload Type Identifier field set to 000, indicating “User Data cell, congestion not experienced, SDU-type=0”

(R) All four User Data cell Payload Type Identifier values (000, 001, 010 and 011) shall be accepted by the receiver.

4.3 Impairments

Sections 2.1 and 3.1 specify performance characteristics of the CBR Service Interface. The ATM performance impairments should be commensurate with these. An initial mapping of service performance requirements to ATM performance requirements is provided in Annex A.

4.3.1 Cell Transfer Delay

Overall delay is often critical for Circuit Emulation applications, particularly those involving voice. Delay introduced by the ATM network interconnecting CES IWFs is composed of two components:

Maximum Delay gives the largest expected cell delay between entrance and exit of the ATM network.

Cell Delay Variation (CDV) gives the uncertainty in the delay that might be experienced by any particular cell.

Circuit Emulation equipment must have reassembly buffers large enough to accommodate the largest CDV present on a virtual channel to prevent underflow or overflow, with resulting reframe or slip events. At the same time, it should be noted that reassembly buffers larger than required to accommodate CDV will result in excessive overall delay.

The number of intervening switches, and their queue management, and line speeds have a significant impact on the distribution of CDV that must be handled by the reassembly buffer in the destination IWF. There are currently no standards that define a bound on CDV; however some information on CDV and reassembly buffer sizes can be found in TA-NWT-001110 and TA-TSV-001409. The BICI 1.1 specification, Section 5.1.2 gives an approximation of how CDV accumulates across multiple nodes. Implementors are advised to design the reassembly buffer in excess of these values, possibly making the size of the reassembly buffer configurable to optimize the jitter versus absolute delay trade-off in various configurations.

The amount of CDV that the reassembly process can accommodate is configured with the MIB entry atmfCESCDVRxT. This entry allows the network provider to configure the maximum cell arrival jitter that the reassembly process will tolerate in the cell stream without producing errors on the CBR Service Interface. This parameter may be set to a small value if the connection will produce minimal CDV and a large value if the connection will produce large CDV.

An informative example of the implementation of a receiver which uses the atmfCESCDVRxT paramter is as follows: The receiver will place the contents of the first cell to arrive after an underrun into the receive buffer in a position such that it will be played out at least one CDVT (atmfCESCDVRxT) later.

5 Signalling

This section specifies ATM UNI 3.1 signalling between the IWFs that support CES. There is no mapping specified between signalling that pertains to traditional DS1, E1, and Nx64 Services and ATM UNI 3.1 signalling.

The call/connection control procedures of UNI 3.1 apply. The following section details the content of the setup message. CES signalling places no explicit constraints on other signalling messages.

5.1 Addresses and Identifiers for CES Switched Virtual Channels (SVCs)

All CES SVCs are point-to-point. As with all SVCs, the endpoints must be identified during call setup with an ATM address; these may be of any of the three formats identified in section 5.1.3 of the UNI 3.1 Specification. Additional identifiers in the Broadband Low Layer Information (B-LLI) information element (IE) distinguish the particular type of CES SVC being set up.

5.2 SETUP Message Contents

Section 5.3.1.7 in the UNI 3.1 Specification lists the mandatory and optional information elements in the SETUP message. This CES specification places constraints on the values of certain fields in the following mandatory information elements:

1. ATM Traffic Descriptor
2. Broadband bearer capability
3. QoS Parameter

The following sections describe those constraints.

The following information elements (which in general are optional) are required for CES signalling:

1. The AAL Parameters Information Element
2. The Broadband Low Layer Information Information Element

The required contents of these information elements are discussed in the following sections.

The other information elements identified in UNI 3.1 Section 5.3.1.7 as optional remain optional for CES SVCs; this CES specification places no constraints on the values of the fields in these optional information elements.

Note that in the following sections we have omitted the fixed information element header fields and field identifiers from this specification; these should be inserted in the appropriate place in the information element.

5.2.1 ATM Traffic Descriptor

For CES SVCs, the following two fields in this information element must be specified:

1. Forward peak cell rate CLP=0+1
2. Backward peak cell rate CLP=0+1

The values for these fields should be calculated as specified in Section 4.1.

The Best Effort Indicator and the Traffic Management Options Identifier *must* be omitted. We recommend that the other fields be omitted as well.

5.2.2 Broadband Bearer Capability

The following table specifies the values for the fields in this information element.

Field	Value
Bearer Class	'1000 0' BCOB-X
Traffic Type	'001' Constant bit rate
Timing Requirements	'01' End-to-end timing required
Susceptibility to clipping	'00' Not susceptible to clipping
User Plane Connection Configuration	'00' Point-to-point

Table 5-1: Broadband Bearer Capability IE Field Values for CES SVCs

5.2.3 Quality of Service Parameter

The following table specifies the values for the fields in this information element.

Field	Value
QoS Class Forward	'0000 0001' QoS Class 1
QoS Class Backward	'0000 0001' QoS Class 1

Table 5-2: QoS Parameter IE Field Values for CES SVCs

The Coding Standard field in this Information Element shall be coded as "11" when operating over ATM Forum compliant networks. However, when interfacing to an ITU conformant network that is not ATM Forum compliant, the Coding Standard shall be coded "00" and the QoS Class Forward and QoS Class Backward are each coded "0000 0000", meaning QoS Class 0 — Unspecified Qos Class.

