The ATM Forum

Technical Committee

Voice and Multimedia Over ATM - Loop Emulation Service Using AAL2

AF-VMOA-0145.000

July, 2000

The ATM Forum
Worldwide Headquarters
2570 West El Camino Real, Suite 304
Mountain View, CA 94040-1313
Tel: +1-650-949-6700
Fax: +1-650-949-6705

Preface

This specification uses three levels for indicating the degree of compliance necessary for specific functions, procedures, or coding. They are indicated by the use of key words as follows:

- **Requirements:** "Shall" indicates a required function, procedures or coding necessary for compliance. In some cases "shall" used in text indicates a conditional requirement, since the operation described is dependent on whether or not an objective or option is chosen.
- **Objective:** "Should" indicates an objective which is not required for compliance, but which is considered desirable.
- **Option:** "May" indicates an optional operation without implying a desirability of one operation over another. That is, it identifies an operation that is allowed while still maintaining compliance.

Acknowledgements

The editor would like to thank particularly the following people for their input to this document:

Malcolm Airst (VMOA Vice Chair)
Marty Borden
Don Choi (VMOA Chair)
Eric Deichstetter
David Frankel
Richard Joerger
Gerhard Maegerl
Ronald Mueller
Curtis Siller
Peter Silverman
Greg Wetzel

Editor: Martin Taylor
mtaylor@coppercom.com

Contents

1 Introduction

1.1 Objectives

The Loop Emulation Service using AAL2 for Narrowband Services described in this specification fulfills a market need for an efficient transport mechanism to carry voice, voice-band data, fax traffic, ISDN B-channels and D-channels over a broadband subscriber line connection such as xDSL, HFC or wireless between customer premises and a Service Node such as provided by the public switched telephone network. Voice transport will include support for compressed voice and non-compressed voice together with silence removal.

1.2 Scope

This specification describes the procedures and signaling required to support the efficient transport of voiceband services across an ATM network between two Interworking Functions (IWF) located respectively at a customer premises and at a service provider premises. It specifies the use of ATM virtual circuits with AAL2 to transport bearer information and signaling. The virtual circuits used may be PVCs, SPVCs, or SVCs. The specification supports the transport of common channel signaling (CCS) information as well as channel associated signaling (CAS) information.

The scope of this specification is to define the following

- The functionality of the IWFs
- Relevant control plane aspects of the Loop Emulation Service using AAL2
- Relevant user plane aspects of the Loop Emulation Service using AAL2
- Relevant management plane aspects
- Timing and synchronization requirements specific to the Loop Emulation Service

An IWF complying with this specification shall conform to the procedures described in ITU-T Recommendation I.366.2 except where stated.

1.3 Abbreviations

The following abbreviations as used in this specification:

AAL2	ATM Adaptation Layer type 2
AAL5	ATM Adaptation Layer type 5
AAL2 VCC	An ATM VCC using AAL2
AAL5 VCC	An ATM VCC using AAL5
ADPCM	Adaptive Differential Pulse Code Modulation
ADSL	Asymmetric Digital Subscriber Line

AINI	ATM Inter Network Interface
AIS	Alarm Indication Signal
AppId	APPlication ID
AN	Access Node
ANSI	American National Standards Institute
ATM	Asynchronous Transfer Mode
B-HLI	Broadband – High Layer Information
BCC	Bearer Channel Connection Protocol
BRI	Basic Rate Interface
CAS	Channel Associated Signaling
CCS	Common Channel Signaling
CDV	Cell Delay Variation
CID	AAL2 Channel Identifier
CMIP	Common Management Information Protocol
CO	Central Office
CO-IWF	Central Office Interworking Function
CP-IWF	Customer Premises Interworking Function
CPS	Common Part Sublayer
CRV	Call Reference Value
CSC	Common Signaling Channel
DSS1	Digital Subscriber Signaling System number 1
DSS2	Digital Subscriber Signaling System number 2
DTMF	Dual Tone Multi-frequency
ELCP	Emulated Loop Control Protocol
EOC	Embedded Operations Channel
ETSI	European Telecommunications Standards Institute
FAX	Facsimile
FCS	Frame Check Sequence
FSK	Frequency Shift Keyed
GIT	Generic Identifier Transport

HDLC	High-level Data Link Control
HDLC-F	HDLC – Framing
HDSL	High-speed Digital Subscriber Line
HFC	Hybrid Fiber Coax
IDT	Integrated Digital Terminal
IE	Information Element
IEC	International Electro-technical Commission
ILMI	Integrated Local Management Interface
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ITU-T	International Telecommunications Union, Telecommunications sector
IWF	Interworking Function
LAPD	Link Access Protocol for ISDN D-channel
LAPV5	Link Access Protocol for V5-interface
LAPV5-DL	LAPV5 Data Link sublayer
LE	Local Exchange
LES	Loop Emulation Service
MBS	Maximum Burst Size
MIB	Management Information Base
OAM	Operation Administration and Maintenance
OUI	Organizational Unit Identifier
PBX	Private Branch exchange
PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PDV	Packet Delay Variation
PNNI	Private Network-to-Network Interface
PRS	Primary Reference Source
PSTN	Public Switched Telephone Network
PVC	Permanent Virtual Circuit
RDI	Remote Defect Indication

RDT	Remote Digital Terminal
RFC	Request For Comments
SAAL	Signaling ATM Adaptation Layer
SAPI	Service Access Point Identifier
SAR	Segmentation And Reassembly
SCR	Sustainable Cell Rate
SDU	Service Data Unit
SHDSL	Symmetric High-speed Digital Subscriber Line
SID	Silence Insertion Descriptor
SigVCCI	Signaling VCCI
SNI	Service Node Interface
SNMP	Simple Network Management Protocol
SPVC	Soft Permanent Virtual Circuit
SSCS	Service Specific Convergence Sublayer
SSSAR	Service Specific SAR
SSTED	Service Specific Transmission Error Detection
SSTED-CI	SSTED – Congestion Indication
SSTED-LP	SSTED – Loss Priority
SSTED-UU	SSTED – User-to-User indication
SVC	Switched Virtual Circuit
TDD	Telecommunications Device for the Deaf
TDM	Time Division Multiplexing
TED	Transmission Error Detection
TMC	Timeslot Management Channel
TMF	Timeslot Management Function
UNI	User Network Interface
UUI	User-to-User Indication
VCC	Virtual Channel Connection (where it may be a PVC, SPVC, or SVC)
VCCI	VCC Identifier
xDSL	Any variety of Digital Subscriber Line, e.g. ADSL or SDSL

1.4 Reference Model

This specification is intended to support the delivery of voiceband services from the PSTN to customer premises over bandwidth-constrained ATM connections such as those provided by Digital Subscriber Line systems.

Figure 1 shows the reference model for the Loop Emulation Service using AAL2.

NOTE: In this Reference Model, only those entities are shown that pertain to voice band services. In an implementation, the equipment providing the CP-IWF may also provide data interfaces (e.g. Ethernet) toward the customer. Traffic originating from or terminating at such interfaces will be carried over AAL5 or other appropriate AAL on the same ATM interface to the ATM network as the voice band traffic.

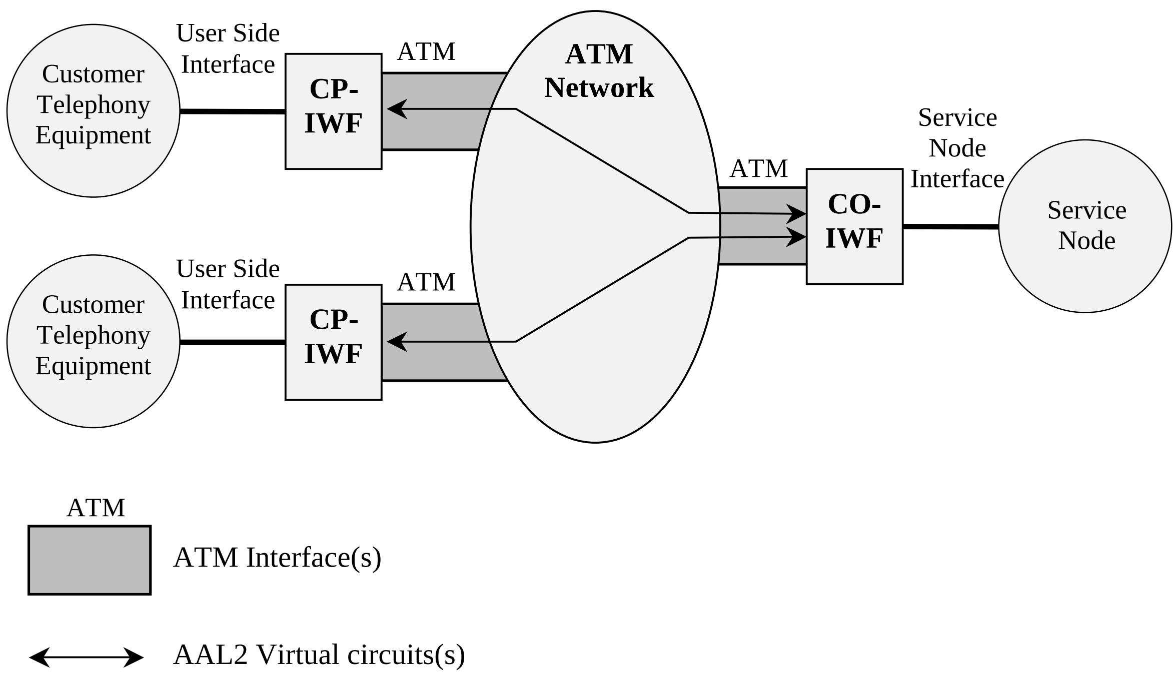


Figure 1: The Reference Model; Loop Emulation Service Using AAL2

The CO-IWF and CP-IWF described in this specification are functional units, which may be implemented as stand-alone devices, as parts of larger devices, or distributed among several devices. This specification does not dictate the implementation of any one of these configurations.

The Service Node shown in Figure 1 may represent a Class 5 PSTN switch delivering public switched telephone services over a narrowband Service Node Interface (SNI), or it may represent a PBX in a private network. The SNI may also be packet-based. The Service Node may connect to the CO-IWF via one or more physical interfaces. Alternatively, the CO-IWF functionality may be present as an integral part of a Service Node, in which case there is no external appearance of the physical interface between CO-IWF and Service Node.

The physical connection between the CP-IWF and the ATM network is typically provided by a DSL, HFC or wireless link. The ATM network may be a full network, a single ATM switching element or simply a direct interconnection between a CO-IWF and a CP-IWF.

The ATM virtual circuits through the ATM network between the CP-IWF and the CO-IWF shall be SVCs, PVCs, or SPVCs carrying:

- bearer traffic and CAS using AAL2, where CAS is carried in the same AAL2 channel as the associated bearer traffic.
- bearer traffic and CCS using AAL2, where CCS for the control of Narrowband services is carried in a specific AAL2 channel that does not carry bearer traffic, within the same ATM VCC as the associated bearer traffic.

1.5 Speech Encoding

An IWF shall support one or more standard speech encoding schemes. Changes within a family of related algorithms should be possible with no disruption in the audio.

An IWF should support silence removal, i.e., suppression of the transfer of AAL2 packets during silent intervals and insertion of the appropriate background noise (Comfort Noise Generation) at the distant end.

1.6 Protocol Architecture

Figure 2 depicts the manner in which the services listed above are supported by the various portions of the ATM protocol architecture.

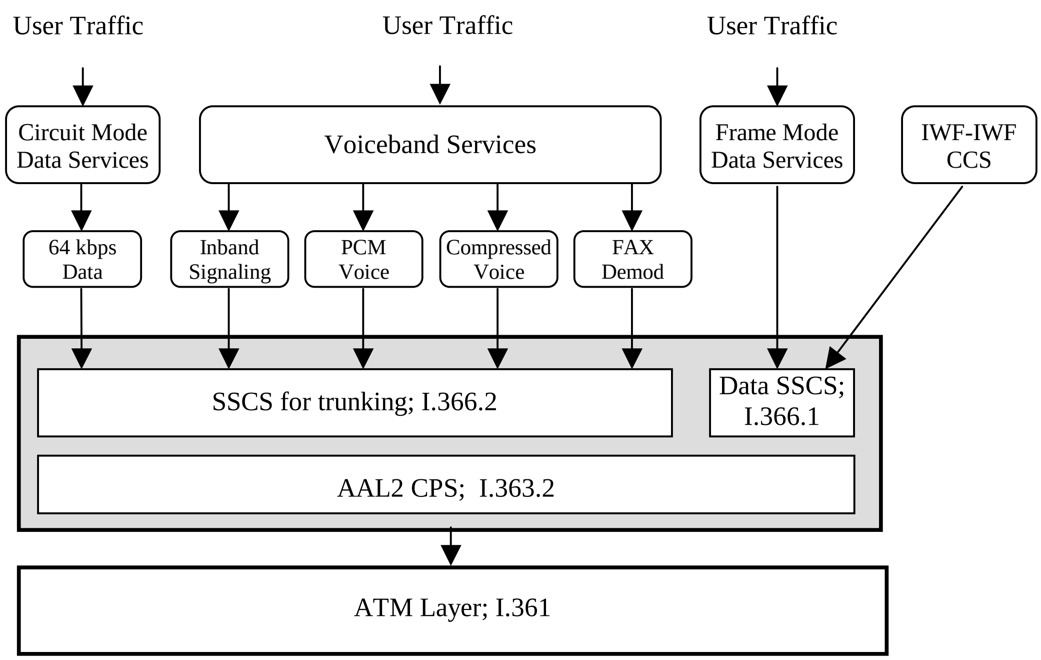


Figure 2: ATM Protocols that Support the Services

NOTE: N x 64 kbps circuit mode bearer service is not supported.

1.7 CO-IWF Functionality

Depending on the configuration, a CO-IWF includes a subset of the following functions:

- Switch function, to allow any individual channel from the SNI to be connected to any individual AAL2 channel.
- Signaling Interworking, to receive signaling from and insert signaling into both the SNI (if present) and the ATM broadband interfaces
- Call Handling, to interpret the call set-up and release signals from the connected Service Node and broadband equipment and control the connection of SNI channels to AAL2 channels
- SSCS User functions, including e.g. voice codecs for speech compression, echo cancellers and Fax demodulation/remodulation units
- AAL2 SSCS functions, to format User information into packets for transport on AAL2 connections
- AAL2 CPS functions, for multiplexing AAL2 connections into ATM cells

- ATM VCC Management, to allocate and deallocate ATM VCCs to distant CP-IWFs as needed to support the traffic
- AAL2 Channel Management, to allocate and de-allocate AAL2 channels to distant CP-IWFs as needed to support the traffic
- SAAL functions to support ATM UNI signaling activity for the establishment of SVCs on demand
- A management interface to allow management of the telephony functions on the CP-IWF remotely from the CO-IWF

1.8 CP-IWF Functionality

Depending on the configuration, a CP-IWF includes a subset of the following functions:

- Physical layer interfaces to customer-located telephony equipment such as analog POTS, basic rate ISDN or channelized DS1
- Signaling Interworking, to receive signaling from and insert signaling into both the narrowband interfaces, and the ATM broadband interfaces
- SSCS User functions, including e.g. voice codecs for speech compression, echo cancellers and Fax demodulation/remodulation units
- AAL2 SSCS functions, to format User information into packets for transport on AAL2 connections
- AAL2 CPS functions, for multiplexing AAL2 connections into ATM cells
- ATM VCC Management, to allocate and deallocate ATM VCCs to distant CO-IWFs as needed to support the traffic
- AAL2 Channel Management, to allocate and de-allocate AAL2 channels to distant CO-IWFs as needed to support the traffic
- SAAL functions to support ATM UNI signaling activity for the establishment of SVCs on demand
- A management interface to allow management of the telephony functions remotely from the CO-IWF

1.9 References

1.9.1 Normative

The following references contain provisions that, through reference in this text, constitute provisions of this specification. At the time of publication, the editions indicated were valid. All references are subject to revision, and parties to agreements based on this specification are encouraged to investigate the possibility of applying the most recent editions of the references indicated below.

1. DSL Forum TR-017, 1999, ATM over ADSL Recommendations.

2. ANSI T1.401-1993, Interface between carriers and customer installations - analog voice grade switched access lines using loops-start and ground-start signaling.

3. ANSI T1.405-1996, Network-to-customer installation interfaces – direct-inward-dialing analog voicegrade switched access using loop-reverse battery signaling.

4. ANSI T1.409-1996, Network-to-customer installation interfaces – analog voice grade special access lines using E&M signaling.

5. ANSI T1.602-1996, Integrated services digital network (ISDN) - Data-link layer signaling specification for application at the user-network interface.

6. ANSI T1.607-1990 (R 1995) and ANSI T1.607a-1996, Digital subscriber signaling system number 1 (DSS1) – layer 3 signaling specification for circuit-switched bearer services.

7. ATM Forum af-pnni-0055.000, 1996, Private Network-Network Interface Specification Version 1.0 (PNNI 1.0).

8. ATM Forum af-sig-0061.000, 1996, ATM User-Network Interface (UNI) Signalling Specification Version 4.0.

9. ATM Forum af-ilmi-0065.000, 1996, Integrated Local Management Interface (ILMI) Specification Version 4.0.

10. ATM Forum af-vtoa-0113.000, 1999, ATM Trunking using AAL2 for Narrowband Services.

11. ATM Forum af-cs-0125.000, 1999, ATM Inter-Network Interface (AINI) Specification 1.0.

12. ETSI ETS 300 012-1, 1998, Integrated Services Digital Network (ISDN); Basic user-network interface; Layer 1 specification and test principles.

13. ETSI EN 300 324-1, 1999, V5.1 interface for the support of Access Network (AN) Part 1: V5.1 interface specification.

14. ETSI EN 300 347-1, 1999, V5.2 interface for the support of Access Network (AN) Part 1: V5.2 interface specification.

15. ETSI ETS 300 402-1, 1995, Integrated services digital network (ISDN); Digital subscriber signalling system no. 1 (DSS1) protocol; Data link Layer; Part 1: General aspects.

16. ETSI ETS 300 402-2, Nov 1995 Integrated services digital network (ISDN); Digital subscriber signalling system no. 1 (DSS1) protocol; Data link Layer; Part 2: General protocol specification.

17. IETF STD0002 (RFC1700), 1994, Assigned numbers

18. ITU-T G.991.2, Draft, Single-pair high speed digital subscriber line (SHDSL) transceivers.

19. ITU-T G.992.1, 1999, Asymmetric Digital Subscriber Line (ADSL) transceivers.

20. ITU-T G.992.2, 1999, Splitterless Asymmetric Digital Subscriber Line (ADSL) transceivers

21. ITU-T G.964, 1994, V-Interfaces at the Digital Local Exchange (LE) – V5.1-Interface (based on 2048 Kbit/s) for the Support Of Access Network (AN).

22. ITU-T G.965, 1995, V-Interfaces at the Digital Local Exchange (LE) – V5.2-Interface (based on 2048 Kbit/s) for the Support Of Access Network (AN).

23. ITU-T I.363.2, 1997, B-ISDN ATM Adaptation Layer specification: Type 2 AAL.

24. ITU-T I.363.5, 1996, B-ISDN ATM Adaptation Layer specification: Type 5 AAL.

25. ITU-T I.366.1, 1998, Segmentation and reassembly service specific convergence sublayer for the AAL type 2.

26. ITU-T I.366.2, 1999, AAL Type 2 service specific convergence sublayer for trunking.

27. ITU-T I.430, 1995, Basic User-Network Interface – Layer 1 Specification.

28. ITU-T I.432.1, 1996, B-ISDN user-network – Physical layer specification: General characteristics.

29. ITU-T I.432.2, 1996, B-ISDN user-network – Physical layer specification: 155 520 kbit/s and 622 080 kbit/s operation.