5.2.4 ATM Adaptation Layer Parameters

The values in this information element vary with the particular choice of CES. The following three tables specify the field values for Nx64 Service, DS1 (+ Logical) Unstructured Service, and E1 (+ Logical) Unstructured Service, respectively. If the called party does not accept these parameters, it should release the call with cause 93 (AAL Parameters not Supported).

Field	Value
AAL Type	'0000 0001' AAL Type 1
Subtype	'0000 0010' Circuit Transport
CBR rate	'0000 0001' 64 kbit/s '0100 0000' Nx64 kbit/s, N>1

Table 5-3: AAL Parameters IE Field Values for Nx64 Service SVCs

Field	Value
Multiplier	The value ‘N’ for Nx64 kbit/s. Omit field for 64 kbit/s case.
Structured Data Transfer Blocksize	Size in octets, as defined in Section 2.3.1
Partially filled cells method	K, the number of AAL-user octets filled per cell; see Section 2.2.2. Omit field if partial cell fill is not used

Table 5-3: AAL Parameters IE Field Values for Nx64 Service SVCs

Field	Value
AAL Type	‘0000 0001’ AAL Type 1
Subtype	‘0000 0010’ Circuit Transport
CBR rate	‘0000 0100’ 1544 kbit/s (DS1)
Source Clock Frequency Recovery Method	‘0000 0000’ Null (synchronous circuit transport)
	‘0000 0001’ SRTS method (asynchronous circuit transport)
	‘0000 0010’ Adaptive method (asynchronous circuit transport)

Table 5-4: AAL Parameters IE Field Values for DS1 Unstructured Service and DS1 Logical Unstructured Service SVCs

Field	Value
AAL Type	‘0000 0001’ AAL Type 1
Subtype	‘0000 0010’ Circuit Transport
CBR rate	‘0001 0000’ 2048 kbit/s (E1)
Source Clock Frequency Recovery Method	‘0000 0000’ Null (synchronous circuit transport)
	‘0000 0001’ SRTS method (asynchronous circuit transport)
	‘0000 0010’ Adaptive method (asynchronous circuit transport)

Table 5-5: AAL Parameters IE Field Values for E1 Unstructured Service and E1 Logical Unstructured Service SVCs

5.2.5 Broadband Low Layer Information

This information element identifies that the signaling entities are ATM Forum CES AAL User Entities as specified in this CES-IS. It also identifies the specific service and coding approach for Nx64 Service.

Field	Value
User Information Layer 3 Protocol (octet 7)	'01011' ISO/IEC TR 9577
ISO/IEC TR 9577 Initial Protocol Identifier (IPI) (octet 7a, 7b)	IPI is coded '1000 0000' to indicate IEEE 802.1 SNAP identifier. Hence, octets 7a and 7b are coded as '0100 0000' and '0000 0000', respectively.
Organizational Unit Identifier (OUI) (octets 8.1-8.3)	x'00 A0 3E' ATM Forum OUI
Protocol Identifier (PID) (octets 8.4-8.5)	x'00 00' Ignored for Unstructured Service
	x'00 06' DS1/E1 Nx64 Basic Service
	x'00 07' E1 Nx64 Service w/CAS
	x'00 08' DS1 SF Nx64 Service w/CAS
	x'00 09' DS1 ESF Nx64 Service w/CAS

Table 5-6: Broadband Low Layer Information IE Field Values for CES SVCs

6 Management

In general, the CES IWF will be instantiated in equipment that supports one or more ATM ports and one or more CBR interfaces (nominally DS1 and/or E1 ports). Thus, the equipment that incorporates one or more IWFs will have an “ATM side”, a “CBR side” (corresponding to the Service Interface), and a set of entities that cause the two to interwork. The ATM Forum’s Network Management Working Group is specifying the management of the ATM equipment (the “ATM side”). However, the Network Management Working Group will not address management aspects pertaining to the Service Interface and interworking entities:

1. The DS1 or E1 Service Interfaces
2. The CES Mapping Functions
3. The AAL1 entities

This section describes the management of CES IWF via SNMP or SNMPv2. If SNMP is implemented in a device this section specifies the implementation. It is outside the scope of this document to specify a MIB for CMIP. The relationships between different logical and physical interfaces is described in accordance with IETF RFC1573. This MIB is written in compliance with SMIv2 RFC1442.

One of the basic functions of this section is to define cross-connections between Constant Bit Rate Service interfaces and ATM interfaces. The example shown in Figure 6-1 below depicts how a single device can have multiple CES IWF entities mapping CBR interfaces to ATM interfaces. The number in "()" represents a unique number identifying each interface called the instance number or ifIndex as described in RFC 1573. For each ifIndex listed in Figure 6-1, there is one ifTable entry as defined in RFC 1573. RFC 1573 also describes the layering of one interface above and below another interface. This section defines the interfaces per RFC1573, the layering of the interfaces per RFC 1573, the DS0 channel to CES IWF mapping per RFC 1406, and finally the CES SMIv2 MIB.