30. ITU-T I.432.3, 1996, B-ISDN user-network – Physical layer specification: 1544 kbit/s and 2048 kbit/s operation.

31. ITU-T I.432.4, 1996, B-ISDN user-network – Physical layer specification: 51 840 kbit/s operation.

32. ITU-T I.432.5, 1997, B-ISDN user-network – Physical layer specification: 25 600 kbit/s operation.

33. ITU-T I.610, 1998, B-ISDN Operation and Maintenance Principles and Functions.

34. ITU-T Q.2931, 1999, Broadband Integrated Services Digital Network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS 2) – User-Network Interface (UNI) Layer 3 specification for basic call/connection control.

35. ITU-T Q.2941.2, 1999, Broadband Integrated Services Digital Network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS 2): Generic identifier transport (Draft).

36. ITU-T Q.921, 1997, Digital Subscriber Signaling System No. 1, ISDN user-network interface – Data link layer specification.

37. ITU-T Q.931, 1998, Digital subscriber signalling system No. 1 (DSS 1) – ISDN user-network interface layer 3 specification for basic call control.

38. ITU-T V.8, 1998, Procedures for starting sessions of data transmission over the general switched telephone network.

39. ITU-T V.25, 1996, Automatic answering equipment and general procedures for automatic calling equipment on the general switched telephone network including procedures for disabling of echo control devices for both manually and automatically established calls.

40. Telcordia Generic Requirements GR–303–CORE Issue 2, 1998, Integrated Digital Loop Carrier System Generic Requirements, Objectives, and Interface.

NOTE: ITU-T G.964 and G.965 are functionally equivalent to ETSI EN 300 324-1 and ETSI EN 300 347-1 respectively. In cases where detail differences exist between the ITU-T and ETSI versions of the specifications, the ETSI versions of the specifications should apply.

1.9.2 Informative

1. ANSI T1.101-1994, Telecommunications - Synchronization Interface Standard.

2. ANSI T1.508-1992, Network Performance – Loss Plan for Evolving Digital Networks.

3. DSL Forum WT-043 Rev 0.5, 2000, Requirements for Voice over DSL.

4. ITU-T G.114, 1996, One-way transmission time.

5. ITU-T G.131, 1996, Control of talker echo.

6. ITU-T G.168, 1997, Digital network echo cancellers.

7. Telcordia Technical Reference TR-TSY-000008 Issue 2, 1987, Digital Interface between the SLC®96 Digital Loop Carrier and a Local Digital Switch.

8. Telcordia Technical Reference TR-NWT-000057 Issue 2, 1993, Functional Criteria for Digital Loop Carrier Systems.

9. Telcordia TR-NWT-000393, 1991, Generic Requirements For ISDN Basic Access Digital Subscriber Lines.

2 Interfaces Supported

This specification identifies the user-side interfaces supported at the CP-IWF, and specifies the ATM interfaces at both the CP-IWF and the CO-IWF. It does not define the interfaces on the network side of the CO-IWF, because it is intended that the protocol operating between the IWFs should offer generic support for the delivery of narrowband services at the CP-IWF user-side interfaces in a manner that is independent of the Service Node Interface at the CO-IWF.

It is anticipated that some implementations of the CO-IWF will support narrowband Service Node interfaces to circuit-switched voice networks in accordance with well known access network interface specifications such as Telcordia GR-303, Telcordia TR-008, ETSI V5.1 (ITU-T G.964) and ETSI V5.2 (ITU-T G.965). To assist implementors with the development of such devices, a series of informative appendices are included with this specification which provide examples of mappings between the protocols that exist across these well-known interfaces, and the protocols that are defined in this specification between CO-IWF and CP-IWF.

2.1 CO-IWF ATM Interfaces

2.1.1 Physical Layer

The interface between a CO-IWF and the ATM network should be any ATM interface defined by the ATM Forum or by the ITU-T I.432.x series of UNI recommendations, or the following interface types:

- ATM over ADSL in accordance with DSL Forum TR-017
- Other ATM physical layer specifications for SDSL, HFC and wireless transmission systems depending on the application.

Examples of SDSL presently being standardized are:

- ITU-T SHDSL (Draft Recommendation G.991.2, Single-pair high speed digital subscriber line (SHDSL) transceivers)
- ANSI HDSL2 (High bit rate Digital Subscriber Line – 2nd Generation (HDSL2))
- ETSI SDSL (Symmetric single pair high bit rate digital subscriber line (SDSL) transmission system on metallic local lines)

2.1.2 Adaptation Layer

A CO-IWF shall implement AAL2 as defined in I.363.2. If AAL5 is used (to support SAAL), it shall be as defined in I.363.5.

2.1.3 Signaling Layer

If a CO-IWF signals to the ATM network to setup ATM SVCs, the signaling to that network shall be ATM Forum UNI 4.0 (af-sig-0061.000), ATM Forum PNNI 1.0 (af-pnni-0055.000), ATM Forum AINI 1.0 (af-cs-0125.000), or ITU-T Q.2931.

2.2 CP-IWF User-Side Interfaces

A CP-IWF should support appropriate interfaces for connection to customer-located telephony equipment. These interfaces may include analog telephony, basic rate ISDN, and DS1 with robbed-bit signaling.

Specifications for these interfaces include the following:

- Analog telephony interface in accordance with ANSI T1.401, ANSI T1.405, ANSI T1.409, Telcordia TR-NWT-000057 or equivalent national standard

- Basic rate ISDN interface in accordance with ITU-T I.430, Telcordia TR-NWT-000393, ETSI ETS 300 012 or equivalent national standard
- Other line side customer interfaces depending on the application.

2.3 CP-IWF ATM Interfaces

The ATM interfaces that may be supported at the CP-IWF are the same as those that may be supported at the CO-IWF, described in section 2.1 above.

3 Capabilities Supported

This section provides a high level description of the capabilities to be supported by the CO-IWF and CP-IWF for the AAL2 Loop Emulation Service . It should be noted that an IWF may be realized as a set of functions within a larger device and may reside with other capabilities not identified here.

3.1 IWF-IWF Communication

A CP-IWF and a CO-WF are connected by an ATM VCC. A CP-IWF is connected to a single CO-IWF, while a CO-IWF supports ATM connections to a number of CP-IWFs. The ATM VCCs can be PVCs, SVCs or SPVCs. The ATM VCCs may be carried over a direct ATM link or via an ATM network.

Within such an ATM VCC, AAL2 is used to carry bearer traffic, CAS, CCS, and other control and management plane traffic.

3.2 ATM VCCs carrying AAL2 channels for the support of LES

An ATM VCC between a CP-IWF and a CO-IWF may contain traffic from one or more analog lines and/or one or more ISDN Basic Rate Interfaces.

Supervisory signaling for analog lines is either carried as CAS in the same AAL2 channel as the bearer traffic or carried in a separate AAL2 channel as CCS. Within a given AAL2 VCC these methods are mutually exclusive.

Traffic from a given ISDN BRI is carried as "2B + D" with separate AAL2 channels for each B-channel and the D-channel.

For a detailed description see section 5.

3.3 Signaling

The CP-IWF and the CO-IWF shall support the transport of signaling information across the ATM network between the narrowband interface of the customer-located telephony equipment at the CP-IWF, and the Service Node Interface at the CO-IWF.

This section provides protocol reference models that illustrate the interworking between the narrowband user side interfaces and the ATM network side interface at the CP-IWF.

Protocol reference models for the CO-IWF are not illustrated here because this specification does not define the Service Node Interface at the CO-IWF. The ATM network side protocols are terminated at the CO-IWF in the same manner as illustrated here for the CP-IWF. Example protocol reference models for the CO-IWF can be found in informative Appendices B and C that describe the operation of the CO-IWF with specific narrowband Service Node Interfaces including GR-303 and V5.

3.3.1 Signaling Between CO-IWF And CP-IWF for Analog Telephony

Control signaling information in support of narrowband service delivery at the user side interfaces of the CP-IWF and the Service Node Interface of the CO-IWF shall be transported between CP-IWF and CO-IWF in the form of CAS over AAL2, or CCS over AAL2. In both cases the signaling information is carried in the same ATM VCC that contains the AAL2 channels for the bearers.

Analog signaling states at POTS interfaces of the CP-IWF shall be converted by the CP-IWF into CAS or CCS information.

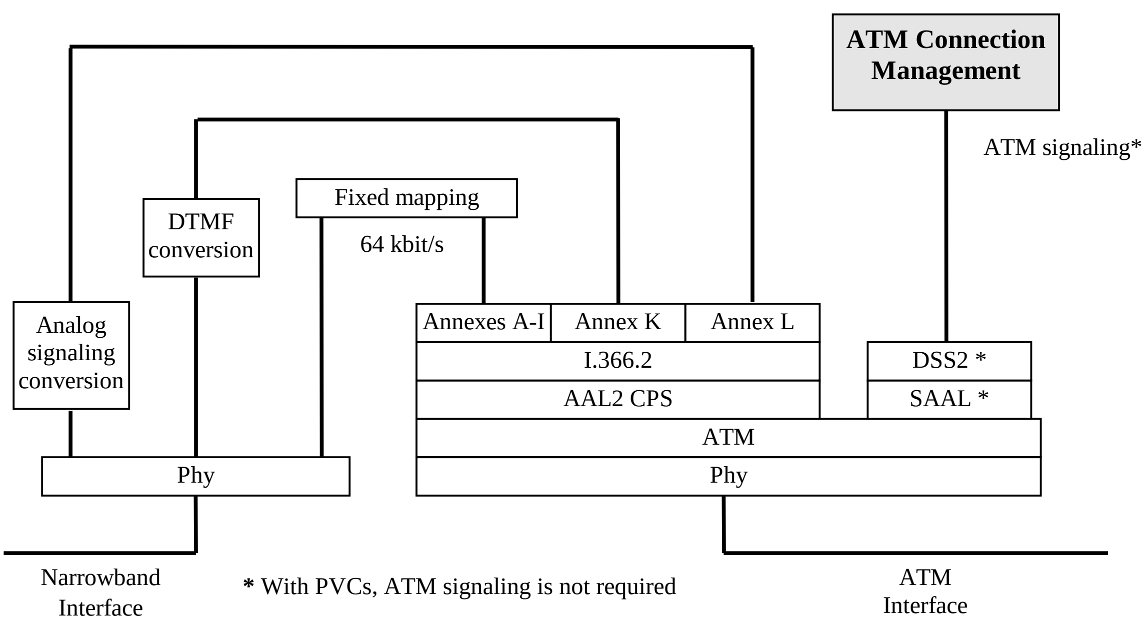


Figure 3: Protocol Reference Model for CP-IWF with analog telephony user side interfaces with CAS transported over AAL2 between IWFs

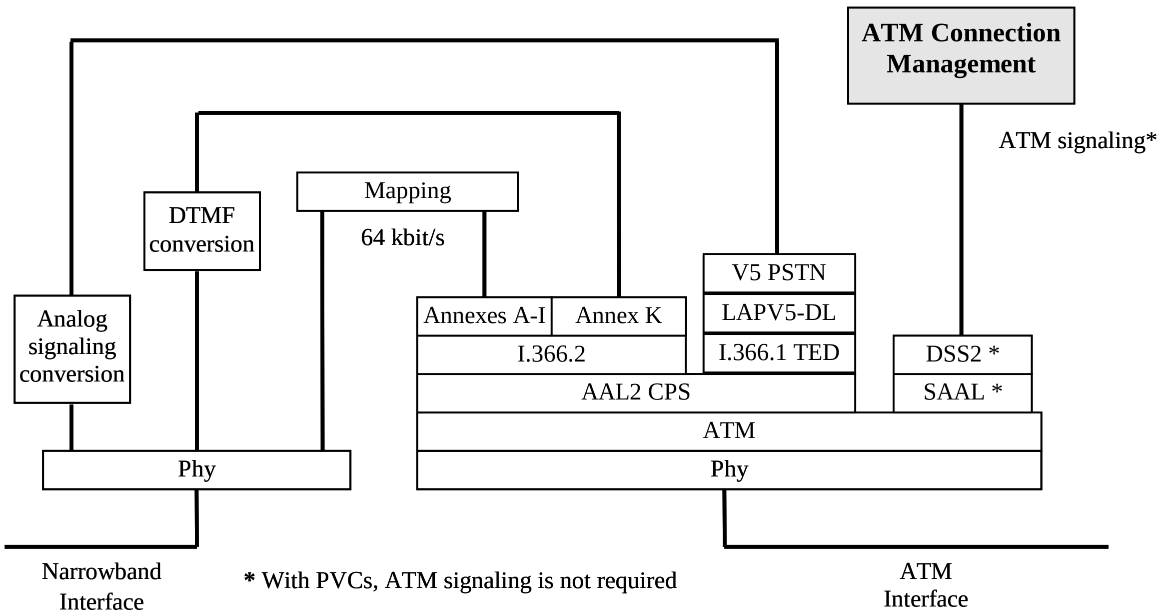


Figure 4: Protocol Reference Model for CP-IWF with analog telephony user side interfaces with CCS transported over AAL2 between IWFs

Figure 3 shows the protocol reference model for a CP-IWF with analog telephony user side interfaces, with CAS transported over AAL2 between CP-IWF and CO-IWF. Analog line states are mapped to ABCD codewords in the CP-IWF and transported via the CAS service defined in Annex L of I.366.2. Narrowband 64 kbps media streams are mapped to AAL2 channels in accordance with the methods specified in Annexes A-I of I.366.2. In the event that the CP-IWF employs a voice codec that does not support transparent transport of DTMF tones via the bearer channel, DTMF tones may be mapped to digits and transported via the dial digits service defined in Annex K of I.366.2.

Figure 4 shows the protocol reference model for a CP-IWF with analog telephony user side interfaces, with CCS signaling transported over AAL2 between CP-IWF and CO-IWF. The model is the same as for CAS with the exception that analog line states are mapped to V5 PSTN protocol messages.

Note that the term “CCS signaling” as used in this document refers to Common Channel Signaling in support of analog telephony services, and does not refer to ISDN D-channel signaling. Note also that the term “PSTN signaling” as used in this document refers specifically to the use of the V5 PSTN protocol message set as defined in ETSI EN 300 324-1.

3.3.2 Signaling Between CO-IWF And CP-IWF for ISDN BRI

The protocol reference model for a CP-IWF with ISDN BRI user side interfaces is illustrated in Figure 5. The transport of media streams between CP-IWF and CO-IWF, with optional use of the DTMF dial digits service, is the same as for analog telephony. DSS1 signaling is not terminated in the CP-IWF. DSS1 signaling messages are relayed by the CP-IWF from the narrowband D-channel across the AAL2 VCC via the Transmission/Error Detection service specified in I.366.1.

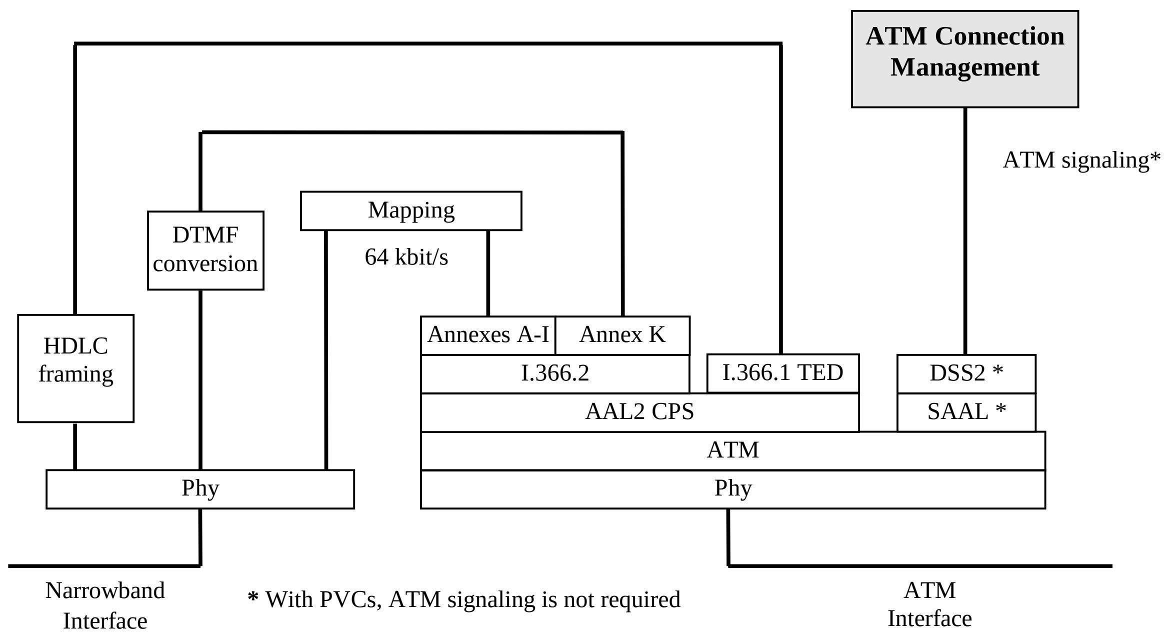


Figure 5: Protocol Reference Model for CP-IWF with ISDN BRI user side interfaces with DSS1 relay over AAL2 between IWFs

3.4 Voice Encoding Support

3.4.1 Types Of Encoding Supported

The support of voice encoding algorithms is application dependent. IWFs may support any ITU-T standardized voice encoding algorithms. Annexes B through H of I.366.2 identify the currently standardized encoding algorithms.

Selection of the algorithms to be supported shall be by mutual agreement between the interconnected IWFs. In addition, an IWF may also support the use of algorithms not identified in Annexes B through H of I.366.2.

3.4.2 Selection And Changing Of Encoding

Each IWF shall support at least one voice coding profile and optionally may support more. Each coding profile contains one or more entries, with each entry specifying a coding algorithm and information regarding how the media stream is to be packed into a packet. If multiple profiles are possible, the profile to be applied to each call must be known prior to call set-up.

For information on profiles see I.366.2.

3.5 Idle Channel Suppression

For the efficient operation of Loop Emulation using AAL2, it is desirable that measures be taken to prevent the use of bandwidth for channels that are idle because no call exists. This specification identifies the following methods of Idle Channel Suppression which may be utilized by the CO-IWF.

Idle channel suppression is controlled by the CO-IWF. In the event that a CO-IWF performs idle channel suppression, it shall be responsible for the activation and de-activation of AAL2 channels using either the procedures described in section 5.3.1.1 or the procedures described in section 5.3.2.1.

3.5.1 Idle Call State Determination

A transmitting CO-IWF can determine when the call state of a given AAL2 channel is idle by monitoring CAS, CCS or ISDN D-channel call establishment and disestablishment activity.

If the SNI at the CO-IWF is a narrowband interface that supports dynamic timeslot allocation, then the timeslot allocation state of a given bearer channel provides an indication as to whether a call is active on that bearer channel.

3.5.2 Idle Code Detection

This capability depends on the CO-IWF being able to determine that a channel is idle by examining the contents of the bearer information in the direction towards the user and recognizing certain data as representing an "idle" condition, for example, a certain number of repetitions of a predefined data pattern. Procedures for the use of this method are not included in this specification. Annex A of ATM Forum document af-vtoa-0085 contains informative notes on the application of idle code detection.

3.6 Silence Detection And Removal

During active call periods, there are normally periods of silence on a transmission path (actually near-silence), either because the other party is speaking or due to the regular silent intervals in speech. Significant improvements in bandwidth efficiency can be gained by not transmitting during these silent intervals, that is, if the transmitter does not transmit encoded speech information to represent this silence.

When using voice encoding schemes that do not include inherent silence suppression, an IWF should monitor the bearer information being transferred to determine when silent periods exist. If it provides this capability, it shall suppress the transmission during these silent intervals and transmit the appropriate Silence Insertion Descriptor at the appropriate time to specify the background noise to be regenerated at the receiving IWF. The methods used to detect silent periods are not specified here. I.366.2 contains procedures to ensure that relative timing is maintained through each silent interval.