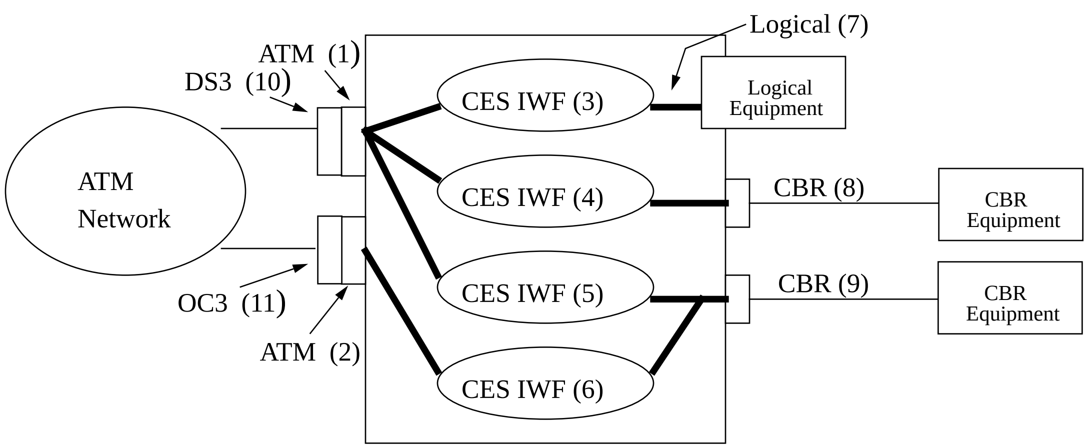


Figure 6-1: CES IWF Instances Mapping CBR Instances to ATM Instances

6.1 CES IWF Interfaces (per RFC 1573)

Each interface (e.g. ATM, CES, CBR) shall have a single entry in the ifTable as defined by RFC 1573. This ensures all instance numbers are unique and allows the CES IWF to define which variables in the CES MIB may cause CES IWF linkup and linkdown traps to be generated. The following tables are sample ifTable entries.

.

RFC 1573 ObjectId	Value	Description
ifIndex	9	Unique number to identify an interface.
ifDescr	"CBR mapped to CES 5 and CES 6"	This is a string of up to 255 characters used to describe the interface. In this case it is useful to describe that this CBR (9) interface is mapped to CES (5) and CES (6).
ifType	ds1e1 (18)	All CBR interfaces can be defined by RFC 1406 which defines interfaces of ifType equal to ds1e1 (18).
ifSpeed	1,544,000	Bits per second speed of interface.
ifAdminStatus	up (1)	Value is up (1) or down (2) depending on whether the interface has been administratively configured.
ifOperStatus	up (1)	This object is set to the value down (2) if the object dsx1LineStatus has any value other than dsx1NoAlarm(1) or ifAdminStatus is down (2).
ifLastChange	0	Time when operational state last changed.
ifLinkUpDownTrapEnable	enabled (1)	Enable/Disable the sending of LinkUp and LinkDown traps. If enabled, LinkUp or LinkDown traps will be sent based on the value of ifOperStatus.
ifName	"CBR_9"	A string representing the interface. This allows other devices to use the same name and perform functions like "ping" without knowledge of cryptic numbers.

Table 6-1: Sample CBR (9) ifTable entry of ifType ds1(18).

RFC 1573 ObjectId	Value	Description
ifIndex	10	Unique number to identify an interface.
ifDescr	"DS3"	This is a string of up to 255 characters used to describe the interface.
ifType	ds3e3 (30)	DS3 interfaces are defined by RFC 1407 which defines interfaces of ifType equal to ds3e3 (30).
ifSpeed	44,736,000	Bits per second speed of interface.
ifAdminStatus	up (1)	Value is up (1) or down (2) depending on whether the interface has been administratively configured.
ifOperStatus	up (1)	This object is set to the value down (2) if the object dsx3LineStatus has any value other than dsx3NoAlarm(1) or ifAdminStatus is down (2).
ifLastChange	0	Time when operational state last changed.
ifLinkUpDownTrapEnable	enabled (1)	Enable/Disable the sending of LinkUp and LinkDown traps. If enabled, LinkUp or LinkDown traps will be sent based on the value of ifOperStatus.
ifName	"ATM_1 - DS3_10"	A string representing the interface.

Table 6-2: Sample DS3 (10) ifTable entry of ifType ds3 (30).

RFC 1573 ObjectId	Value	Description
ifIndex	1	Unique number to identify an interface.
ifDescr	"ATM mapped to CES (3), CES (4), and CES (5). "	This is a string of up to 255 characters used to describe the interface. In this case it is useful to describe that this ATM (1) interface is mapped to CES (3), CES (4), and CES (5).
ifType	atm (37)	ATM interfaces are defined by RFC 1695.
ifSpeed	44,736,000	Bits per second speed of interface.
ifAdminStatus	up (1)	Value is up (1) or down (2) depending on whether the interface has been administratively configured.
ifOperStatus	up (1)	Assumes the value down(2) if the ATM cell layer or any layer below that layer is down.
ifLastChange	0	Time when operational state last changed.
ifLinkUpDownTrapEnable	enabled (1)	Enable/Disable the sending of LinkUp and LinkDown traps. If enabled, LinkUp or LinkDown traps will be sent based on the value of ifOperStatus.
ifName	"ATM_1"	A string representing the interface. This allows other devices to use the same name and perform functions like "ping" without knowledge of cryptic numbers.

Table 6-3: Sample ATM (1) ifTable entry of ifType atm (37).