3.7 Echo Cancellation

For voice applications, the combination of delay and echo causes an impairment to speech quality which is subjectively determined and which may require measures to be taken to minimize the impact. Since most causes of delay can not be avoided or minimized, reduction of echo must be considered.

Delay is introduced into an end-to-end connection by a variety of factors including:

- Packetization
- Compression algorithms
- Physical transmission time
- Switching of ATM cells in the network
- Queuing
- Build-out delay for accommodating PDV

Echo is caused by:

- Hybrids used to go from 4-wire circuits to 2-wire circuits (typically at analog loops)
- Acoustical feed-back at the end user's terminal (especially when the user places a telephone receiver down on a hard surface)

DSL Forum WT-043 suggests that the one-way delay introduced in the voice path by systems that implement LES-AAL2 with typical DSL access connections is of the order of 20-25 ms. This is well in excess of the upper limit of delay specified in ANSI T1.508 for digital access networks without echo cancellation. The use of echo cancellation is therefore strongly advised.

Applicable ITU-T Recommendations such as G.131, G.114, G.165, G.168, and other references contain information on this subject. Generally, the control of echo is best performed as close to the source of that echo as practicable. This specification addresses neither the methods used to determine the need for nor the procedures for applying echo cancellation. An IWF may support echo cancellation.

3.8 DTMF Signaling Transport

DTMF tones need to pass transparently through the end-to-end connection over the ATM network between the customer-located telephony equipment and the Service Node. Interpretation of DTMF tones by either the CP-IWF or the CO-IWF is not required for the correct operation of the AAL2 Loop Emulation Service. Since some of the low bit-rate coding algorithms used may not properly pass the DTMF tones, special capabilities must be employed to ensure the tones are not blocked. During a connection period using one of the subject low bit-rate encoding schemes in which DTMF may occur, an IWF shall monitor for the presence of DTMF on the transmit path to the AAL2 transmission side. Upon detection of a DTMF tone pair, it shall employ one of the following methods.

3.8.1 Use Of Higher Bit-Rate Encoding

Upon detection of DTMF, an IWF may immediately switch to a higher bit-rate encoding. If it does change to a higher bit-rate encoding, it shall continue to monitor for DTMF activity and switch back to the previous bit-rate encoding after a period without further DTMF being detected.

3.8.2 Transfer By Dialed Digits Packets

Upon detection of DTMF, an IWF shall block the remainder of the tone pair from being transferred to the speech channel to the other IWF and shall transfer an indication to the other IWF that a specific DTMF tone pair has started. When a valid silent period occurs to indicate the end of the DTMF tone pair, the originating IWF shall transfer an indication to the other IWF that the DTMF tone pair has ended. The terminating IWF shall transmit the DTMF tone pair to the Service Node interface or user-side interface at its end based on the receipt of indications to start and end the tone pair. This procedure is described in Annex K of I.366.2.

3.9 Transport Of Voiceband Data

Some of the low bit-rate encoding schemes supported by an IWF may not pass modem signals with optimal performance. When using one of these encoding schemes, an IWF may take special steps to transport voiceband data. Such steps may include changing the profile entry to select a higher transmission speed. If so, the IWF shall detect the tone or tones used in the handshake of fax, modem and TTY/TDD calls.

An IWF should detect the end of modem operation and return to a low bit-rate encoding to support voice operation. Typically, the IWF will continue to operate with the codec required to support voiceband data transmission until the termination of the call, and then return to the lower bit-rate codec ready for the next call.

This specification does not identify which encoding schemes might not correctly pass modem signals and hence require an IWF to change to a different encoding scheme.

Alternatively, an IWF may choose to monitor for the presence of facsimile information and employ the Fax demodulation/remodulation procedures described in Annex M of I.366.2.

4 Control of ATM AAL2 VCCs And Channels

4.1 AAL2 VCC and Channel Characteristics

At the time AAL2 VCCs are created, their characteristics need to be agreed. This specification defines characteristics and attributes for AAL2 VCCs that adhere uniformly to a protocol reference model of Section 3.3. This specification does not support the mixing of CAS and CCS on the same VCC. Combinations of these characteristics may be created by suitable provisioning under bilateral agreement, but the procedures related to such combinations are beyond the scope of this specification.

In these procedures, Soft PVCs (SPVCs) are treated as PVCs by CO-IWF and CP-IWF.

4.1.1 Application Identifier (AppId)

The Application Identifier (AppId) specifies protocol combinations used between IWFs. Values are defined under the ATM Forum OUI for the following:

- Loop Emulation Service using CAS (POTS only) without ELCP
- Loop Emulation Service using PSTN signaling (POTS only) without ELCP
- Loop Emulation Service using PSTN signaling (POTS only) with ELCP
- Loop Emulation Service using DSS1 in support of BRI (BRI only) without ELCP
- Loop Emulation Service using DSS1 in support of BRI (BRI only) with ELCP
- Loop Emulation Service using CAS in support of POTS and DSS1 in support of BRI (without ELCP)
- Loop Emulation Service using PSTN signaling in support of POTS and DSS1 in support of BRI (without ELCP)
- Loop Emulation Service using PSTN signaling in support of POTS and DSS1 in support of BRI (with ELCP)
- Loop Emulation Service using other variety of CCS
- Unspecified mode of Loop Emulation Service

The AppId of a VCC determines which protocol stacks are used on the VCC, as shown in the figures of section 3.3.

NOTE: The values of the AppIDs can be found at the ATM Forum public web site in section 5 of a document entitled “ATM Forum Well-known Addresses and Assigned Codes.”

4.1.2 SSCS Type

The SSCS type that applies to each channel of an AAL2 VCC will vary according to the usage of that channel. Channels that are used to carry media streams (POTS or ISDN B-channels) shall use the SSCS defined in I.366.2. Channels that are used to carry control and management plane traffic (CCS, ELCP, ISDN D-channels and LES-EOC) shall use the SSCS defined in I.366.1.

4.1.3 Default SSCS Parameter Values

The SSCS parameters of operation are used to ensure that interconnected CP- and CO-IWFs agree on the set of capabilities to be applied to an AAL2 channel. The parameters are defined in I.366.1 and I.366.2.

A given VCC may have channels supporting different types of AAL2 SSCS. Each type of SSCS should have an associated set of default SSCS parameter values.

In the absence of signaling or provisioning on a per-AAL2 channel basis, either explicit or implicit, the default SSCS parameter values for that SSCS type shall apply to each AAL2 channel of that SSCS type within the ATM AAL2 VCC.

4.1.4 AAL2 CPS Parameter Values

AAL2 parameters of the Common Part Sublayer that have to be agreed are:

- maximum number of CIDs that can be active
- maximum packet length

4.2 Provisioning PVCS

For an AAL2 PVC, the following characteristics shall be specified during the provisioning process:

- AppId
- default SSCS parameter values for each SSCS type
- AAL = AAL type 2
- AAL2 CPS parameter values

4.3 Signaling Of SVCs

If an SVC is used to establish the ATM connection between a CP-IWF and a CO-IWF, the VCC characteristics listed in section 4.2 (except default SSCS parameter values) shall be signaled between IWFs. The broadband IEs carrying these characteristics have to be conveyed transparently by intervening ATM switches.

4.3.1 AppId

The AppId shall be passed in SETUP as part of the B-HLI IE. Specific values are assigned under the ATM Forum's OUI (see section 4.1.1 for more details). The B-HLI IE shall be encoded as described in SIG 4.0 including errata. The codings of OUI in SIG 4.0 (and in this document) will have bit 8 as the Most Significant Bit (i.e. the normal Q.2931 coding rules shall apply).

4.3.2 SSCS Type and Parameter Values

The SSCS type and parameter values shall not be signaled at the ATM layer. They are typically provisioned.

4.3.3 AAL2 CPS Parameter Values

AAL2 CPS parameter values may be passed in SETUP as part of the AAL Parameters IE. If a value is omitted for any AAL2 CPS parameter, the default value of I.363.2 Section 11 shall apply. The AAL Parameters IE shall be encoded as described in section C.1.1 of Annex C of af-vtoa-0113.000.

4.3.4 Error Conditions

If a valid AppId is not received in the SETUP message, the request shall be rejected.

4.4 Assignment Of AAL2 Channels

4.4.1 CID Allocation

No use is made of the CID values reserved in I.363.2. Therefore CID values 1 through 7 shall not be allocated.

If CCS and/or Emulated Loop Control protocol (as described in section 5) is to be transported between CP-IWF and CO-IWF, then CID = 8 is to be used for this purpose. Otherwise no use shall be made of CID = 8.

If the LES-EOC (as described in section 6) is supported, then CID = 9 is to be used for this purpose. Otherwise no use shall be made of CID = 9.

The range of CID values 10 through 15 is set aside for possible use by future versions of this specification. The range of CID values 224 through 255 is set aside for vendor-specific usage. Bearer channels and ISDN D-channels shall use CID values in the range 16 through 223.

4.4.2 Allocation of CIDs when ELCP is not used

If the ELCP is not used, the default assignment of CIDs to bearer channels and ISDN D-channels shall be as specified in this section. These default assignments may be overridden by provisioning or by management action.

CID Value	**Purpose**
8	CCS and ELCP
9	LES-EOC
10..15	Reserved for future use
16..127	Bearer channels for POTS
128..159	D-channels for ISDN BRI
160..223	B-channels for ISDN BRI
224..255	Reserved for vendor specific use

Table 1: Static CID assignments

POTS ports at the CP-IWF shall be numbered from 1 to N, where N is the number of POTS ports that exist at the CP-IWF. CID = 16 shall be assigned to POTS port number 1, CID = 17 shall be assigned to POTS port number 2, and so on up to POTS port number N.

ISDN BRI ports at the CP-IWF shall be numbered from 1 to M, where M is the number of ISDN BRI ports that exist at the CP-IWF. Each ISDN BRI port requires three CIDs, one for the D-channel and two for B-channel number 1 and B-channel number 2 respectively. CID = 128 shall be assigned to the D-channel of ISDN BRI port number 1, CID = 129 shall be assigned to the D-channel of ISDN BRI port number 2, and so on up to ISDN BRI port number M. CID = 160 shall be assigned to B-channel number 1 of ISDN BRI port number 1, CID = 161 shall be assigned to B-channel number 2 of ISDN BRI port number 1. Likewise, CID = 162 shall be assigned to B-channel number 1 of ISDN BRI port number 2, and so on up to ISDN BRI port number M.

The CID assignments for bearer channels and D-channels can be expressed algorithmically as shown in Table 2.

Channel Type	**CID Value**
POTS	15 + (POTS port number)
ISDN D-channel	127 + (ISDN BRI port number)
ISDN B-channel #1	158 + (2 * (ISDN BRI port number))
ISDN B-channel #2	159 + (2 * (ISDN BRI port number))

Table 2: Formulae for deriving CID value from channel type and CP-IWF port number

4.4.3 Allocation of CIDs when ELCP is used

CID allocations are made by the CO-IWF through the use of the ALLOCATION message as defined in section 5.3.1.1. CID ranges of 1 through 15 shall not be allocated by these procedures.

4.5 Implementation Options for AAL2 CPS

The Loop Emulation Service is intended for the delivery of voice and voiceband data services over ATM connections where bandwidth is tightly constrained. Therefore efficient use of bandwidth is paramount. In many applications of LES, the number of voice channels that is concurrently active on a given VCC may be small. In these circumstances, optimum usage of bandwidth can be achieved by ensuring that each ATM cell contains a single AAL2 packet whose length is chosen to ensure that the AAL2 packet exactly fills the entire cell payload. The AAL2 payload size that meets this condition is 44 octets.

Employing this optimization may also permit a substantial simplification in the implementation of the AAL2 Common Part Sublayer in both transmitters and receivers of IWFs. In this simplification, the Combined Use timer "Timer_CU" is set to zero such that every ATM cell transmitted contains one, and only one, AAL2 packet, and the first octet of the AAL2 packet header follows immediately after the Start Field in the ATM cell payload. If the AAL2 packet payload is less than 44 octets, the remainder of the ATM cell payload following the end of the AAL2 packet shall be filled with zeros as padding, as per I.363.2.

CO-IWFs and CP-IWFs may implement the simplified AAL2 CPS described in this section. Note that both ends must agree on the use of the simplified AAL2 CPS in order to achieve interoperability.

5 Narrowband Signaling Procedures

In this section, procedures for the transport of narrowband signaling between the CO-IWF and the CP-IWF are specified for the Loop Emulation Service supporting the delivery of POTS with both CAS and CCS signaling, and the delivery of ISDN BRI with layer 2 signaling message relay.

5.1 Signaling Procedures for POTS

5.1.1 LES using CAS between CP-IWF and CO-IWF

CP-IWFs and CO-IWFs may use CAS to support the delivery of POTS over the Loop Emulation Service. IWFs that support CAS shall follow the procedures described below in this section.

5.1.1.1 Supervisory Signaling

Supervisory line states such as on-hook, off-hook, idle and ringing are conveyed between the CP-IWF and the CO-IWF in the form of 4-bit codewords known as ABCD bits. Each value of the ABCD bit codeword represents a specific supervisory line state. IWFs that support CAS shall transport the CAS ABCD bits to the other IWF as type 3 packets using AAL2 in accordance with the procedures in Annex L of I.366.2. An IWF may have the capability to debounce the CAS bits before transport over the ATM network in order to reduce unnecessary transmission.

The CP-IWF shall map the CAS ABCD bits associated with each AAL2 channel to analog line states at the POTS port that corresponds with this channel. The mapping between analog line states and ABCD bit codewords shall be as defined in Telcordia GR-303-CORE tables 12-3 through 12-6.

5.1.1.2 Address Signaling

5.1.1.2.1 Tone Dialing

The usual form of address signaling for POTS is DTMF tones which are generated by telephone keypads, PBXs or CO switches to indicate the called number. If the voice encoding scheme that is employed between the CP-IWF and the CO-IWF is capable of transporting DTMF tones in a manner compatible with typical DTMF detectors employed in the network, then the IWFs should transport these tones in-band. Otherwise, the DTMF tones should be transported between IWFs encoded in type 3 packets in accordance with the procedures of I.366.2 Annex K, the dialled digits packet format.

The identification of voice encoding schemes other than G.711 that are capable of supporting transparent in-band transport of DTMF tones is outside the scope of this specification.

5.1.1.2.2 Pulse Dialing

Pulse dialing consists of a sequence of on-hook and off-hook indications that meet specific timing requirements. A single pulse comprises an on-hook indication followed by an off-hook indication. Pulses occur with a nominal frequency of 10 pulses per second. Pulse dialing is supported by CAS signaling using transmission of type 3 packets to convey the change of state between on-hook and off-hook at each edge of a pulse.

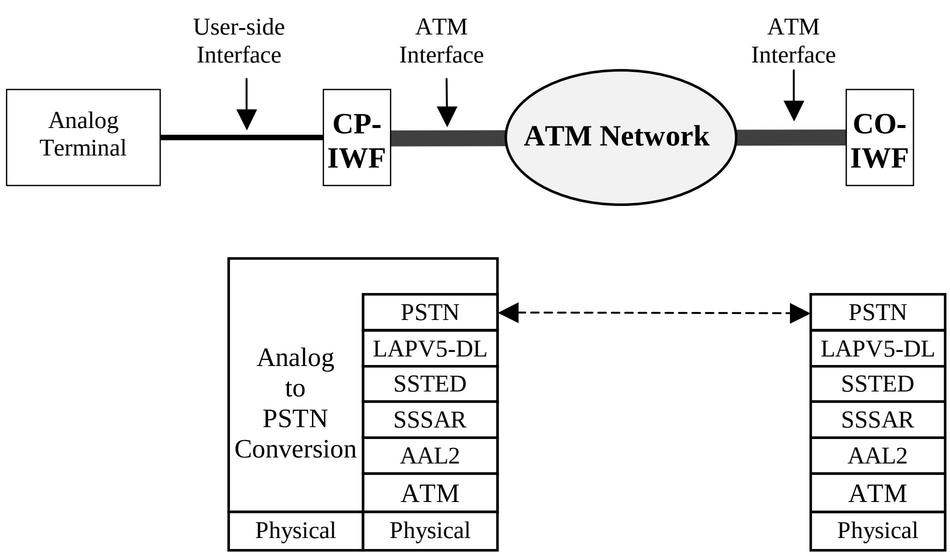
5.1.2 LES using CCS between CP-IWF and CO-IWF

CP-IWFs and CO-IWFs may use CCS to support the delivery of POTS over the Loop Emulation Service. IWFs that support CCS shall follow the procedures described below in this section.

5.1.2.1 Supervisory Signaling

IWFs that support CCS to support the delivery of POTS shall use the PSTN protocol defined in ETSI EN 300 324-1 clause 13 to convey analog supervisory signaling states. Usage of the PSTN protocol for the Loop Emulation Service shall be as specified in ETSI EN 300 324-1 except where noted below.

At the CP-IWF, conversion of analog line states to and from the PSTN protocol messages shall be performed as specified in ETSI EN 300 324-1.



Note: the protocol layers SSTED and SSSAR are described in I.366.1

Figure 6: PSTN signaling model

5.1.2.1.1 Encoding of PSTN Messages

The PSTN protocol defines the following message types:

ESTABLISH
ESTABLISH ACK
SIGNAL
SIGNAL ACK
STATUS
STATUS ENQUIRY
DISCONNECT
DISCONNECT COMPLETE
PROTOCOL PARAMETER

The coding of these messages and the information elements carried within them shall be as specified in ETSI EN 300 324-1, clause 13.4. with the following exception: the Layer 3 address information element shall be used to hold the identity of the user port at the CP-IWF to which this PSTN protocol message relates. See section 5.4.2.2 for details.

5.1.2.1.2 Transport of PSTN Messages

PSTN messages shall be transported and handled according to the CCS common procedures described in 5.4 below.

5.1.2.1.3 Country/Operator Specific Usage of PSTN Messages

The PSTN message set defined in clause 13 of ETSI EN 300 324-1 and its associated information elements provides a flexible and comprehensive solution to signaling analog line states, taking into account the many variations that are seen in individual national implementations of analog POTS.

Most real implementations of POTS require only a small subset of the information elements that are specified for use with PSTN protocol messages. Details of the PSTN messages and information elements that are needed for any specific implementation should be available from the service provider that is making use of this implementation.

An example usage of PSTN messages to support analog POTS in North American markets is given in Appendix D.

5.1.2.2 Address Signaling

5.1.2.2.1 Tone Dialing

The most common form of address signaling for POTS is by means of DTMF tones which are generated by telephone keypads, PBXs or CO switches to indicate the called number. If the voice encoding scheme that is employed between the CP-IWF and the CO-IWF is capable of transporting DTMF tones in a manner compatible with typical DTMF detectors employed in the network, then the IWFs should transport these tones in-band. Otherwise, the DTMF tones should be transported between IWFs encoded in type 3 packets in accordance with the procedures of I.366.2 Annex K, the dialled digits packet format.

The identification of voice encoding schemes other than G.711 that are capable of supporting transparent in-band transport of DTMF tones is outside the scope of this specification.

5.1.2.2.2 Pulse Dialing

The PSTN protocol supports the transmission of dial pulses by means of the Digit-signal information element as defined in ETSI EN 300 324-1, clause 13.4.7.5.

5.1.3 Voiceband Data Transmissions

Services such as Calling Number Delivery make use of voiceband data transmissions between CO switch and customer premises equipment. Such voiceband data transmissions are normally carried using low bit-rate modem schemes, such as the 1200 baud frequency-shift keyed (FSK) scheme which is used in North America.

If the voice encoding scheme which is employed between the CP-IWF and the CO-IWF is capable of transporting voiceband data transmissions in a manner which is compatible with the type of receivers normally employed in the network, then the IWFs should transport these transmissions in-band. Otherwise, the sending IWF should switch to another encoding scheme that is capable of transporting the voiceband transmission transparently for the duration of the transmission. Methods for determining whether a voiceband data transmission is present are outside the scope of this specification.

It should be noted that some networks require the presence of an upstream channel for voiceband data transmission while downstream data transmission is taking place. If it is necessary to change temporarily to a different voice encoding scheme to support downstream voiceband data transmissions, then it will similarly be necessary to apply this change of voice encoding scheme to the upstream channel.

5.2 Signaling Procedures for ISDN BRI

CP-IWFs and CO-IWFs may support the delivery of the ISDN Basic Rate Interface over the Loop Emulation Service.

Each ISDN BRI comprises two bearer channels (B-channels) and a signaling channel (D-channel). Each B-channel and each D-channel shall be carried in a separate AAL2 channel on the same ATM VCC. The allocation of B-channels and D-channels to AAL2 channels shall be as specified in section 4.4 above. The protocol that operates over the D-channels is known as Digital Signaling System number 1 (DSS1).

5.2.1 DSS1 Message Relay

An IWF that supports the delivery of ISDN BRI over the Loop Emulation Service shall have the capability to transport DSS1 layer 2 (Q.921) messages transparently using the Service Specific Transmission Error Detection sublayer (SSTED) on top of the Segmentation and Reassembly

Service Specific Common Sublayer (SSSAR) as specified in ITU-T Rec. I.366.1. This is known as DSS1 message relay. When this capability is selected, the IWF shall operate as follows.

Figure 7 illustrates the principle of DSS1 message relay. The CP-IWF shall implement the DSS1 message relay function as shown in Figure 7. The message relay function shown for the CO-IWF is given by way of example only since the Service Node Interface between the CO-IWF and the PSTN is outside the scope of this specification.

IWFs shall transport all valid HDLC frames. All invalid frames shall be dropped. Definition of an invalid frame shall be as defined in Q.921 section 2.9 conditions a, b, c, d, and e. CP- and CO-IWFs shall not validate HDLC frames based on their SAPI value (condition g of Q.921 section 2.9). Instead, they shall transport all HDLC frames with any SAPI value.

The HDLC-F layer shown in Figure 7 shall drop all invalid frames and pass all valid frames for transport. The messages shall be transported without flags, stuff bits, and FCS octets. In the opposite direction, this layer shall insert FCS octets and stuff bits, add the necessary flags, and deliver the layer 2 message to the narrowband device.

The SSSAR and SSTED sublayer shown in Figure 7 shall be as defined in I.366.1. The SSTED sublayer drops all corrupted data received from the ATM link and passes valid data only. The mapping layer shown in Figure 7 shall pass each layer 2 frame received from the HDLC-F layer as an SSTED PDU and vice-versa. The parameters SSTED-LP, SSTED-UU, and SSTED-CI shall be set to zero when sent and shall be ignored when received.

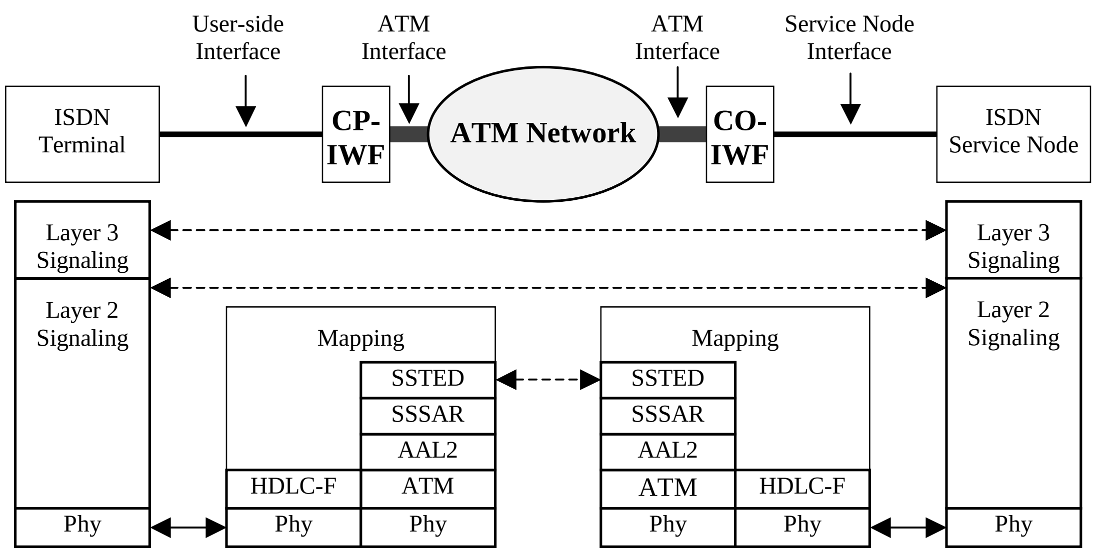


Figure 7: DSS1 message relay over AAL2

5.3 Control of the Emulated Loop

CP-IWFs and CO-IWFs may use the procedure defined in section 5.3.1 below to control bearer channel activation and user port activation. This procedure makes use of the common signaling channel to support an exchange of messages between IWFs for the purpose of channel and port activation and de-activation, and is applicable only to IWFs that support CCS.

CP-IWFs and CO-IWFs that do not support emulated loop control via the common signaling channel should employ the procedures defined in section 5.3.2 to control bearer channel activation and user port activation.

5.3.1 Emulated Loop Control Protocol

Emulated loop control may be carried out by means of protocol messages exchanged between IWFs over the common signaling channel (AAL2 CID = 8). If this capability is enabled, then IWFs shall provide control of the emulated loop according to the procedures described in this section.

The Emulated Loop Control Protocol (ELCP) provides capabilities for channel activation and user port control. If a CP-IWF does not support ELCP, then it shall ignore all incoming messages of the types described in this section. The message types used for the ELCP are based on message types defined by ETSI EN 300 324-1 and ETSI EN 300 347-1.

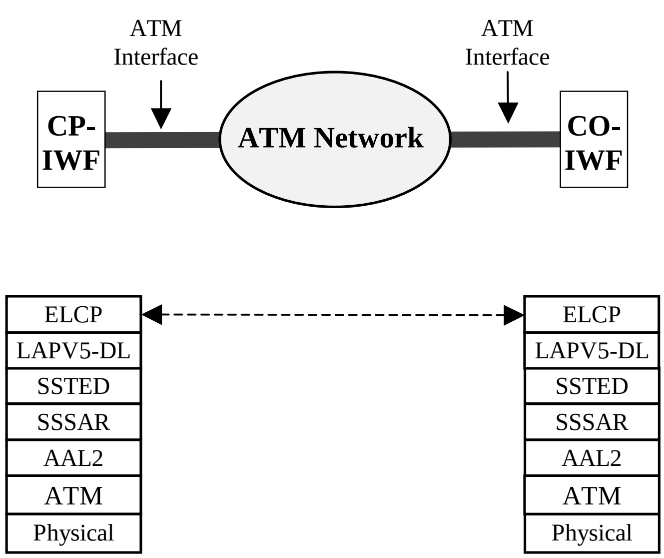


Figure 8: ELCP signaling model

5.3.1.1 Emulated Loop Control Protocol – Channel Allocation Procedure

IWFs that support ELCP shall control the allocation of CIDs to bearer channels and ISDN D-channels and the activation and de-activation of these channels by exchanging messages over the common signaling channel. The messages to be used form a subset of the messages defined in ETSI EN 300 347-1 clause 17.3, the Bearer Channel Connection protocol.

5.3.1.1.1 Encoding of Channel Allocation Messages

The messages to be used are as follows:

ALLOCATION
ALLOCATION COMPLETE
ALLOCATION REJECT
DE-ALLOCATION
DE-ALLOCATION COMPLETE
DE-ALLOCATION REJECT

The information elements to be used in these messages shall be as described in ETSI EN 300 347-1 clause 17.3, except as noted below.

1. The **User Port Identification** information element shall be used and coded as described in section 5.4.2.3.

2. The **V5 Time Slot Identification** and **Multi-Slot Map** information elements shall not be used.

3. The CID of the AAL2 channel to be allocated and activated is held in the (new) **Channel Identifier** information element, which is encoded as described below. This information element is mandatory in the ALLOCATION and the DE-ALLOCATION message and not contained in the other messages listed above.

Bits								
8	7	6	5	4	3	2	1	
0	1	0	0	1	0	0	0	Octet 1
	Information element identifier							
Length of the information element content								Octet 2
Channel identifier field (NOTE)								Octet 3

NOTE: the channel identifier field reflects the CID as specified in ITU-T Recommendation I.363.2.

Figure 9: Channel Identifier information element

4. To support the detection of voice-only calls when dealing with ISDN calls, an optional **Information Transfer Capability** information element is added. This information element may be contained in the ALLOCATION message and is not contained in the other messages listed above.

The content of this information element is a subset of the bearer capability IE present within DSS1. Its coding is shown below.

Bits 8	7	6	5	4	3	2	1	
0	1	0	0	0	1	1	1	Octet 1
	Information element identifier							
Length of the information element content								Octet 2
1	0	0	Information transfer capability					Octet 3

Figure 10: Information Transfer Capability information element

The coding of octet 3 is identical to the coding of octet 3 in the bearer capability information element in DSS1 messages (see ITU-T Recommendation Q.931, Figure 4-11).

5. Within the **ISDN Port Time Slot Identification** IE, the D-channel shall be referred to as ISDN user time slot number 0 (00000).

5.3.1.1.2 Usage of Channel Allocation Messages

When a CO-IWF determines that a particular AAL2 channel is to be allocated, it shall send an ALLOCATION message with the relevant information to the CP-IWF. If the CP-IWF is able to allocate the AAL2 channel, it shall follow the procedure below according to whether it is operating in “master/slave mode” or “independent” mode. These modes are defined in sections 7.2.3.1 and 7.2.3.2 respectively.

- In master/slave mode, the CP-IWF shall send an ALLOCATION COMPLETE message to the CO-IWF. When the CO-IWF receives the ALLOCATION COMPLETE message, it shall commence transmitting bearer packets towards the CP-IWF. The CP-IWF shall wait to receive bearer packets from the CO-IWF on this channel before commencing transmitting bearer packets towards the CO-IWF.
- In independent mode, the CP-IWF shall commence transmitting bearer packets on this channel and then send an ALLOCATION COMPLETE message to the CO-IWF. The CO-IWF shall then commence transmitting bearer packets on this AAL2 channel.

If the CP-IWF is not able to allocate the requested AAL2 channel, it shall send an ALLOCATION REJECT message with the appropriate reject cause type (see ETSI EN 300 347-1, table 41) to the CO-IWF. In any of these circumstances, neither the CP-IWF nor the CO-IWF shall commence transmission of bearer packets on the requested channel.

NOTE: In assigning reject cause types, substitute “AAL2 CID” for “V5 time slot” in the reject cause types in ETSI EN 300 347-1, table 41.

When a CO-IWF determines that a particular channel is to be de-allocated, it shall send a DE-ALLOCATION message to the CP-IWF. The CP-IWF shall then cease transmitting bearer packets on the requested channel and send a DE-ALLOCATION COMPLETE message to the CO-IWF. On receipt of this message the CO-IWF shall cease transmitting bearer packets on the requested channel. If the CP-IWF is not able to de-allocate the requested channel for any reason, it shall continue to transmit bearer packets on this channel and shall send a DE-ALLOCATION REJECT message with the appropriate reject cause type (see ETSI EN 300 347-1, table 41) to the CO-IWF.

NOTE: In assigning reject cause types, substitute “AAL2 CID” for “V5 time slot” in the reject cause types in ETSI EN 300 347-1, table 41.

5.3.1.2 Emulated Loop Control Protocol – User Port Control Procedure

IWFs that support ELCP shall control the activation and de-activation of both POTS and ISDN user ports by means of messages exchanged over the common signaling channel. The messages to be used are a subset of the messages defined in ETSI EN 300 324-1 clause 14.4, the V5.1 Control protocol.

5.3.1.2.1 Encoding of User Port Control Messages

The messages to be used are as follows:

PORT CONTROL
PORT CONTROL ACK

The coding of these messages shall be as described in ETSI EN 300 324-1 clause 14.4. The usage of information elements in these messages shall be as described in ETSI EN 300 324-1 clause 14.4 except as noted below.

The Layer 3 address information element shall be used to hold the POTS or ISDN port number of the CP-IWF to which the user port control message relates. See section 5.4.2.2 for details.

5.3.1.2.2 Usage of User Port Control Messages

Procedures for user port control shall be as described in ETSI EN 300 324-1 clause 14.4.4.5. When an IWF receives a PORT CONTROL message, it shall respond with a PORT CONTROL ACK message, and shall act upon the message according to the value of the Control function element contained in the message.

The finite state machines that describe the transitions between user port states at the CP-IWF shall be as defined in ETSI EN 300 324-1 clause 14 for the “AN” states.

5.3.1.3 Transport of Emulated Loop Control Protocol Messages

ELCP messages shall be transported and handled according to the CCS common procedures described in 5.4 below.

5.3.2 Emulated Loop Control without ELCP

IWFs that do not support ELCP should use the methods described in this section to perform channel activation and user port control.

5.3.2.1 Implicit Channel Activation Procedure

IWFs that support idle channel suppression but do not support ELCP shall use the following procedure to perform channel activation.

When a CO-IWF determines that a particular channel should be activated, it shall commence transmission of bearer packets towards the CP-IWF on that channel, and start a timer. For this purpose, bearer packets are defined as packets containing voice, voiceband data, silence insertion descriptors or demodulated fax. It shall then monitor the bearer channel from the CP-IWF for the presence of bearer packets. If bearer packets are detected, the timer shall be stopped and the channel shall now be considered activated. If the timer expires, the channel activation attempt shall be considered failed, and the CO-IWF shall cease transmitting bearer packets on that channel. The CO-IWF channel activation timer expiration period shall be of the order of 300 ms.

A CP-IWF shall monitor all de-activated bearer channels for the presence of bearer packets from the CO-IWF. Upon the detection of bearer packets on a given channel, the CP-IWF shall commence the transmission of bearer packets on the corresponding channel, and shall consider that channel to be activated. Upon the receipt of each bearer packet on a given channel from the CO-IWF, the CP-IWF shall start a timer. If the timer is already running, it shall be re-started. If the timer expires, the CP-IWF shall consider that channel to be de-activated, and shall cease transmitting bearer packets on that channel. The CP-IWF channel de-activation timer expiration period shall be of the order of 300 ms.

5.3.2.2 User Port Control via the LES Embedded Operations Channel

IWFs that do not support ELCP may make use of the Loop Emulation Service Embedded Operations Channel described in section 6 below to support blocking and unblocking of user ports. Definition of the MIBs required to support blocking and unblocking of user ports is outside the scope of this specification.

5.4 CCS Common Procedures

Common Channel Signaling (CCS) means the exchange of messages between the IWFs for the purpose of PSTN supervisory signaling using the PSTN protocol, and/or for controlling the Emulated Loop using the Emulated Loop Control Protocol (ELCP), described in section 5.3.1. These protocols are derived from the PSTN protocol, the Control protocol and the Bearer Channel Connection (BCC) protocol as defined in the V5 specification (ITU-T G.964 and G.965, ETSI EN 300 324 and EN 300 347).

This section provides the description of the transport mechanisms used for those protocols as well as additional information about the use of those protocols supplementing the V5 specifications. It applies when the IWFs support either one of the PSTN protocol or the ELCP.

5.4.1 Transport of CCS

5.4.1.1 Common Signaling Channel

All signaling messages are carried in an AAL2 channel within the same AAL2 VCC carrying the AAL2 bearer channels. This AAL2 channel is identified by the CID value eight (8).

5.4.1.2 Layer 2

For the transport of signaling messages the reliable data link protocol defined in G.964 clause 10, the Data Link sublayer of LAPV5 (LAPV5-DL) is used. LAPV5-DL is a simplified version of LAPD.

Usage of the LAPV5-DL data link protocol shall be as specified by ETSI EN 300 324-1 clause 10, except where noted below.

One common instance of the LAPV5-DL is used for both the PSTN protocol and the ELCP.

V5 Data Link address (V5DL address): the Link Address field variable “V5DLaddr” defined in clause 10.3.2.3 of ETSI EN 300 324-1 shall take the value of all zeros.

NOTE: PSTN messages, AAL2 Channel Allocation messages and Port Control messages are distinguished by means of the Message type information element.

5.4.1.3 AAL2 Service Specific Convergence Sublayer

LAPV5-DL frames shall be transported between IWFs using the services of the Service Specific Transmission Error Detection (SSTED) sublayer on top of the Service Specific Segmentation and Reassembly (SSSAR) sublayer as defined in ITU-T Recommendation I.366.1.

NOTE: Consequently the PH-DATA-(REQUEST, INDICATION) primitives defined in clause 10.4.1 of ETSI EN 300 324-1 is replaced by the SSTED-UNITDATA.request and SSTED-UNITDATA.indication primitives provided by SSTED at the Service Access Point.

The parameters SSTED-LP, SSTED-UU, and SSTED-CI shall be set to zero when sent and shall be ignored when received.

5.4.2 Usage and Coding of Layer 3 protocols

5.4.2.1 Layer 3 Address and User Port Identification information elements

For a given CP-IWF serving a given AAL2 VCC, PSTN user ports and ISDN user ports shall be assigned a unique port number for identification. PSTN user ports and ISDN user ports each have their own independent numbering space. For a CP-IWF that supports a mix of PSTN and ISDN user ports, the PSTN user ports may be numbered from 1 to n and the ISDN user ports may be numbered from 1 to m.

5.4.2.2 Layer 3 Address information element

The Layer 3 Address information element used in the PSTN protocol and the Port Control messages shall be coded as follows:

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>Octet</td></tr>
<tr><td colspan="7">L3 address</td><td>1</td><td>1</td></tr>
<tr><td colspan="8">L3 address (lower)</td><td>2</td></tr>
</table>

Figure 11: PSTN user port in PSTN protocol and Port Control messages

The value of the (binary encoded) L3 address field shall be equal to the assigned port number.

<table>
<tr><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>Octet</td></tr>
<tr><td colspan="6">L3 address</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td colspan="7">L3 address (lower)</td><td>1</td><td>2</td></tr>
</table>

Figure 12: ISDN user port in Port Control messages

The value of the (binary encoded) L3 address field shall be equal to the assigned port number.

NOTE: Layer 3 addresses of ISDN ports and PSTN ports are distinguished by the value of bit 1 in octet 1. Therefore the actual numerical value may be identical for a given pair of an ISDN and a PSTN port.

5.4.2.3 User Port identification information element

The ALLOCATION and DE-ALLOCATION message both contain as a mandatory information element the User Port Identification information element. The User Port Identification Value field of two octets contained in this information element is coded identically and has the same value as the Layer 3 address information element used in the Port Control messages for any given port.

5.4.3 Error Handling Procedures

5.4.3.1 Message Type Error

The PSTN protocol, the Control protocol and the BCC protocol as defined in the V5 specification have slightly different error handling procedures. Since within the LES , these protocols are distinguished by their message type only, a common error handling procedure for “unrecognized message type” errors shall be used.

Whenever an unrecognized message is received, the protocol entity shall generate an internal error indication and ignore the message.

5.4.3.2 PSTN Protocol Message Errors

PSTN protocol message errors shall be handled as specified in ETSI EN 300 324-1, subclause 13.5.2.

5.4.3.3 Channel Allocation Message Errors

If a CP-IWF detects a protocol error according to ETSI EN 300 347-1, subclause 17.5.8, in an ALLOCATION or DE-ALLOCATION message, the CP-IWF shall take the following actions:

- If the message shall be ignored according to the procedures described in ETSI EN 300 347-1, subclause 17.5.8, an internal error indication shall be generated and no consequent action shall be taken.
- Otherwise, the message shall be processed according to the rules described in ETSI EN 300 347-1, subclause 17.5.8, except for the generation of a PROTOCOL ERROR message.

NOTE: For the LES application, the PROTOCOL ERROR message is not used.

5.4.3.4 User Port Control Message Errors

User Port Control message errors shall be handled as specified in ETSI EN 300 324-1, subclause 14.4.4.2.