RFC 1573 ObjectId	Value	Description
ifIndex	5	Unique number to identify an interface.
ifDescr	"Maps CBR (9) to ATM (1)"	This is a string of up to 255 characters used to describe the interface. In this case it is useful to describe that this CES IWF (5) interface is mapping ATM (1) to CBR (9).
ifType	cctEmul (61)	The cctEmul ifType identifies an ATM Emulated Circuit interface. The MIB in this document is used to manage CES IWF instances.
ifSpeed	768,000	Bits per second speed of interface. This is a speed of 12 x 64,000 because there are 12 DS0 channels being mapped to this CES IWF instance.
ifAdminStatus	up (1)	Value is up (1) or down (2) depending on whether the interface has been administratively configured.
ifOperStatus	up (1)	This object is set to the value down (2) if the object atmfCESCellLossStatus has a value of loss (2) or ifAdminStatus is down (2).
ifLastChange	0	Time when operational state last changed.
ifLinkUpDownTrapEnable	enabled (1)	Enable/Disable the sending of LinkUp and LinkDown traps. If enabled, LinkUp or LinkDown traps will be sent based on the value of ifOperStatus. It is suggested that the traps supporting the CES instance send the following data: ifIndex, ifDescr, ifName, atmfCESHdrErrors, atmfCESPointerReframes, atmfCESLostCells, atmfCESBufUnderflows, atmfCESBufOverflows, and atmfCESCellLossStatus.
ifName	"CES_5"	A string representing the interface. This allows other devices to use the same name and perform functions like "ping" without knowledge of cryptic numbers.

Table 6-4: Sample CES IWF (5) ifTable entry of ifType other (1)

RFC 1573 ObjectId	Value	Description
ifIndex	7	Unique number to identify an interface.
ifDescr	"Maps CES (3) to Logical (7)"	This is a string of up to 255 characters used to describe the interface. I
ifType	other (1)	There is no IANAifType defined for logical; therefore, other must be used.
ifSpeed	0	Value depends on the meaning of logical interface.
ifAdminStatus	up (1)	Value is up (1) or down (2) depending on whether the interface has been administratively configured.
ifOperStatus	up (1)	Interface dependent.
ifLastChange	0	Time when operational state last changed.
ifLinkUpDownTrapEnable	enabled (1)	Enable/Disable the sending of LinkUp and LinkDown traps. If enabled, LinkUp or LinkDown traps will be sent based on the value of ifOperStatus.
ifName	"Logical_5"	A string representing the interface. This allows other devices to use the same name and perform functions like "ping" without knowledge of cryptic numbers.

Table 6-5: Sample Logical (7) ifTable entry of ifType other (1)

6.2 CES IWF Layers (per RFC 1573)

Figure 6-1 shows the layers required and which MIBs are used to manage each layer.

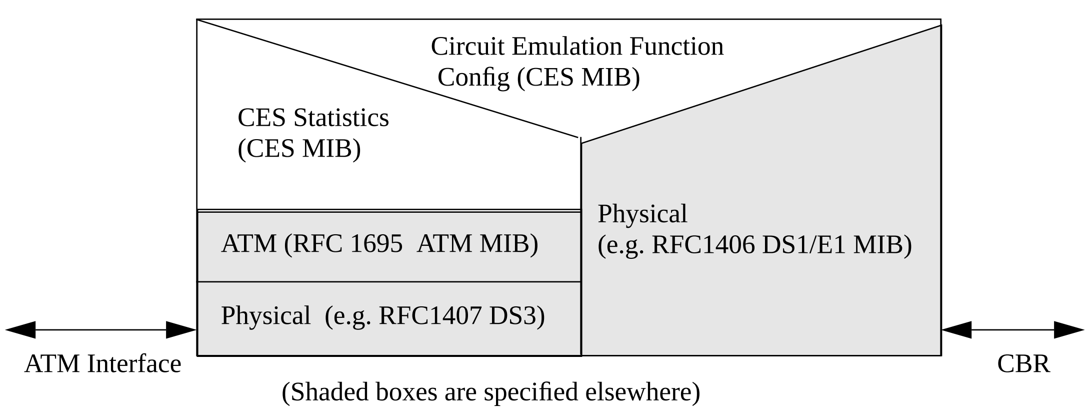


Figure 6-2: CES Layers from CBR Interface to ATM Interface

The objects managing the CES IWF are linked together via the ifStackTable, as defined in RFC1573. The table below displays all ifStackTable entries from Figure 6-1. Table 6-1 references *higher* and *lower*. *higher* and *lower* are ifIndex numbers that represent ifIndex numbers of the higher and lower layers. The meaning of the names higher and lower is relative to ones perspective. The only requirement is the perspective remain consistent within a device. If there is no higher or lower layer within the device, the *higher*/*lower* have a value of zero. Assuming no other ifStackTable entries, a traversal of the ifStackTable for the example shown in Figure 6-1 would yield the results shown in Table 6-6.

ifStackStatus.*higher.lower*	Value
ifStackStatus.0.10	active
ifStackStatus.0.11	active
ifStackStatus.1.3	active
ifStackStatus.1.4	active
ifStackStatus.1.5	active
ifStackStatus.2.6	active
ifStackStatus.3.7	active
ifStackStatus.4.8	active
ifStackStatus.5.9	active
ifStackStatus.6.9	active
ifStackStatus.7.0	active
ifStackStatus.8.0	active
ifStackStatus.9.0	active
ifStackStatus.10.1	active
ifStackStatus.11.2	active

Table 6-6: Example ifStacktable entries

6.3 CES IWF to DS0 Mapping (per RFC 1406)

It is possible to map DS0 channels from one CBR interfaces to multiple CES IWFs. This is NOT accomplished in the CES MIB. This is accomplished in the RFC 1406 DS1/E1 MIB by means of the Fractional T1/E1Table (dsx1FracTable). The fractional table allows each timeslot (dsx1FracNumber) to be mapped to an instance number. Each timeslot may be mapped to a unique instance number, or an instance number sharing one or all other timeslots. Figure 6-3, which is based on Figure 6-1, shows timeslots 1-12 mapped to CES IWF (5) and timeslots 13-24 mapped to CES IWF (6).