5.4.4 Emulated Loop Control System Procedures

5.4.4.1 System Startup

With regards to the remainder of this subclause, actions required for any items that are not provisioned shall be ignored.

5.4.4.1.1 Preconditions

The following shall apply for the LES interface between the CO-IWF and CP-IWF:

a) The AAL2 connection that is used for carrying the ELCP (i.e. CID = 8) is already established.

b) All AAL2 channels under control of the ELCP channel allocation procedure are deactivated and all CIDs from 16 to 223 are de-allocated.

The initial states of the various Finite State Machines (FSM) involved in the start-up of a LES interface are as follows:

FSM	Initial state
Port Control Protocol FSM	Out of Service (AN0/LE0);
PSTN Port Status FSMs	Blocked (AN1.0/LE1.0);
ISDN BRI Port Status FSMs	Blocked (AN1.0/LE1.0);
PSTN Signaling FSM	Port Blocked (AN6/LE6);
ELCP Channel Activation Protocol FSM	Null (ANBcc0/LEBcc0);

Table 3: Initial states of Finite State Machines

NOTE: These FSMs are defined in the V5 specifications ETSI EN 300 324-1 and ETSI EN 300 347-1. The ELCP Channel Allocation Protocol FSM is a subset of the BCC FSM. Further the “LE” states relate to the CO-IWF and the “AN” states relate to the CP-IWF.

5.4.4.1.2 Normal procedure

a) Activation of LAPV5-DL: MDL-Establish-Request shall be sent to the LAPV5-DL.

b) When MDL-ESTABLISH-CONFIRM or MDL-ESTABLISH-INDICATION is received from the LAPV5-DL, START-TRAFFIC shall be sent to the port control protocol FSMs.

c) Entering the normal state

d) Post-processing:

   From now on the following procedures run in sequence for each user port.

   1) All ISDN ports shall have the AAL2 connection that transports the D-channel activated by the CO-IWF using the ELCP channel allocation procedure.

   2) The CO-IWF shall initiate the co-ordinated unblock procedure for all relevant user ports. The CP-IWF shall not initiate unblocking at this time. An ISDN port shall only be unblocked if part (1) above was successful for that port.

5.4.4.1.3 Exceptional procedures in case of failure in system startup

When the system startup cannot be continued for some reason (e.g. LAPV5-DL failure) and is unable to enter the normal state, system restart shall be performed.

5.4.4.2 System restart

System restart refers to the re-starting of a single LAPV5-DL protocol instance between a CO-IWF and a CP-IWF. Under system restart the following actions apply:

1) The LES interface shall be brought into a state in which no established LAPV5-DL exists. NOTE: The remote side takes this as a trigger for system restart.

2) Timer TL1 shall be started.

3) On expiry of TL1 system startup shall be performed.

Timer TL1 shall have a predefined value of 20 seconds.

NOTE: Timer TL1 triggers system startup. It is needed to guarantee that the release of the LAPV5-DL is recognized at the remote side and hence both the CP-IWF and CO-IWF undergo system startup. This timer is started when the system has been stopped for any reason during the system startup or normal operation. It shall also be run prior to invoking the system startup when performing a cold start.

Situations where system restart shall be applied:

a) Reception of Release-Indication of LAPV5_DL

b) Allocation data inconsistency

c) Under request by the Management System

5.4.4.3 Activation of AAL2 channels assigned to ISDN D-channels

The AAL2 channel assigned to an ISDN D-channel shall be activated by the CO-IWF using the ELCP channel allocation procedure. Activation of this AAL2 channel is performed as part of item d) of the normal procedure of system startup. An ISDN port shall remain blocked until the AAL2 channel carrying its associated D-channel has been activated.

An ISDN port may be blocked/unblocked during normal operation of the LES interface. This shall not affect the activation state of the AAL2 channel transporting its D-channel, which shall remain activated until the LES interface undergoes a system restart or is taken out of service.

5.4.4.4 General System Management Requirements

The system management aspects concerning user ports described in Annex C of ITU-T G.964/G.965 and, in particular, in Annex C of ETSI EN 300 324-1/ 300 347-1, should be taken into account.

6 Management, Alarms and Status

Two kinds of management functions are defined between CO-IWFs and CP-IWFs: ATM OAM cells, and the Loop Emulation Service Embedded Operations Channel (LES-EOC).

6.1 Support for ATM OAM Cells

The OAM cell flows that are applicable to management functions between CP-IWFs and CO-IWFs are end-to-end F5 flows. F5 cells transmitted on an AAL2 VCC between a CP-IWF and a CO-IWF may be used to check end-to-end continuity of the VCC.

CO-IWFs and CP-IWFs shall perform loopback operations, as described in section 9.2.2.1.3 of ITU-T I.610, when they receive end-to-end F5 loopback cells on an AAL2 VCC that supports LES. CO-IWFs and CP-IWFs may support the origination of end-to-end F5 loopback cells.

When a CO-IWF or CP-IWF originates an end-to-end F5 loopback cell, it shall set the values of the fields described in section 10.2.3 of ITU-T I.610 as follows:

Loopback indication field (1 octet) shall be set to binary 00000001.
LLID field (16 octets) shall be set to all 1s.

Other fields may take any value.

When a CO-IWF or CP-IWF receives an end-to-end F5 loopback cell with loopback indication field of value binary 00000001, it shall change the value of the loopback indication field to all 0s, recalculate the CRC-10 checksum in the OAM cell information field, and transmit the cell on the same VCC as it was received on.

CO-IWF and CP-IWF shall be able to detect incoming F5-AIS and transmit back F5-RDI, as described in sections 9.2.2.1.1.1 and 9.2.2.1.1.2 of ITU-T I.610.

CO-IWFs and CP-IWFs may support other end-to-end F5 flows such as continuity check flows.

6.2 LES Embedded Operations Channel

The LES-EOC provides a method of transporting higher level protocol elements in the payload of the frame mode bearer service identified in I.366.2 section 8.3, using AAL2 CID = 9. CO-IWFs and CP-IWFs should support the LES-EOC.

The frame mode bearer service used to transport the LES-EOC PDUs shall be as specified in I.366.1, and shall comprise the Segmentation and Re-assembly sublayer (SSSAR) and the Transmission Error Detection sublayer (SSTED). The value of Segment length used by the SSSAR sublayer for LES-EOC PDUs shall be 44 octets to ensure efficient usage of ATM cell payload.

A LES-EOC PDU (or frame) is defined as a two byte protocol identifier followed by the payload. All segments making up a LES-EOC PDU except the last shall use a value of 27 in the CPS-UUI field of the SSSAR sublayer to indicate that additional segments of this PDU will follow. A value of 26 indicates that this segment is the last in the LES-EOC PDU. Thus a frame ends with a CPS-Packet whose UUI field is set to 26 and the next LES-EOC PDU begins with the next CPS-Packet whose CID is 9 and UUI field is set to 27.

The first two bytes of any LES-EOC PDU are a protocol identifier field. The two bytes contain the ethertype of the higher layer protocol carried in the LES-EOC PDU. Ethertypes are defined in STD0002. The LES-EOC may be used to transport SNMP PDUs as described below, in which case the value 814C (hex) as defined in STD0002 will be used. At this time all other values for this header are reserved. The remainder of the LES-EOC PDU is payload and contains the higher layer protocol PDU.

6.2.1 Use of SNMP over the LES-EOC

CO-IWFs and CP-IWFs that support the LES-EOC shall support the use of SNMP over the LES-EOC.

The LES-EOC enables a management application to interact with a management agent in the CP-IWF by means of Simple Network Management Protocol (SNMP) messages carried over a specific channel of an AAL2 VCC between a CO-IWF and a CP-IWF. The LES-EOC supports remote management operations between the CP-IWF and the CO-IWF using SNMP messages.

The management operations that may be carried out over the LES-EOC are supported by SNMP messages which pass between a management application in the CO-IWF and a management agent in the CP-IWF. The version of SNMP to be used shall be that defined by the current version of the ATM Forum Integrated Local Management Interface 4.0 specification af-ilmi-0065.000.

6.2.1.1 SNMP Message Format

At the time of publication of this specification, the version of SNMP that is specified by the ILMI 4.0 is version 1. The message format for SNMP v1 is as specified in RFC 1157.

All SNMP messages shall use the community string value "LESEOC", that is, the OCTET STRING value: "4C4553454F43".

In all SNMP Traps, the agent-addr field (which has syntax NetworkAddress), shall have the IpAddress value: 0.0.0.0.

In all SNMP Traps, the time-stamp field in the Trap-PDU shall contain the value of the CP-IWF’s sysUpTime MIB object at the time of trap generation.

In any standard SNMP Trap, the enterprise field in the Trap-PDU shall contain the value of the agent’s sysObjectID MIB object.

NOTE: sysUpTime and sysObjectID are defined in the system group of MIB-II.

6.2.1.2 Message Sizes

All LES-EOC SNMP implementations shall be able to support SNMP messages of size up to and including the maximum size specified by ILMI 4.0.

6.2.1.3 LES-EOC Functions in the CP-IWF

If a CP-IWF supports SNMP over the LES-EOC, it shall receive SNMP GetRequest, GetNextRequest and SetRequest PDUs from the CO-IWF via the frame mode bearer service on AAL2 CID = 9. The CP-IWF shall transmit appropriate responses to the CO-IWF using SNMP GetResponse PDUs via the frame mode bearer service on AAL2 CID = 9.

A CP-IWF may transmit Trap PDUs on the LES-EOC to inform the CO-IWF of events that could impact the delivery of telephony service, for example the re-negotiation of bandwidth on an ADSL connection.

If a CP-IWF supports the LES-EOC, it shall transmit a coldStart Trap PDU to the CO-IWF when the CP-IWF function is initialized after start-up. It is desirable for CP-IWFs to delay for a configurable pseudo-random period following system initialization before sending the coldStart Trap, to reduce the loading experienced by the CO-IWF following power outage events.

If a CP-IWF does not support the LES-EOC, it shall ignore any messages received on AAL2 CID = 9.

6.2.1.4 MIB Support in the CP-IWF

If a CP-IWF supports SNMP over the LES-EOC, it shall support the System group of the MIB-II as defined in RFC1213.

The primary purpose of the LES-EOC is remote management of the Loop Emulation Service at the CP-IWF. Standard MIBs do not exist for many of the objects that need to be managed as part of the Loop Emulation Service, for example analog telephony ports, voice codecs, the AAL2 layer etc. Until such standard MIBs have been defined, management of the Loop Emulation Service via the LES-EOC shall be based on vendor-specific enterprise MIBs.

The definition of MIBs for the management of the Loop Emulation Service is outside the scope of this specification.

A CP-IWF may support access via the LES-EOC to other MIBs that are not directly concerned with management of the Loop Emulation Service.

6.2.1.5 LES-EOC Functions in the CO-IWF

A CO-IWF may transmit SNMP GetRequest, GetNextRequest and SetRequest PDUs to a CP-IWF via the frame mode bearer service on AAL2 CID = 9. A CO-IWF may receive Trap PDUs from the CP-IWF on AAL2 CID = 9. If a CO-IWF does not support the LES-EOC, it shall ignore messages received on AAL2 CID = 9.

A CO-IWF may originate GetRequest, GetNextRequest and SetRequest PDUs and send them to a CP-IWF either autonomously, or as a result of management operations performed at other management ports of the CO-IWF. The definition of mappings between management operations performed at other management ports and operations performed over the LES-EOC is outside the scope of this specification.

6.2.2 Traffic Shaping on the LES-EOC

Support for the LES-EOC involves the transmission of LES-EOC PDUs over the frame mode bearer service on the same AAL2 VCC as is used to transport voice and voiceband data. An AAL2 VCC that supports the Loop Emulation Service permits a peak rate of cell transmission that is limited either by the traffic parameters set during VCC establishment, or by the available bandwidth of the access network connection, whichever is the lower. If transmission is attempted on an AAL2 VCC at cell rates in excess of this peak rate, there is a likelihood that cells will be randomly dropped, causing impairments to both voice and management traffic.

IWFs that support the LES-EOC shall limit the rate at which cells containing LES-EOC PDUs are transmitted on AAL2 CID = 9 to an agreed maximum value. Unless negotiated otherwise, the rate of cell transmissions on the LES-EOC shall be limited to 100 cells per second.

IWFs may implement mechanisms that support the negotiation of higher rates of cell transmission on the LES-EOC, provided that such mechanisms protect against impairments to voice and voiceband data communication caused by excessive transmission activity on the LES-EOC. The definition of such mechanisms is outside the scope of this specification.

7 Voice Compression Handling Procedures

7.1 Encoding Algorithms

In order to allow IWFs to select and manage encoding algorithms according to prearranged agreements, the algorithms are grouped into profiles. A pair of IWFs which are to communicate shall agree on the profile or profiles to be used. The profiles used may be from Annex P of I.366.2, from Annex A of this specification, or from another source.

An IWF conforming to this specification shall be capable of operation using the mandatory ITU-T profile #1 "PCM-64" as specified in Table P-1/I.366.2.

7.2 Selection of Encoding

7.2.1 Default Profile for an IWF

One or more coding profiles may be established in an IWF. If multiple profiles are possible, a common default profile to be applied to all ATM VCCs with AAL2 may be specified.

7.2.2 Default Profile for Each VCC

When an individual VCC is created (PVC or SVC), a common default profile to be applied to all AAL2 channels that belong to this VCC may be specified. It shall be from the set of profiles established for an IWF.

7.2.3 Selection of Profile Entry

When each IWF transmits the bearer information utilizing the profile determined as above, it indicates the entry within the profile by the procedures defined in I.366.2.

There are two possible modes of operation of CP-IWF: “master/slave” mode, and “independent” mode.

7.2.3.1 Master/Slave Mode

In master/slave mode, the same profile entry (e.g., encoding algorithm) shall be used in each direction.

A CP-IWF shall monitor the contents of the LI and UUI fields of each incoming AAL2 voiceband bearer packet so as to determine which encoding algorithm is being used by the CO-IWF on each AAL2 channel. If a CP-IWF detects a difference between the encoding algorithm it is using to transmit on a given AAL2 channel and the encoding algorithm that the CO-IWF is using to transmit on this AAL2 channel, then it shall change the encoding algorithm it is using to transmit on this AAL2 channel so as to match the encoding algorithm being used by the CO-IWF on this AAL2 channel.

The purpose of master/slave mode is to enable the CO-IWF to determine which profile entry a CP-IWF shall use under all circumstances. This is intended to reduce the burden of configuration on the CP-IWF as well as to support fax/modem detection at the CO-IWF, avoiding the need for this capability at the CP-IWF.

If fax/modem detection is to be supported at the CO-IWF, then the CO-IWF should choose a codec for the initial portion of the call that is capable of passing fax and modem tones with sufficient fidelity for these tones to be accurately detected by the CO-IWF.

7.2.3.2 Independent Mode

In independent mode, the CP-IWF is free to determine which profile entry is to be used from the configured profile.

7.3 Silence Removal and Comfort Noise Generation

If a transmitting IWF provides the option of silence removal, it shall do so as described in this section. The receiving comfort noise generation procedures are required if the profile in use includes SID.

7.3.1 Detection

The procedures for detection of silent intervals are not described in this specification. They may be implementation dependent and the exact method used does not impact interoperability with the peer IWF.

7.3.2 Removal and Comfort Noise Generation

Upon detection of a silence interval, an IWF shall utilize the procedures of I.366.2 to stop sending packets containing speech encoding samples and shall send the appropriate silence descriptor at the appropriate time.

For an encoding algorithm that provides a Silence Insertion Descriptor (SID), an IWF shall utilize this SID when operating with this algorithm. For types of encodings that do not provide a SID, an IWF shall insert the Generic SID defined in Annex C of I.366.2 after the last active voice packet of the talk spurt at the first opportunity consistent with the proper operation of sequence numbers. The receiving IWF shall generate comfort noise based on the content of the received SID.

If the implicit channel activation procedure is in use (per section 5.3.2.1) then the CO-IWF shall re-transmit the SID packet periodically during silence intervals. The interval between re-transmission of SID packets shall be 100 ms.

7.3.3 Start of Talk Spurt

An IWF shall detect the end of a silence interval, that is, the start of a talk spurt. It shall begin transmitting normal audio encoding packets quickly so that audio loss is minimized.

7.4 Special Handling of Inband Signals

7.4.1 Modem Detection

If a CO-IWF uses the method described in section 3.9 to pass voiceband data, it shall monitor for the presence of the 2100 Hz tone in the direction towards the ATM side. This tone is used in the hand shake for modem calls in accordance with V.25 and V.8. A CO-IWF shall detect both the 2100 Hz tone defined in V.25 and the modified, amplitude modulated 2100 Hz tone defined in V.8.

Upon detection of any of these tones, a CO-IWF shall change over to a suitable bit-rate encoding in the transmit direction which ensures that the 2100 Hz tone is successfully transferred for a sufficient period of time through the CO-IWF to CP-IWF connection as might be required for the proper control of other equipment such as echo cancellers. A CO-IWF may choose subsequent encoding algorithms in the transmit direction based on classification of modem signals.

Where the CP-IWF is operating in master/slave mode, a CO-IWF may also monitor for the 2100 Hz tone in the direction towards the Service Node interface. This applies only where the compression scheme supports transparent transmission of the 2100 Hz tone. A CP-IWF operating in master/slave mode shall use the procedures of 7.2.3.1 to maintain a match between the encoding algorithm used by the CP-IWF for transmission towards the CO-IWF and the encoding algorithm selected by the CO-IWF for transmission towards the CP-IWF.

A CO-IWF should monitor for the end of the data transmission. Upon detection of the end of the voiceband data phase, the CO-IWF should change back to a low bit-rate encoding. The method for detection of end of data phase is beyond the scope of this specification.

IWFs that support echo cancellation should turn off echo cancellation when a 2100 Hz tone is detected, in accordance with the procedures defined in G.168.

7.4.2 DTMF

As described in section 3.8.2, one of the methods for transparently passing DTMF when using an encoding algorithm not capable of passing the in-band tones is to detect the tones at the originating IWF, transport the information as dialled digit packets as specified in I.366.2, and to regenerate the tones at the terminating IWF. The specific IWF procedures at each end are described in the following sections.

7.4.2.1 Operation of the Originating Side IWF

In order to support the transport of DTMF when using a voice encoding algorithm that does not properly carry these dual tone signals, an IWF shall monitor such connections for the presence of DTMF.

This specification does not identify which encoding algorithms will not pass DTMF. In fact, whether or not one will successfully pass DTMF is sometimes dependent on the implementation of the DTMF receiver circuit at the distant end and the actual signal level present. When an IWF chooses to apply the dialed digit packets method to transport DTMF through the ATM connection, it must ensure that the original DTMF tones do not "leak" through the speech connection, since they could be inadvertently detected at the distant end.

If such monitoring is to be performed on a voice connection, an IWF shall monitor the direction of the connection from the narrowband side going to the ATM side. It shall apply validation parameters according to the DTMF signaling specification applicable to the environment of an IWF, i.e., frequency, level, and timing tolerances. However, it shall ensure that all transitions (tone-on and tone-off) last at least 20 ms. In addition, it shall ensure that no more than 20 ms of the DTMF tones is passed through as voice. It is desirable to limit this to 10 ms. In accordance with I.366.2 an IWF shall include a time stamp of the tone-on and tone-off occurrences in the DTMF packets so that the other IWF is able to regenerate the tone with an acceptable tolerance concerning the length.

It should be noted that the "tone-off" condition in actuality means that the previous valid tone pair has ended, that is, that one or both of the tones of the pair has ceased.

In accordance with I.366.2, an IWF shall specify the signal level in all DTMF packets . It is desirable that an IWF determine the total signal level of the received tones and include the value in the DTMF packets. However, if an IWF is unable to do so, it shall use a pre-set value in all packets.

The information described above shall be transmitted to the other IWF using the procedures in I.366.2 Annex H.