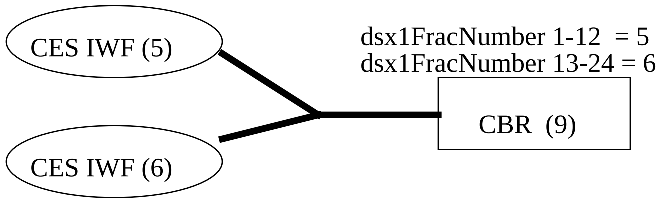


Figure 6-3: ATM, CES and CBR mappings

A traversal of the DS1 MIB instance for CBR (9) would yield the following results. *dsx1FracIndex* is the ifIndex number for this CBR DS1 interface. *dsx1FracNumber* is the DS0 channel number. The value is the ifIndex to which the DS0 channels are mapped.

ifFracIfIndex.*dsx1FracIndex.dsx1FracNumber*	Value
ifFracIfIndex.9.1	5
ifFracIfIndex.9.2	5
ifFracIfIndex.9.3	5
ifFracIfIndex.9.4	5
ifFracIfIndex.9.5	5
ifFracIfIndex.9.6	5
ifFracIfIndex.9.7	5
ifFracIfIndex.9.8	5
ifFracIfIndex.9.9	5
ifFracIfIndex.9.10	5
ifFracIfIndex.9.11	5
ifFracIfIndex.9.12	5
ifFracIfIndex.9.13	6
ifFracIfIndex.9.14	6
ifFracIfIndex.9.15	6
ifFracIfIndex.9.16	6
ifFracIfIndex.9.17	6
ifFracIfIndex.9.18	6
ifFracIfIndex.9.19	6
ifFracIfIndex.9.20	6
ifFracIfIndex.9.21	6
ifFracIfIndex.9.22	6
ifFracIfIndex.9.23	6
ifFracIfIndex.9.24	6