7.4.2.2 Operation of the Destination Side IWF

The destination side IWF shall turn on and off the designated tone pair in response to the messages from the originating side IWF. It may also apply additional timing requirements according to its environment; for example, ensuring that each tone-on period is at least 40 ms long regardless of the message contents. An IWF shall apply the tone pair at the level specified in the message. While transmitting a tone pair to the narrowband interface, an IWF shall cease transmission of any other audio signal that might be indicated by the received AAL2 packets.

Precautions should to be taken to ensure that the echo path signal (DTMF reflected from the distant end) does not cause detection and regeneration of DTMF tones in the opposite direction.

8 Enhanced Transport

8.1 Fax Demodulation And Remodulation (Fax Relay)

If a CO-IWF or CP-IWF supports fax demodulation and remodulation, then the procedures described in I.366.2 apply.

NOTE: these procedures are likely to be incompatible with the procedure for implicit channel activation described in section 5.3.2.1, because fax transmission may involve long periods with no packet transmission in one direction.

9 Performance Considerations

9.1 Packet Delay Variation

Packet delay variation (PDV) is defined by a 2-point measurement across the AAL2 Common Part Sublayer (CPS): between submission to the CPS at one IWF and delivery by the CPS at the peer IWF.

The sources of PDV are;

- AAL2 common part Timer_CU
- Queuing below the CPS interface, in either AAL2 or ATM, to shape output cells to the traffic contract
- ATM-level cell delay variation (CDV)

An IWF shall have the capability to accommodate a maximum delay variation in packet transport across an AAL2 channel (including the effects of ATM cell delay variation) up to 20 ms.

In the absence of bilateral agreements about the packet delay variation, an IWF shall operate using the default value of 20 ms.

9.2 Timing Considerations

A CO-IWF shall derive its timing from the Service Node interface.

A CP-IWF should derive its timing by one of the following methods.

- From the physical layer timing derived from the xDSL or HFC receiver interface, corrected if appropriate by Network Timing Reference information as specified by, for example, T1.413 Issue 2.
- By deducing timing information which is implicit in the rate of arrival of incoming AAL2 packets from the CO-IWF.

In both cases, the objective is that the timing used by the CP-IWF should be traceable to a Primary Reference Source. Information on the distribution of network timing may be found in ANSI T1.101 and ISO/IEC 11573. If the physical layer timing derived from the xDSL or HFC receiver interface at the CP-IWF is not traceable to a PRS, then the CP-IWF should not use this method to obtain timing information, but should instead deduce timing information from the rate of arrival of AAL2 packets from the CO-IWF.

A CP-IWF may use a free-running local timing source. The use of a free-running clock less accurate than Stratum 3 is not recommended since it may result in service impairments due to periodic clock slips.

Annex A: ATM Forum Predefined Profiles

This Annex forms an integral part of this Specification.

This annex defines a number of ATM Forum predefined profiles for use by voice/voiceband data connections using UUI codepoints 0-15 with type 1 packets. By making reference to the identifiers of these profiles, IWFs can agree on the profile to be used for a connection.

Inclusion in this Annex does not imply that all implementations are required to support every profile. An implementation may choose to support any or none of the profiles defined here. In addition, an implementation may support one or more profiles defined in I.366.2 or elsewhere.

Identifier	Description of Profile	Reference
0	Not used	–
1-6	Allocated to af-vtoa-0113.000	–
7	PCM-64, ADPCM-32, 44 octet packets, and silence	Table A-2
8	PCM-64, 44 octet packets, and silence	Table A-3
9	PCM-64, 44 octet packets, without silence	Table A-4
10	PCM-64 and ADPCM-32, 44 octet packets, without silence	Table A-5
11	PCM-64, ADPCM-32, 40 octet packets, without silence	Table A-6
12	PCM-64, ADPCM-32, 40 octet packets, with silence	Table A-7
13-255	Reserved for future ATM Forum assignment	

Table A-1: Identifiers for ATM Forum Predefined Profiles

The table above lists the ATM Forum assigned code points that shall be used to identify predefined profiles and the remaining tables define the individual profiles. The definition of each profile includes the following information for each profile:

- UUI codepoint range
- Packet length

- Reference to a figure (Annex A of this specification) depicting the encoding data unit format
- Description of the algorithm
- Value of M, the number of service data units in a packet
- Packet time
- Sequence number interval

Table A-2: PCM-64, ADPCM-32, 44 octet packets and silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 - 7	44	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5.5	5.5
8 - 15	44	Figure E-2/I.366.2	ADPCM, G.726-32	1	11	5.5
0 - 7	1	Figure I-1/I.366.2	Generic SID	1	5.5	5.5

Table A-3: PCM-64, 44 octet packets and silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 -15	44	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5.5	5.5
0 - 15	1	Figure I-1/I.366.2	Generic SID	1	5.5	5.5

Table A-4: PCM-64, 44 octet packets, without silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 -15	44	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5.5	5.5

Table A-5: PCM-64 and ADPCM-32, 44 octet packets without silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 - 7	44	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5.5	5.5
8 – 15	44	Figure E-2/I.366.2	ADPCM, G.726-32	1	11	5.5

Table A-6: PCM-64 and ADPCM-32, 40 octet packets, without silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 - 7	40	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5	5
8 – 15	40	Figure E-2/I.366.2	ADPCM, G.726-32	1	10	5

Table A-7: PCM-64 and ADPCM-32, 40 octet packets, with silence

UUI Codepoint Range	Packet Length (octets)	Encoding Format Reference	Description of Algorithm	M	Packet Time (ms)	Seq. No. Interval (ms)
0 - 7	40	Figure B-1/I.366.2	PCM, G.711-64, Generic	1	5	5
8 – 15	40	Figure E-2/I.366.2	ADPCM, G.726-32	1	10	5
0 – 7	1	Figure I-1/I.366.2	Generic SID	1	5	5

Appendix A: Operation of CO-IWF and CP-IWF

This informative appendix provides a description of possible modes of operation of CO-IWF and CP-IWF devices, by way of example only.

A.1 Operation of CO-IWF

A CO-IWF may operate in “concentrated” or “non-concentrated” mode. In non-concentrated mode, each timeslot in each TDM connection between CO-IWF and Service Node is statically allocated to a specific AAL2 channel. In concentrated mode, the allocation of timeslots to AAL2 channels is carried out dynamically in the CO-IWF, as and when originating or terminating call attempts occur.

The operation of the CO-IWF, in terms of the functionality depicted in Figure A-1, is described in the following paragraphs for the case of concentrated access mode. In the case of non-concentrated access mode, the Call Handling function is null and signaling and bearer information is passed through the IWF according to a fixed mapping of narrowband time slots to AAL2 channels.

E1/DS1 TDM trunks terminate on a Multiplexer/Demultiplexer function, which distributes the individual 64 kbit/s channels between the trunks and the Switch function. The narrowband signaling associated with the individual 64 kbit/s channels, whether out-of band or -in-band is extracted via the Switch by the Signaling Interworking function. This narrowband signaling includes both end-to-end signaling in CAS or CCS format that will be forwarded over the ATM network to the CP-IWF, and local signaling supporting the Timeslot Management Function.

The Signaling Interworking function separates the local TMF signaling from the end-to-end CAS or CCS signaling, and passes the TMF signaling to the Call Handling Function. The Call Handling Function instructs the Switch to set up and tear down connections between specific narrowband channels and AAL2 channels in accordance with information received via the TMF signaling.

The Signaling Interworking function also performs any conversion that may be necessary between the CAS or CCS signaling on the narrowband and ATM sides of the CO-IWF. In networks where Loop Emulation Service is supported by means of SVCs, the Signaling Interworking Function interacts with the VCC Management function to initiate the setup and teardown of SVCs to carry AAL2 bearer traffic.

Individual bearer streams leaving the switch on the ATM side are processed by the SSCS User function. For voice, this comprises a Codec with or without Speech Activity Detection, as indicated by the profile in use on the connection. For facsimile, the SSCS User may comprise a facsimile demodulation/remodulation capability. The resulting SDUs from the SSCS User are passed to an SSCS (either I.366.1 or I.366.2) for AAL2 packetization. The AAL2 packets are then transferred to the AAL2 CPS function for multiplexing into cells for transfer to the ATM function. An inverse set of procedures is followed for information arriving at an IWF in the opposite direction of transmission.

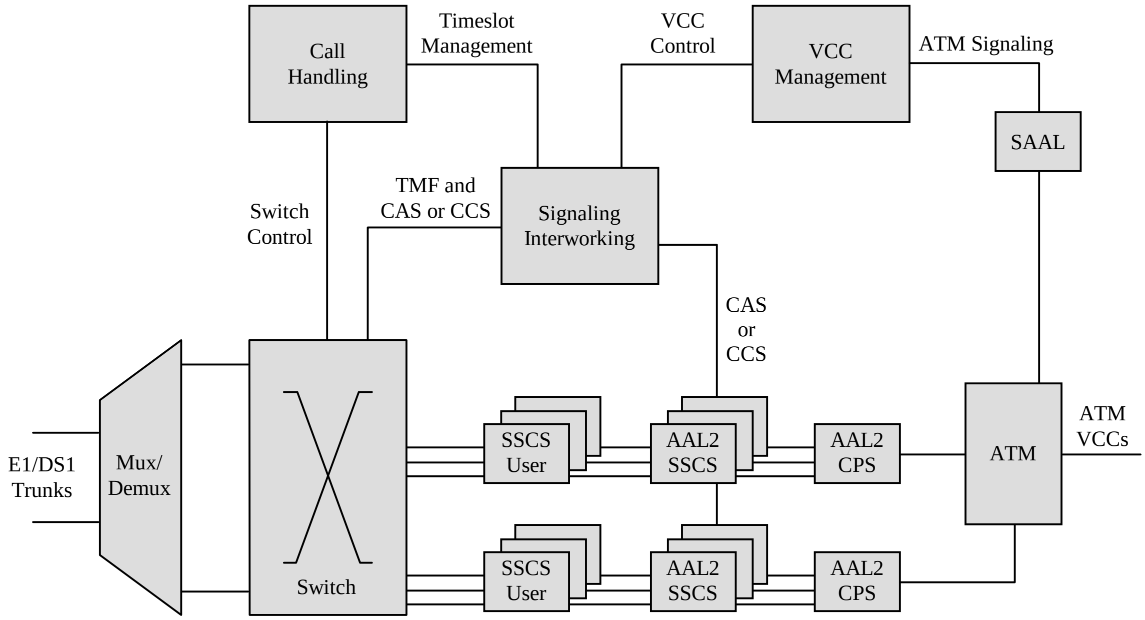


Figure A-1: Example of functions within a CO-IWF

A.2 Operation of CP-IWF

Signaling and bearer information is passed through the CP-IWF according to a fixed mapping of narrowband time slots or analog telephony interfaces to AAL2 channels.

The Signaling Interworking function performs any conversion that may be necessary between the analog, CAS or CCS signaling on the narrowband side of the CP-IWF, and the CAS or CCS signaling on the ATM side of the CP-IWF. In networks where Loop Emulation Service is supported by means of SVCs, the Signaling Interworking Function interacts with the VCC Management function to initiate the setup and teardown of SVCs to carry AAL2 bearer traffic.

Individual bearer streams leaving the physical telephony interface on the ATM side are processed by the SSCS User function. For voice, this comprises a Codec with or without Speech Activity Detection, as indicated by the profile in use on the connection. For facsimile, the SSCS User may comprise a facsimile demodulation/remodulation capability. The resulting SDUs from the SSCS User are passed to an SSCS (either I.366.1 or I.366.2) for AAL2 packetization. The AAL2 packets are then transferred to the AAL2 CPS function for multiplexing into cells for transfer to the ATM function. An inverse set of procedures is followed for information arriving at a CP-IWF in the opposite direction of transmission.

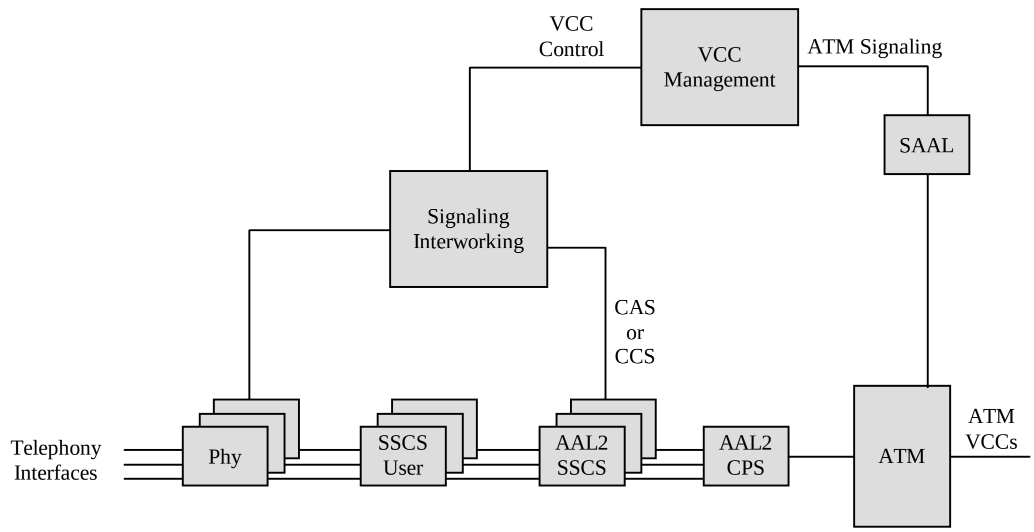


Figure A-2: Example of functions within a CP-IWF

Appendix B: Operation of GR-303 or TR-008 Service Node Interface at CO-IWF

This informative appendix describes two kinds of Service Node Interface that are prevalent in markets where North American telecoms standards apply, and illustrates interworking functions within the CO-IWF that are appropriate for these Service Node Interfaces.

B.1 The GR-303 Interface

B.1.1 Overview of the GR-303 Interface

GR-303 is defined in the Telcordia specification GR-303-CORE. It describes an access interface between an Integrated Digital Terminal (IDT) which is part of a Central Office Class 5 switch, and a Remote Digital Terminal (RDT) which is typically a digital loop carrier system. GR-303 supports both POTS and ISDN Basic Rate services. This appendix discusses only the support of POTS over GR-303.

The GR-303 interface typically comprises from 2 to 28 physical DS-1 links, each providing 24 x DS-0 timeslots. A total of 4 timeslots in a GR-303 interface are reserved for communication links between the RDT and the IDT. These communication links comprise the Timeslot Management Channel, which is used to control the dynamic assignment of timeslots to user ports, and the Embedded Operations Channel, which supports remote management operations between the RDT and the IDT. The TMC and the EOC each occupy one timeslot. The remaining two reserved timeslots provide backup paths for the TMC and EOC. Alternatively, a GR-303 interface may comprise a single DS-1 link with 2 timeslots reserved for TMC and EOC respectively. In this case, there are no backup paths for TMC and EOC.

B.1.1.1 Supervisory Signaling

The supervisory signaling on each POTS line is handled using the hybrid signaling method defined by GR-303. This uses a channel-associated signaling (CAS) method known as robbed-bit signaling. The framing format used on the DS-1 links that comprise a GR-303 interface is an extended superframe (ESF) format which “robs” some of the least significant bits in each DS-0 timeslot to provide a 4-bit ABCD bit codeword for each timeslot that is repeated each ESF interval, which is 3 milliseconds. In the upstream direction from the RDT to the IDT the ABCD bits are used to convey the user supervisory state of each port, e.g. on-hook or off-hook, while in the downstream direction from the IDT to the RDT the ABCD bits are used to control the network supervisory state of the port, e.g. idle or ringing.

GR-303 supports dynamic assignment of timeslots to user ports. The user supervisory state of each port is conveyed to the IDT by ABCD bits associated with the timeslot that is connected to a given user port. This means that when there is no timeslot assigned to a given user port, no path exists over which to convey the user supervisory state of the port to the IDT. It is therefore necessary for the RDT to monitor the user supervisory state of all user ports that are not currently assigned to a timeslot within the GR-303 interface in order to notify the IDT (via the TMC) of changes in user supervisory state on these ports so that the IDT can take appropriate action.

The GR-303 specification defines an alternative method for supervisory signaling known as the Common Signaling Channel (CSC). In this scheme, all supervisory signaling is communicated between RDT and IDT by means of messages that are sent over the same communications link as the TMC. To date, all existing IDT implementations of GR-303 have supported CAS-based supervisory signaling only, and no Class 5 switch vendors have implemented the CSC.

B.1.1.2 Timeslot Management Channel

The Timeslot Management Channel (TMC) provides the means by which an IDT instructs an RDT to assign a particular timeslot within the GR-303 interface to a particular user port. The TMC makes use of a message-based protocol which is physically carried between IDT and RDT over a single timeslot on one of the DS-1 links that make up the GR-303 interface.

The message structure used for TMC messages is based on that defined by ITU-T Q.931, the Digital Signaling System number 1. TMC messages are carried over a reliable link layer protocol which is based on a subset of LAPD, defined by Q.921.

TMC messages are concerned with the setting up and tearing down of cross-connections between timeslots in the GR-303 interface and user lines. For the purposes of identifying timeslots, the physical DS-1 links that make up the GR-303 interface are numbered 1 through n, where n is the number of DS-1 links in the interface (in the range 1 through 28). An individual timeslot is identified by the DS-1 link and the DS-0 timeslot (1 through 24) within that DS-1 link. A user port is identified by a Call Reference Value (CRV) which is a number in the range 1 through 2048.

A terminating call (in the direction from network to user) is notified by the IDT to the RDT by means of a SETUP message that specifies the timeslot and the CRV. The RDT connects the specified timeslot and CRV and confirms this by sending a CONNECT message to the IDT. The call is then in progress. An originating call (from the user to the network) is initiated when the RDT notices that the user port supervisory state has changed from the on-hook state to some other state (off-hook or ring ground, depending on the type of line). When this happens, the RDT sends a SETUP message to the IDT specifying the CRV that identifies this user line. The IDT responds with a CONNECT message that specifies which timeslot this CRV should be connected to. When the RDT has set up the connection, it sends a CONNECT ACKNOWLEDGE message to the IDT and the call is then in progress.

The de-allocation of a timeslot is always initiated by the IDT, which sends a DISCONNECT message specifying the CRV to disconnect. The RDT tears down the cross-connection and confirms with a RELEASE message. The IDT acknowledges this with a RELEASE COMPLETE message and the call state then returns to null.

The primary TMC occupies timeslot 24 of DS-1 link number 1. The secondary TMC, which is used as backup in the event of failure of the primary TMC, occupies timeslot 24 of another DS-1 link, the identity of which is provisioned. The secondary TMC exists only if the GR-303 interface comprises more than one DS-1 link.

B.1.1.3 Embedded Operations Channel

The Embedded Operations Channel (EOC) provides management support across the connection between and RDT and an IDT. The EOC supports the following kinds of management operations:

- Control of protection switching between primary and secondary TMC and EOC
- Reporting of alarms and other events by the RDT to the IDT
- Communication of provisioning information from the IDT to the RDT
- Retrieval of provisioning information by the IDT from the RDT
- Initiation of test functions, e.g. Mechanized Loop Testing

The EOC uses a message set that is based on the Common Management Information Protocol (CMIP), with convergence protocol layer that supports the transport of CMIP messages directly over a LAPD-based link layer between RDT and IDT. For the purpose of CMIP message exchange, the IDT functions as a manager application while the RDT functions as a managed system. The information model that is used to describe the managed objects in the RDT is defined in TR-303 Supplement 3, although all real implementations of GR-303 use a very small subset of this object model.

The primary EOC occupies timeslot 12 of DS-1 link number 1. The secondary EOC, which is used as backup in the event of failure of the primary EOC, occupies timeslot 12 of another DS-1 link, the identity of which is provisioned. The secondary EOC exists only if the GR-303 interface comprises more than one DS-1 link.

B.1.2 Protocol Reference Model for CO-IWF with GR-303, using CAS

A protocol reference model for a CO-IWF with a GR-303 interface, using CAS between CO-IWF and CP-IWF, is illustrated in Figure B-1. For simplicity, the model does not show the EOC.

The call handling function in the model includes a switching capability that enables any 64 kbps timeslot from the Service Node Interface to be mapped to any channel within any AAL2 VCC on the ATM side. This switching capability is controlled by the timeslot management application, which exchanges TMC messages with the CO switch across the SNI, and which also receives CAS input from the ATM side. CAS input to timeslot management from the ATM side is required so that the CO-IWF can respond to off-hook events on AAL2 channels that are not currently active, and send the appropriate TMC message to the CO switch requesting a timeslot allocation.

CAS supervisory signaling is mapped from the extended superframe format on the SNI side to type 3 CAS packets on the ATM side. The values of ABCD bits are transported unchanged across this mapping function in each direction.

TMC messages arriving at the narrowband interface of the CO-IWF from the CO switch identify user ports by means of CRVs which are numerical values in the range 1 through 2048. Each CRV needs to be associated with a logical user port, which is equivalent to a single AAL2 channel. The association between CRVs and AAL2 channels is created by means of provisioning, and is effectively a static mapping. The association between CRVs and timeslots is created by means of messages exchanged over the TMC, and takes place dynamically on a call-by-call basis. The relationship between AAL2 channels, CRVs and timeslots is illustrated in Figure B-2 below.

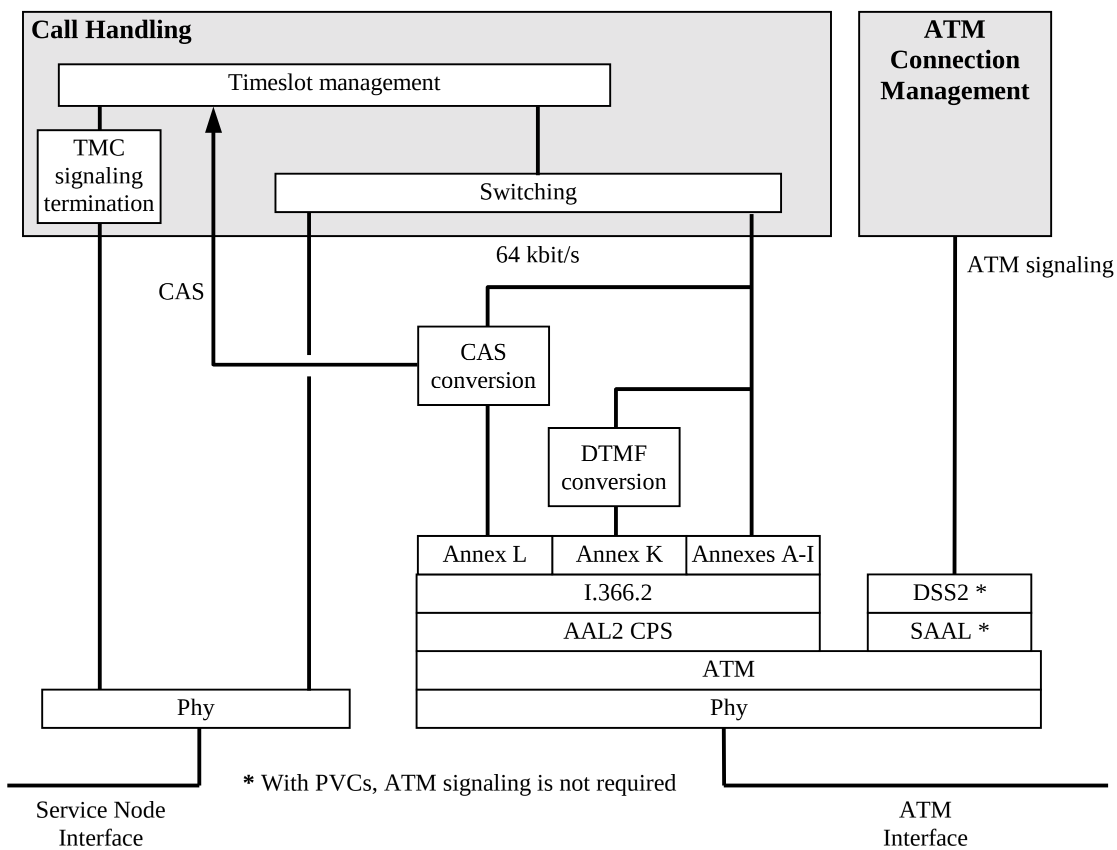


Figure B-1: Protocol Reference Model for CO-IWF with GR-303, using CAS

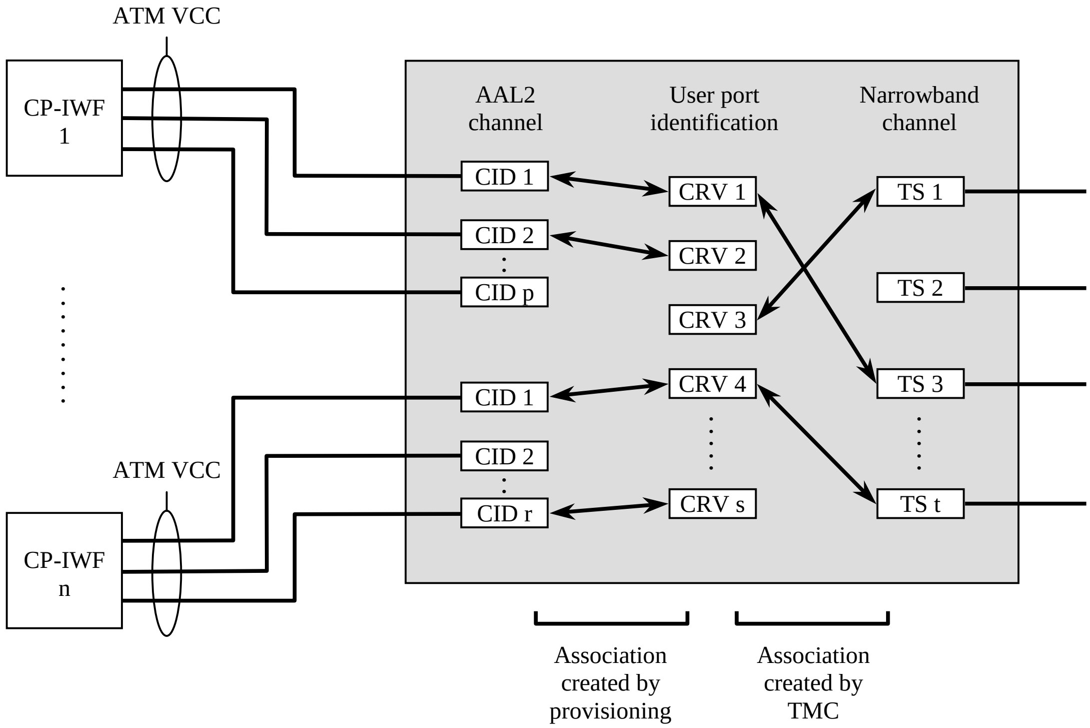


Figure B-2: Relationship between AAL2 channels, CRVs and timeslots in GR-303 CO-IWF

B.1.3 CO-IWFs Supporting GR-303 with CCS

The protocol model shown above in Figure B-1 illustrates a GR-303 CO-IWF using CAS between IWFs. This is clearly the simplest solution for a GR-303 CO-IWF, since the supervisory signaling on each narrowband timeslot is mapped directly into type 3 CAS packets that are sent over the AAL2 channel that is currently associated with this timeslot.

Although CAS provides the simplest solution for a GR-303 CO-IWF, it is not the only solution. The CAS-based supervisory signaling at the SNI can be mapped to PSTN messages on the ATM side. A mapping between GR-303 CAS supervisory signaling and PSTN messages is provided in Appendix D.

B.2 The TR-008 Interface

B.2.1 Overview of the TR-008 Interface

The TR-008 interface represents an earlier generation of digital access network interface than GR-303. This interface is defined in Telcordia document TR-TSY-000008. It is based on the proprietary interface of the SLC®96 digital loop carrier system from Lucent Technologies. TR-008 supports POTS only, and does not support ISDN.

A TR-008 interface comprises between 1 and 4 DS-1 links. Two modes of operation are defined: Mode I which supports static allocation of timeslots to user ports, and Mode II which supports a simple dynamic allocation scheme offering 2:1 concentration. Mode II has not been widely used, and this section discusses only the use of static timeslot assignment using Mode I.

B.2.1.1 Supervisory Signaling

Like GR-303, TR-008 uses a channel-associated signaling scheme for supervisory signaling on POTS lines. However TR-008 uses a different framing structure from GR-303, a superframe structure which supports only two signaling bits (AB). These signaling bits are repeated at the superframe interval, which is 1.5 ms. However some signaling states in the downstream direction are represented by a value of the B-bit that alternates between 1 and 0 in successive superframes.

B.2.1.2 Other Communications Functions

TR-008 makes use of some of the framing bits in the first DS-1 link to implement a 4 kbps Facilities Data Link that supports some simple alarm notification and control functions. There are no other communications facilities provided between RDT and IDT, and all timeslots on all DS-1 links are available for POTS services.

B.2.3 Protocol Reference Model for CO-IWF with TR-008, using CAS

The protocol reference model for a TR-008 CO-IWF using CAS is a subset of that shown in Figure B-1 above for GR-303. The timeslot management function is absent, as is the TMC termination function, and the switching function is replaced by a fixed mapping between timeslots and AAL2 channels, which is set up by provisioning.

The CAS supervisory signaling function maps TR-008 AB bit values to GR-303 ABCD bit values as described below.

B.2.4 Mapping of CAS Bits

CP-IWFs that comply with this specification interpret ABCD bits as analog line states according to the GR-303 specification, tables 12-3 through 12-6. CO-IWFs that support TR-008 at the Service Node Interface must therefore map TR-008 AB bit values at the SNI to GR-303 ABCD bit values at the ATM interface.

These mappings are set out in tables B-1 and B-2 below.

TR-008 States			Equivalent GR-303 States		
TR-008 Channel Configuration	**TR-008 Supervisory State**	**AB bits**	**GR-303 Signaling Type**	**GR-303 Supervisory State**	**ABCD bits**
Single Party	On-hook	0 0	Loop Start	Loop Open	0 1 0 1
	Off-hook	1 0		Loop Closure	1 1 1 1
Universal Voice Grade	On-hook	0 0	Ground Start	Loop Open	0 1 0 1
	Ring Ground	0 1		Ring Ground	0 0 0 0
	Off-hook	1 0		Loop Closure	1 1 1 1
DID DPT	Normal Battery	0 0	Loop Reverse Battery	Loop Current Feed	0 1 0 1
	Reverse Battery	1 1		Reverse Loop Current Feed	0 1 0 0

Table B-1: TR-008 States Mapped to GR-303 States in the Direction Customer to Network

TR-008 States			**Equivalent GR-303 States**		
TR-008 Channel Configuration	**TR-008 Supervisory State**	**AB bits**	**GR-303 Signaling Type**	**GR-303 Supervisory State**	**ABCD bits**
Single Party	Forward Disconnect	1 0	Loop Start	Loop Current Feed Open	1 1 1 1
	Idle	1 1		Loop Current Feed	0 1 0 1
	-R Ringing	1 1/0*		-R Ringing	0 0 0 0
Universal Voice Grade	Ground Start	0 0	Ground Start	Loop Current Feed Open	1 1 1 1
	-R Ringing	1 1/0*		-R Ringing	0 0 0 0
	Idle	0 1/0*		Loop Current Feed	0 1 0 1
DID DPT	Loop Open	0 0	Loop Reverse Battery	Loop Open	0 1 0 1
	Loop Closure	1 1		Loop Closure	1 1 1 1

* NOTE: The value 1/0 signifies that the B-bit alternates in value between successive superframes

Table B-2: TR-008 States Mapped to GR-303 States in the Direction Network to Customer

Appendix C: Operation of a V5 Service Node Interface at the CO-IWF

This informative appendix describes two kinds of Service Node Interface that are prevalent in markets where European telecoms standards apply, and illustrates interworking functions within the CO-IWF that are appropriate for these Service Node Interfaces.

C.1 The V5 Interfaces

The V5 specifications define digital access network interfaces based on European (E1) standards, and were originally specified by the European Telecommunications Standards Institute (ETSI) although these specifications have now been adopted by the ITU. The relevant specification references are:

	ETSI	**ITU-T**
V5.1	ETS 300 324	G.964
V5.2	ETS 300 347	G.965

The V5.x interfaces are based on physical links operating at 2048 kbps which are channelized as 32 x 64 kbps timeslots. Of these, 2 timeslots are reserved for signaling and other purposes, allowing a maximum of 30 timeslots in each 2048 kbps physical link for bearer traffic.

Both interfaces support access networks that provide any mix of analog POTS and ISDN Basic Rate Access lines. V5.1 is defined as a single 2048 kbps link where bearer channels are permanently assigned either to a specific POTS line or a specific ISDN B-channel from an end user. In other words, V5.1 supports only static timeslot assignment.

V5.2 is a superset of V5.1, and much of the V5.2 specification refers directly to clauses in V5.1. The key differences between V5.1 and V5.2 are as follows:

- V5.2 interfaces comprise between 1 and 16 physical 2048 kbps links.
- Timeslots in the 2048 kbps links are allocated dynamically to end-user POTS lines or ISDN B-channels, usually on a call-by-call basis.
- V5.2 interfaces can support ISDN Primary Rate Access as well as POTS and ISDN Basic Rate.

Since V5.2 is a superset of V5.1, and since the majority of LES applications in markets outside North America will likely be based on V5.2 rather than V5.1 to take advantage of the concentration capabilities offered by dynamic timeslot assignment, this appendix will consider the details of V5.2 first.

C.2 The V5.2 Interface

C.2.1 Overview of V5.2

A V5.2 interface connects an "Access Network" (AN) to a "Local Exchange" (LE). These are equivalent to the GR-303 terms RDT (Remote Digital Terminal) and IDT (Integrated Digital Terminal).

A V5.2 interface comprises between 1 and 16 physical 2048 kbps links which support both bearer channels and logical "communications channels" which convey signaling and control information over the interface. In general the communications channels occupy timeslot 16 on one or more of the 2048 kbps links. Where the V5.2 interface comprises two or more 2048 kbps links, two of these links are designated respectively the "primary" and the "secondary," and the communications channels are provisioned on timeslot 16 of these two links. A protection protocol is used to switch communications from the primary to the secondary link in the event of the failure of the primary link.

The communications channels supported over the V5.2 interface transport the following protocols between the AN and the LE:

- ISDN D-channel signaling to and from end-user ISDN ports.
- PSTN signaling which conveys supervisory line states to and from end-user analog POTS ports.
- Control protocol which is used to block, unblock, activate and de-activate both ISDN and analog POTS user ports.
- Bearer Channel Connection protocol which is used for dynamic assignment of timeslots to both ISDN B-channel and analog POTS user ports.
- Protection protocol which is used to support the switchover of communications channels between primary and secondary links in the event of a communications channel failure.
- Link control protocol which is used to identify and control the state of the physical 2048 kbps links that make up the V5.2 interface.

These protocols are multiplexed onto the communications channels by means of an encapsulation known as the LAPV5 Envelope Function. The LAPV5-EF uses an Envelope Function Address (EFaddr) to identify the destination process of the encapsulated message. EFaddr values in the range 0-8175 are reserved for ISDN D-channel signaling messages. For these, the value of EFaddr maps to the ISDN end-user port number. EFaddr values in the range 8176-8180 are assigned to the other protocols that operate over the communications channels, including the PSTN protocol, the BCC protocol and the Protection protocol.

The ISDN D-channel protocols are not terminated by the AN. They are forwarded by the AN to the BRA or PRA port on the end-user terminal equipment that is identified by the value of EFaddr. The assignment of EFaddr values to end-user BRA or PRA ports is carried out by provisioning.

All the other protocols that are supported by the communications channels between the AN and the LE are terminated in the AN. Each of these protocols runs over its own Data Link layer using the Link Access Protocol V5 Data Link (LAPV5-DL) which is a subset of the LAP-D protocol defined by Q.921.

C.2.1.1 D-Channel Message Relay Function

The AN does not terminate the Data Link layer supporting the ISDN D-channel messages. The LAP-D Data Link layer that supports the ISDN D-channel protocols is terminated at one end by the end-user terminal equipment and at the other end by the LE.

In the downstream direction towards the end-user, the AN checks D-channel messages for valid Frame Check Sequence, then strips off the EFaddr header, calculates the new value of FCS and transmits the frame on the D-channel associated with the end-user port identified by EFaddr.

In the upstream direction towards the network, the AN checks D-channel messages for valid FCS, looks up the EFaddr associated with this end-user port, adds the EFaddr header to the message, calculates the new value of FCS and transmits the message on the communications channel to the LE.

C.2.1.2 Control Protocol

This protocol is used to take individual bearer channels (user POTS ports or ISDN ports) in or out of service, primarily for maintenance and testing purposes.

The Control protocol is based on four message types: PORT CONTROL, PORT CONTROL ACK, COMMON CONTROL, and COMMON CONTROL ACK.

C.2.1.3 PSTN Protocol

The PSTN protocol conveys the supervisory state of all analog POTS end-user lines between the AN and the LE. There is one instance of the PSTN protocol between the AN and the LE, and this handles the supervisory states of all the analog POTS ports defined at the AN. The port with which any given PSTN protocol message is associated is identified by means of a Layer 3 Address in each PSTN protocol message. The L3 Address is effectively the user port number of the analog POTS port, equivalent to a CRV in the GR-303 specification.

The V5 PSTN protocol is described as essentially a “stimulus” protocol, in that it conveys information about analog line state changes in the upstream direction from AN to LE, and requests to change state in the direction from LE to AN.

A call may be initiated from either end with an ESTABLISH message. This is acknowledged by the other end with an ESTABLISH ACK message. If the call is a terminating call (from the network to the user) then the ESTABLISH message may contain information about what ringing cadence is to be used.

The ESTABLISH message effectively seizes the line. Once seized, and until it is released, further supervisory signaling on the line is conveyed in either direction by means of a SIGNAL message, which is acknowledged by the other end with a SIGNAL ACK message. The SIGNAL message may be used to convey in the upstream direction, for example, a switch hook flash (known in V5 as “register recall”), a pulsed dial digit or a return to on-hook. In the downstream direction, the SIGNAL message may be used to convey DDI digits or metering pulses.

The line may be released from either end with a DISCONNECT message, and is acknowledged from the other end by DISCONNECT COMPLETE.

The PSTN protocol as defined in V5.1 and V5.2 is extremely flexible and supports a very wide range of possible operations on an analog line. The actual subset of PSTN protocol messages and information elements that is used in a given implementation of the V5 interface is defined by the “National PSTN” protocol specification which is the responsibility of the local service provider. The V5 specifications give some simple examples of how the PSTN protocol may be used to support telephony services over analog lines, but little detail is provided. It would not be possible to create a useful implementation of V5 support for analog POTS without first obtaining details of the National PSTN protocol that applied to the territory to be served.

C.2.1.4 Bearer Channel Connection Protocol

The BCC protocol is used to control the dynamic assignment of timeslots within the 2048 kbps links that make up the V5 interface to end-user bearer channels that may be analog POTS lines or ISDN B-channels.

The BCC protocol is somewhat simpler than the TMC protocol used in GR-303. One of the reasons for this is that, unlike GR-303, it is not necessary for the AN to monitor the supervisory signaling on user ports that are not currently assigned to timeslots, as is the case with GR-303. Supervisory signaling from all user ports, regardless of whether they are assigned to timeslots or not, is carried by the PSTN protocol to the LE. The LE monitors this signaling and when it sees an off-hook event on a user port which does not currently have a timeslot assignment, it initiates the timeslot assignment process.