Table 6-7: Example dsx1FracTable entries

6.4 CES MIB

The entire CES MIB is mandatory.

```
ATMF-CES-MIB DEFINITIONS ::= BEGIN


IMPORTS
   enterprises                                  FROM RFC1155-SMI
   OBJECT-TYPE, MODULE-IDENTITY, Counter32      FROM SNMPv2-SMI
   TEXTUAL-CONVENTION                           FROM SNMPv2-TC
   ifIndex                                      FROM IF-MIB ;

atmForum                   OBJECT IDENTIFIER ::= { enterprises  353 }
atmForumNetworkManagement  OBJECT IDENTIFIER ::= { atmForum 5 }
atmfCESmib              OBJECT IDENTIFIER ::= { atmForumNetworkManagement 2 }

atmfDS1E1CESmib MODULE-IDENTITY
   LAST-UPDATED "9502030000Z"
   ORGANIZATION "ATM Forum Circuit Emulation Working Group"
   CONTACT-INFO "fedorkow@cisco.com, myron@kentrox.com"
   DESCRIPTION  "The MIB module to describe the DS1/E1 Circuit Emulation
Interworking Function"
::= { atmfCESmib 1 }

-- an OBJECT IDENTIFIER for all ATM Forum circuit emulation MIBs
-- has been assigned as a branch from the Forum Network Management
-- tree.  The DS1/E1 Circuit Emulation specification is attached
-- as the first branch from the overall atmfCESmib object.  Future
-- branches may be added in the future for further CES work, for
-- example, DS3/E3 circuit emulation.

--  this is the MIB module for the ATM Forum DS1/E1 Circuit Emulation
--  Interworking Function objects

-- the following TEXTUAL-CONVENTIONS are used to link the CES
-- interworking function to ATM interface port, plus the
-- associated VPI and VCI.
VpiInteger ::= TEXTUAL-CONVENTION
    STATUS     current
    DESCRIPTION
      "An integer large enough to hold a VPI"
    SYNTAX     INTEGER (0..4095)

VciInteger ::= TEXTUAL-CONVENTION
    STATUS     current
    DESCRIPTION
      "An integer large enough to hold a VCI"
    SYNTAX     INTEGER (0..65535)

CESConnectionPort ::= TEXTUAL-CONVENTION
    STATUS current
    DESCRIPTION
      "Indicates the port associated with a Circuit Emulation
      connection.
```

```
          Objects of this type are always define as part of a set
          that includes
             fooPort       CESConnectionPort
             fooVPI        VpiInteger
             fooVCI        VciInteger
          The interpretation of these objects is as follows:
          1. If no connection exists, 'fooPort' has a value of 0.
             Because Interfaces table entries always have 'ifIndex'
             values greater than 0, 'fooPort' reliably serves as a
             'connection exists' flag.
             If no connection exists, 'fooVPI' and 'fooVCI' are
             meaningless and have a value of 0.
          2. If a PVC or SVC exists, fooPort is defined to have the
             value of the MIB-II/RFC1573 'ifIndex' of the ATM
             interface associated with the VCC.  'fooVPI' and 'fooVCI'
             will contain its VPI/VCI."

        SYNTAX     INTEGER (0..2147483647)

    atmfDS1E1CESmibObjects  OBJECT IDENTIFIER ::= {atmfDS1E1CESmib 1}

    atmfDS1E1CESConfTable    OBJECT-TYPE
        SYNTAX  SEQUENCE OF AtmfDS1E1CESConfEntry
        MAX-ACCESS  not-accessible
        STATUS  current
        DESCRIPTION
          "The CES configuration table. This includes mapping channels from
           ATM Port to CBR interfaces. There is one AtmfDS1E1CESConfEntry
           per CES Entity"
        ::= { atmfDS1E1CESmibObjects  1 }

    atmfDS1E1CESConfEntry    OBJECT-TYPE
        SYNTAX  AtmfDS1E1CESConfEntry
        MAX-ACCESS  not-accessible
        STATUS  current
        DESCRIPTION
          "An entry in the CES table. For each entry there is a corresponding
         entry in the stack table"
        INDEX   { ifIndex }
        ::= { atmfDS1E1CESConfTable 1 }

    AtmfDS1E1CESConfEntry ::= SEQUENCE  {
        atmfDS1E1CESMapATMIndex                CESConnectionPort,
        atmfDS1E1CESMapVPI                     VpiInteger,
        atmfDS1E1CESMapVCI                     VciInteger,
        atmfDS1E1CESCBRService                 INTEGER,
        atmfDS1E1CESCBRClockMode               INTEGER,
        atmfDS1E1CESCas                        INTEGER,
        atmfDS1E1CESPartialFill                INTEGER,
        atmfDS1E1CESBufMaxSize                 INTEGER,
        atmfDS1E1CESCDVRxT                     INTEGER,
        atmfDS1E1CESCellLossIntegrationPeriod  INTEGER
        }
```

```
atmfDS1E1CESMapATMIndex     OBJECT-TYPE
    SYNTAX      CESConnectionPort
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
     "The value of this object is equal to MIB II's
       ifIndex value of the ATM Port interface mapped
       through this CES to a CBR interface."
    ::= { atmfDS1E1CESConfEntry 1 }

atmfDS1E1CESMapVPI           OBJECT-TYPE
    SYNTAX      VpiInteger
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
     "The value of this object is equal to the VPI used
      for the emulated circuit represented by this entry
      in the ifTable.  If there is no connection, this
      object is meaningless and will have the value zero."
    ::= { atmfDS1E1CESConfEntry 2 }

atmfDS1E1CESMapVCI           OBJECT-TYPE
    SYNTAX      VciInteger
    MAX-ACCESS  read-only
    STATUS      current
    DESCRIPTION
     "The value of this object is equal to the VCI used
      for the emulated circuit represented by this entry
      in the ifTable.  If there is no connection, this
      object is meaningless and will have the value zero"
    ::= { atmfDS1E1CESConfEntry 3 }

atmfDS1E1CESCBRService          OBJECT-TYPE
    SYNTAX INTEGER {
                   unstructured(1),
                   structured(2)
                   }
    MAX-ACCESS    read-write
    STATUS        current
    DESCRIPTION
     "Define if DS1/E1 service as structured or not. A
      structured(2) interface is some nx64Kbps. An unstructured
      (1) interface is 1.544Mbps or 2.048Mbps. unstructured(1)
      passes all bits through the ATM network.
      strucutured(2) passes data bits through the ATM network, and
      may also pass signalling bits"
    ::= { atmfDS1E1CESConfEntry 4 }

atmfDS1E1CESCBRClockMode    OBJECT-TYPE
    SYNTAX INTEGER {
                   synchronous(1),
                   srts(2),
                   adaptive(3)
```

```
                  }
        MAX-ACCESS    read-write
        STATUS        current
        DESCRIPTION
         "Define if DS1/E1 service clocking mode. This maps into
          transmit clock source of CBR interface."
        DEFVAL { synchronous }
        ::= { atmfDS1E1CESConfEntry 5 }

    atmfDS1E1CESCas      OBJECT-TYPE
        SYNTAX INTEGER {
                  basic(1),
                  e1Cas(2),
                  ds1SfCas(3),
                  ds1EsfCas(4)
                  }
        MAX-ACCESS    read-write
        STATUS        current
        DESCRIPTION
         "This parameter selects which AAL1 Format should be used:
          Basic does not carry CAS bits, and uses a single 125 usec frame.
          e1Cas, ds1SfCas and dS1EsfCas carry CAS bits in a multiframe
          structure for E1, DS1 SF and DS1 ESF respectively.
          This applies to structured interfaces only. Default is basic (1)."
        DEFVAL { basic }
        ::= { atmfDS1E1CESConfEntry 6 }

    atmfDS1E1CESPartialFill     OBJECT-TYPE
        SYNTAX INTEGER (0 .. 47)
        MAX-ACCESS    read-write
        STATUS        current
        DESCRIPTION
         "If partial cell fill is used, the number of user octets per
         cell must be set with this parameter.  Setting this parameter
         to zero disables partial cell fill, and causes all cells to
         be completely filled before they are sent."
        DEFVAL { 0 } -- Partial Cell Fill not used
        ::= { atmfDS1E1CESConfEntry 7 }

    atmfDS1E1CESBufMaxSize      OBJECT-TYPE
        SYNTAX       INTEGER  (1..65536)
        MAX-ACCESS    read-write
        STATUS        current
        DESCRIPTION
         "Define maximum size in octets of the reassembly buffer.
          Some implementations may want allow the maximum buffer size to
          programmed to a size less than the physical limit to reduce
          the maximum delay through a circuit."
        DEFVAL { 256 }
        ::= { atmfDS1E1CESConfEntry 8 }

       atmfDS1E1CESCDVRxT         OBJECT-TYPE
           SYNTAX       INTEGER  (1..65535)
           UNITS ‘10 usec’
```

```
        MAX-ACCESS    read-write
        STATUS        current
        DESCRIPTION
         “The maximum cell arrival jitter in 10 usec increments that
         the reassembly process will tolerate in the cell stream without
         producing errors on the CBR service interface. ”
        DEFVAL { 100 }
        ::= { atmfDS1E1CESConfEntry 9 }

atmfDS1E1CESCellLossIntegrationPeriod   OBJECT-TYPE
    SYNTAX INTEGER  (1000 .. 65535)
    UNITS "msec"
    MAX-ACCESS read-write
    STATUS     current
    DESCRIPTION
     "The time in milliseconds for the cell loss integration period.
      If a cells are lost for this period of time.
      atmfDS1E1CESCellLossStatus is set to loss (2).The current
      definition is 2500."
    DEFVAL { 2500 }
    ::= { atmfDS1E1CESConfEntry 10 }

atmfDS1E1CESStatsTable    OBJECT-TYPE
    SYNTAX  SEQUENCE OF AtmfDS1E1CESStatsEntry
    MAX-ACCESS  not-accessible
    STATUS  current
    DESCRIPTION
      "The CES AAL1 statistical data table."
    ::= { atmfDS1E1CESmibObjects  2 }

atmfDS1E1CESStatsEntry    OBJECT-TYPE
    SYNTAX  AtmfDS1E1CESStatsEntry
    MAX-ACCESS  not-accessible
    STATUS  current
    DESCRIPTION
      "An entry in the CES AAL1 Stats table."
    INDEX   { ifIndex }
    ::= { atmfDS1E1CESStatsTable 1 }

AtmfDS1E1CESStatsEntry ::= SEQUENCE  {
    atmfDS1E1CESReassCells         Counter32,
    atmfDS1E1CESHdrErrors          Counter32,
    atmfDS1E1CESPointerReframes    Counter32,
    atmfDS1E1CESLostCells          Counter32,
    atmfDS1E1CESBufUnderflows      Counter32,
    atmfDS1E1CESBufOverflows       Counter32,
    atmfDS1E1CESCellLossStatus     INTEGER
    }

atmfDS1E1CESReassCells         OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
```

```
     "This count gives the number of cells played out to the DS1/E1
     Service Interface. It excludes cells that were discarded for
     any reason, including cells that were not used due to being
     declared misinserted, or discarded while the reassembler was
     waiting to achieve synchronization."
    ::= { atmfDS1E1CESStatsEntry 1 }

atmfDS1E1CESHdrErrors         OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
     "The count of the number of AAL1 header errors detected and
     possibly corrected.  Header errors include correctable and
     uncorrectable CRC, plus bad parity."
    ::= { atmfDS1E1CESStatsEntry 2 }

atmfDS1E1CESPointerReframes    OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
     "This records the count of the number of events in which the
     AAL1 reassembler found that an SDT pointer is not where it is
     expected, and the pointer must be reacquired."
    ::= { atmfDS1E1CESStatsEntry 3 }

atmfDS1E1CESLostCells   OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
     "Number of lost cells."
    ::= { atmfDS1E1CESStatsEntry 4 }

atmfDS1E1CESBufUnderflows      OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
     "Number of buffer underflows."
    ::= { atmfDS1E1CESStatsEntry 5 }

atmfDS1E1CESBufOverflows      OBJECT-TYPE
    SYNTAX        Counter32
    MAX-ACCESS    read-only
    STATUS        current
    DESCRIPTION
     "Number of buffer overflows."
    ::= { atmfDS1E1CESStatsEntry 6 }

atmfDS1E1CESCellLossStatus      OBJECT-TYPE
    SYNTAX INTEGER {
                   noLoss(1),
```

```
                       loss(2)
                       }
        MAX-ACCESS    read-only
        STATUS        current
        DESCRIPTION
         "When cells are lost for the number of milliseconds specified
          by atmfDS1E1CESCellLossIntegrationPeriod, the value is set to
          loss (2). When cells are no longer lost, the value is set
          to noLoss (1)."
        ::= { atmfDS1E1CESStatsEntry 7 }
END
```

Annex A Impairment Analysis

This annex addresses the mapping into Circuit Emulation Service impairments—errored seconds (ES) and severely errored seconds (SES)—from the cell loss ratio (CLR) and the cell error rate (CER) impairments of the underlying ATM transport. It complements the broader, more qualitative discussion in the (informative) Annex B, “Relationship between ATM Layer Network Performance and the Network Performance of AAL Type1 for CBR Services”, of T1.511-1994, “B-ISDN ATM Layer Cell Transfer - Performance Parameters”

It is difficult to set requirements on these impairments and other impairments such as cell transfer delay (CTD) and cell delay variation (CDV), since they are application specific; and in some cases, particularly CDV, still being studied. Furthermore, the requirements could be equipment dependent. For example, the addition of error control to equipment would decrease requirements on the ATM transport facility.

For DS1 and fractional DS1, there are some requirements in ANSI T1.510 for SES and ES. When voice was the predominate application, one could, assuming no error control, derive some reasonable requirements for BER since an end-to-end PCM-encoded voice signal would tolerate a 10^{-6} BER in the TDM circuit.(Source: SR-TSV-00275, Iss. 1, March 1991)

The following discussion of ES and SES assumes an absence of error control on the cell information field and that lost cells are replaced with a random bit pattern.

A.1 Errored Second

An ES is a one-second interval with one or more bit errors. Each Nx64 kbit/s and 1.544 Mbit/s channel requires that, over 30 or more consecutive days, fewer than 0.20% and 0.50%, respectively, of the seconds are errored seconds. (Source: ANSI T1.510-1994)

Since 64 kbit/s and even 1.544 Mbit/s channels are likely a small proportion of the underlying ATM transport capacity, then the burstiness of ATM-related binary errors and cell loss should be dispersed in time at both the 64 kbit/s and the 1.544 Mbit/s channel levels. Therefore, the worst case approach of random errors and cell loss may be reasonable. If so, then, ignoring the small (2^{-376}) probability that a cell loss will cause no binary errors:

For a 64 kbit/s channel (which utilizes 170.21 cell/s), an ES less than 0.20% (or 1 in 500) of the seconds implies that CER + CLR < 1.175×10^{-5};

For an Nx64 kbit/s channel (which utilizes Nx170.21 cell/s, $2 \leq N \leq 24$), an ES less than 0.20% (or 1 in 500) of the seconds implies that CER + CLR < 1.175×10^{-5} /N;

For a 2.048 Mbit/s channel (which utilizes 5,447 cell/s) an ES less than 0.50% (or 1 in 200) of the seconds implies that CER + CLR < 9.18×10^{-7}.

These ATM performance parameters map into DS1 Bit Error Rate (BER), Errored Second (ES) and Severely Errored Second (SES) values:

Cell Error Ratio (CER) - an errored bit in a cell payload is likely to result in an error in the emulated circuit, causing an Errored Second.

Cell Loss Ratio (CLR) - a lost cell will result in an average of 188 errored bits in the emulated circuit. A single lost cell will result in a Severely Errored Second for Nx64 services where N is one or two.

Cell Misinsertion Rate (CMR) - undetected, misinserted cells will also cause Severely Errored Seconds for Nx64 circuits where N is one or two.

We summarize the mapping outlined above in Table 6-8.:

Service	Performance Target	ATM Objective
unstructured DS1	ES < 0.5%	CLR+CER < 1.22×10^{-6}
unstructured E1	ES < 0.5%	CLR+CER < 9.18×10^{-7}
64 kbit/s	ES < 0.2%	CLR+CER < 1.175×10^{-5}

Table 6-8: ATM VC Mapping

Annex B Abbreviations

Acronyms and abbreviations in CES baseline document:

AAL - ATM Adaptation Layer
AAL1 - ATM Adaptation Layer Type 1
AIS - Alarm Indication Signal
AMI - Alternate Mark Inversion
ANSI - American National Standards Institute
ATM - Asynchronous Transfer Mode
AUU - ATM-Layer-User to ATM-Layer-User
B-HLI - Broadband High Layer Information
B-LLI - Broadband Low Layer Information
B-ICI - Broadband Intercarrier Interface
B-ISDN - Broadband Integrated Services Digital Network
B8ZS - Bipolar with 8 Zero Substitution
BER - Bit Error Ratio
BITS - Building Integrated Timing System
CAS - Channel Associated Signalling
CBR - Constant Bit Rate
CDV - Cell Delay Variation
CE - Congestion Experienced
CER - Cell Error Ratio
CES - Circuit Emulation Service
CES-IS - Circuit Emulation Service Interoperability Specification
CLP - Cell Loss Priority
CLR - Cell Loss Ratio
CMR - Cell Misinsertion Ratio
CO - Central Office
CRC - Cyclic Redundancy Check
CTD - Cell Transfer Delay
DS0 - Digital Signal level 0 (64 kbit/s)
DS1 - Digital Signal level 1 (1544 kbit/s)
DS3 - Digital Signal level 3 (44736 kbit/s)
DSX1 - Digital Signal Cross(X)connect level 1
E1 - special digital trunk, European (2048 kbit/s)
ES - Errored Second

ESF - Extended Super Frame

FDL - Facility Data Link

HDB3 - High-Density Binary Three

IE - Information Element

IEC - International Electrotechnical Commission

IETF - Internet Engineering Task Force

ILMI - Interim Local Management Interface

ISDN - Integrated Services Digital Network

ISO - International Organization for Standardization

IWF - Inter-Working Function

kbit/s - thousand bits per second

LOS - Loss of Signal

Mbit/s - million bits per second

MIB - Management Information Base

ms - milliseconds

μsec - microsecond

N-ISDN - Narrowband Integrated Services Digital Network

NNI - Network to Network Interface

OAM - Operations And Maintenance

OC3 - Optical Carrier level 3 (155.52 Mbit/s)

OUI - Organizational Unit Identifier

PBX - Private Branch eXchange

PCM - Pulse Code Modulation

PCR - Peak Cell Rate

PLCP - Physical Layer Convergence Protocol

POTS - Plain Old Telephone Service

ppm - parts per million

PRS - Primary Reference Source

QoS - Quality of Service

RAI - Remote Alarm Indication

RFC - Request for Comment

SAA - Service Aspects and Applications

SDT - Structured Data Transfer

SES - Severely Errored Second

SF - Super Frame

SNAP - Sub-Network Access Protocol

SNMP - Simple Network Management Protocol

SONET - Synchronous Optical NETwork

SRTS - Synchronous Residual Time Stamp

SVC - Switched virtual circuit

TDM - Time Division Multiplex

UDT - Unstructured Data Transfer

UI - Unit Interval

UNI - User to Network Interface

UPC - Usage Parameter Control

VC - Virtual Channel

VCC - Virtual Channel Connection