It is based on two kinds of message from LE to AN, ALLOCATE and DE-ALLOCATE, and two kinds of responses from the AN to the LE, COMPLETE or REJECT.

ALLOCATE and DE-ALLOCATE messages from LE to AN request the allocation or de-allocation of a given timeslot to a given user bearer channel. Both types of message contain a unique BCC reference number to uniquely identify the request, and this reference number is repeated by the AN in its response message to the LE so that the LE can correlate the response with the request.

The ALLOCATE message specifies the identity of the timeslot (2048 kbps link identity and timeslot number) and the identity of the user port that are to be cross-connected by the AN. The message contains a marker bit indicating whether the user port is an ISDN user port or a POTS user port. If the user port is an ISDN user port, then the ALLOCATE message also indicates which B-channel on the user port is to be cross-connected to the specified timeslot.

If the AN is able to complete the requested allocation, it responds with an ALLOCATION COMPLETE message, specifying only the BCC reference number of the allocation request. If it cannot complete the requested allocation, then it responds with an ALLOCATION REJECT message, specifying the BCC reference number of the allocation request together with a cause code indicating the reason for the rejection.

When the LE wishes to de-allocate the timeslot, exactly the same procedure is followed as for allocation, except that the message send to the AN is DE-ALLOCATION, and the possible response messages from the AN are DE-ALLOCATION COMPLETE or DE-ALLOCATION REJECT.

The BCC protocol also defines an AUDIT message that allows the LE to query the AN for details of timeslot allocation either by identifying a given timeslot or by identifying a given user bearer channel.

C.2.1.5 Protection Protocol

The Protection protocol is used to control the switchover of communications channels that carry all of the V5 message protocols (including the ISDN D-channels) from a failed 2048 kbps link to a backup 2048 kbps link.

Two of the links in the V5 interface are designated respectively primary and secondary. The Protection Protocol operates over timeslot 16 of both primary and secondary links. Other V5 protocols may also operate over timeslot 16 of the primary link, with failover to the secondary link when needed. Timeslots 16 of the primary and secondary link comprise Protection Group 1.

In some circumstances, there may not be sufficient capacity on timeslot 16 of the primary link to carry all of the message traffic needed to support the V5 interface. This is particularly true if the V5 interface comprises a substantial number of 2048 kbps links. In this case, additional communications channels may be provisioned on further 2048 kbps links, also using timeslot 16. Timeslots 15 and 31 may also be used if necessary to provide additional capacity for message traffic. A similar number of backup communications channels may be provisioned. This group of communications channels comprises Protection Group 2.

C.2.1.6 Link Control Protocol

The Link Control protocol is used to manage the 2048 kbps physical links that make up the V5 interface. Two kinds of control operations are supported: taking links in an out of service, and auditing link identity.

A specified link can be taken out of service in both graceful and forced modes. In the graceful mode, the LE will assign no new calls to timeslots in the specified link and will take the link out of service when all existing calls have terminated.

The identity of a link can be audited to ensure that both LE and AN agree on the identity assigned to the link.

C.2.2 Protocol Reference Model for CO-IWF with V5.2, using CCS

A protocol reference model for a CO-IWF with V5.2, using CCS between CO-IWF and CP-IWF, is shown below in Figure C-1. This reference model is simplified in that it shows the bearer channel and supervisory signaling paths, but it does not show the Emulated Loop Control protocol.

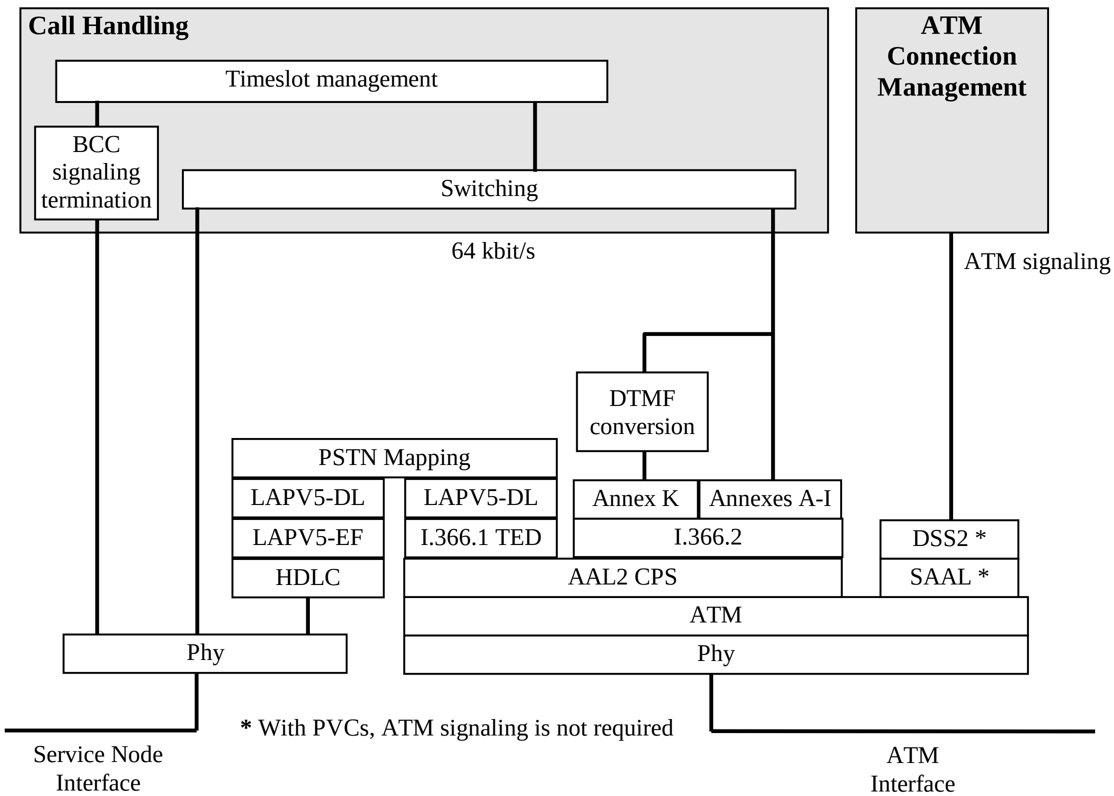


Figure C-1: Protocol Reference Model for CO-IWF with V5.2, using CCS

The call handling function in the model includes a switching capability that enables any 64 kbps timeslot from the Service Node Interface to be mapped to any channel within any AAL2 VCC on the ATM side. This switching capability is controlled by the timeslot management application, which exchanges BCC messages with the CO switch across the SNI.

The PSTN mapping function is illustrated in Figure C-2 below, for the direction from the LE towards the user.

PSTN messages for all user ports arrive at the CO-IWF over the V5.2 interface via a single instance of the LAPV5-Data Link (LAPV5-DL) protocol. LAPV5-DL messages arrive with a LAPV5-Envelope Function (LAPV5-EF) protocol header. The LAPV5-EF protocol header, which distinguishes PSTN signaling messages from other protocols, is removed together with the HDLC flags, and the LAPV5-DL protocol is terminated. This involves checking for a valid FCS and discarding messages with invalid FCS.

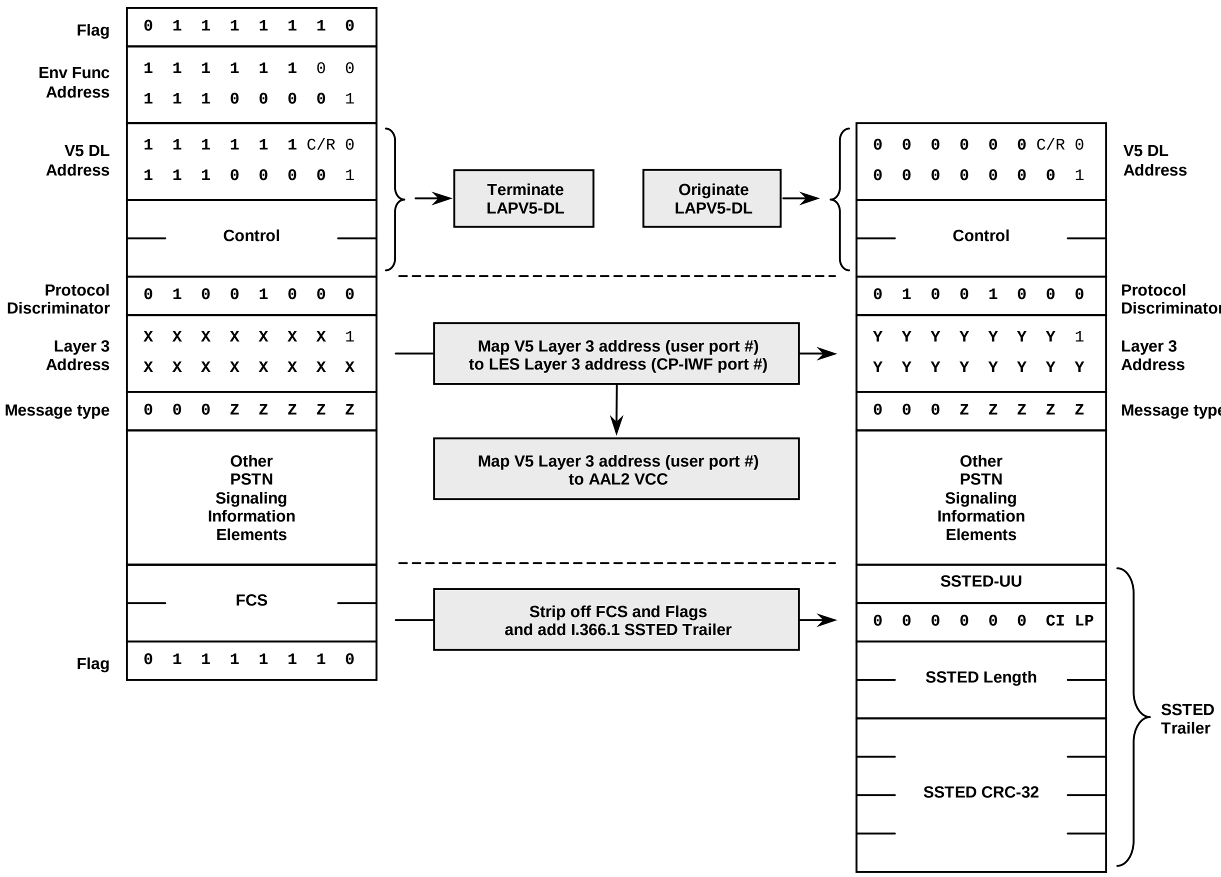


Figure C-2: PSTN mapping function in the direction from network to user

The PSTN signaling message is then processed by extracting the Layer 3 address IE, and looking this up to determine the mapping between the V5.2 user port and the corresponding AAL2 VCC and CP-IWF analog port, which has been established by provisioning. The Layer 3 address IE in the PSTN message is replaced by a new value that identifies the CP-IWF analog port, and the message is passed to the LAPV5-DL protocol instance that is operating over the relevant AAL2 VCC. The LAPV5-DL protocol adds the V5 DL address valid on the data link between CO-IWF and CP-IWF (bits 3 to 8 of the first octet and bits 2 to 8 of the second octet set to zero) plus a control field, but not an FCS. Instead, an I.366.1 SSTED trailer is added, with SSTED-UU, SSTED-CI and SSTED-LP all set to zero. The SSTED length field is set to the appropriate value and the SSTED CRC-32 checksum is calculated. The resulting SSTED-PDU is then passed to the SSSAR sublayer for segmentation into AAL2 common part packets for transmission over AAL2 CID = 8, the common signaling channel.

In the reverse direction, the reverse process applies. SSTED CRC-32 checksum is calculated and messages with invalid CRC-32 checksum are discarded. The V5 Layer 3 address is determined from the combination of the AAL2 VCC and LES Layer 3 address in the incoming PSTN message, and this is inserted into the Layer3 address IE. The message is then transmitted via the LAPV5-DL protocol with V5 DL address = 8176 which identifies this message as PSTN protocol, inside the LAPV5-EF wrapper and flags.

C.2.3 Protocol Reference Model for CO-IWF with V5.2, using DSS1 Message Relay

A protocol reference model for a CO-IWF with V5.2, using DSS1 message between CO-IWF and CP-IWF to support the delivery of ISDN BRI service, is shown below in Figure C-3. This reference model is simplified in that it shows the bearer channel and supervisory signaling paths, but it does not show the Emulated Loop Control protocol.

The protocol reference model is very similar to that shown for the CCS application. The bearer channels are supported in exactly the same way, with a switching function that maps any timeslot in the SNI to any AAL2 bearer channel under the control of the BCC protocol.

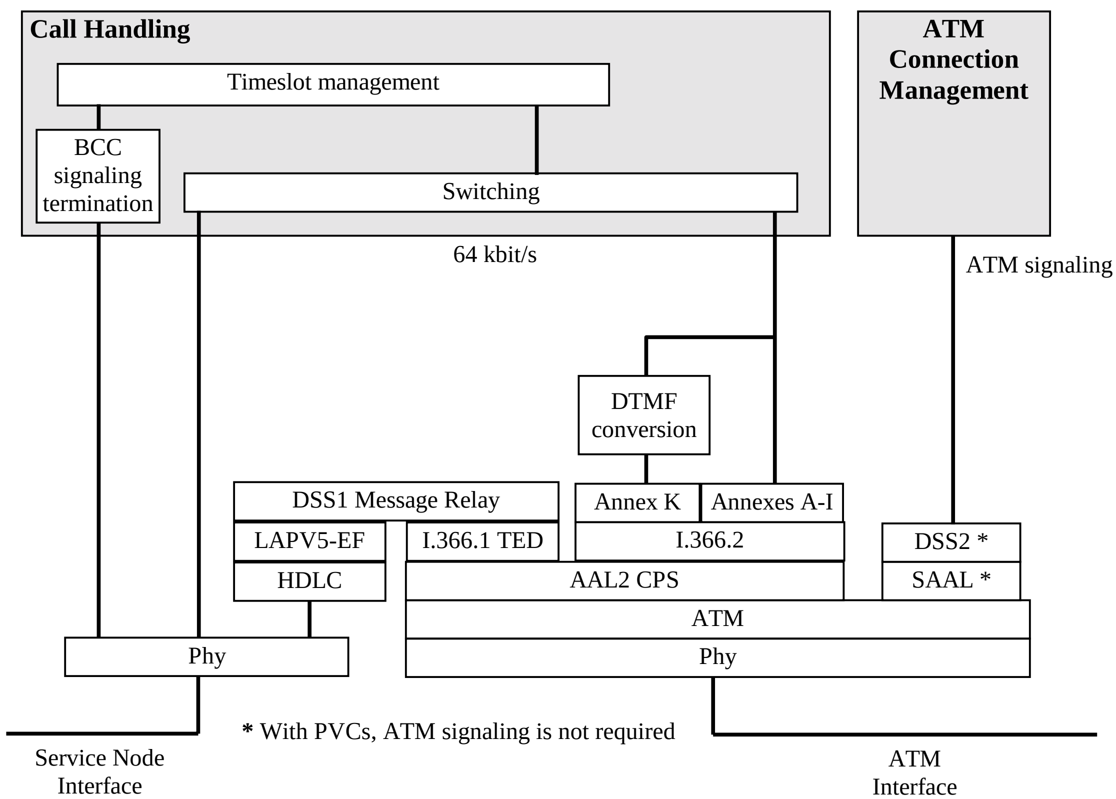


Figure C-3: Protocol Reference Model for CO-IWF with V5.2, using DSS1 Message Relay

The main difference from the CCS application is in the handling of the signaling channels. In the case of CCS, the PSTN signaling for all user ports is delivered over the V5.2 interface via a single LAPV5-DL data link, and a layer 3 relay function is used to map the PSTN messages to another LAPV5-DL data link that exists between the CO-IWF and each CP-IWF. In the case of DSS1 message relay, a separate LAP-D data link exists directly between each CP-IWF and the LE, while the CO-IWF merely relays the layer 2 message via an AAL2 channel. The CO-IWF therefore does not terminate the layer 2 protocol, it merely forwards layer 2 messages transparently.

Each D-channel is conveyed over a separate AAL2 channel. The ISDN user port to which a particular DSS1 message should be sent is identified across the V5.2 interface by means of the LAPV5-Envelope Function address. The CO-IWF maps the LAPV5-EF address to a particular AAL2 VCC, and to the particular AAL2 channel that carries the D-channel for the ISDN user port that is identified by the LAPV5-EF address. The layer 2 mapping process is illustrated in Figure C-4 below.

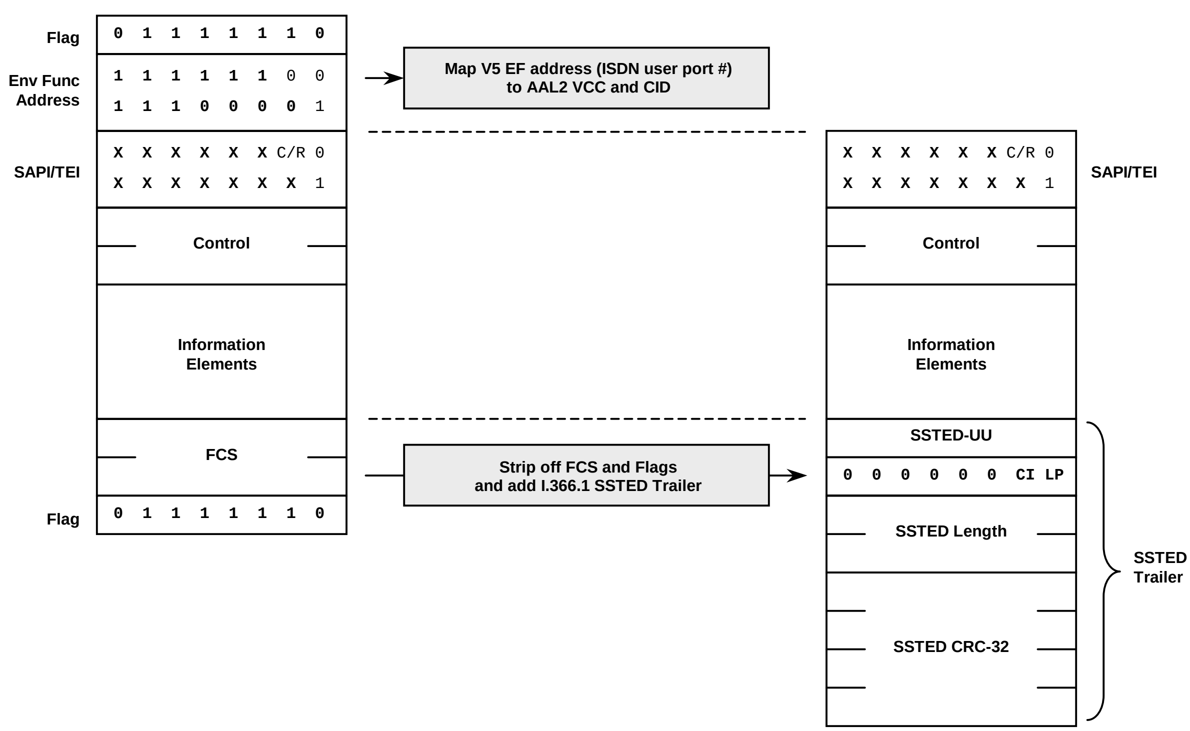


Figure C-4: DSS1 message relay function in the direction from network to user

C.2.4 Protocol Reference Models for CO-IWFs with V5.1

The protocol reference models for CO-IWFs with V5.1, using CCS and using DSS1 message relay respectively, are identical to those shown above for V5.2 with the following exceptions:

- There is no BCC signaling termination function
- The switching function that is part of call handling is replaced by a static mapping which is established by provisioning.

All other aspects of operation are the same for V5.1 as for V5.2.

C.3 Interworking of ELCP with V5 at the CO-IWF

C.3.1 Interworking of ELCP User port control with V5 Control protocol.

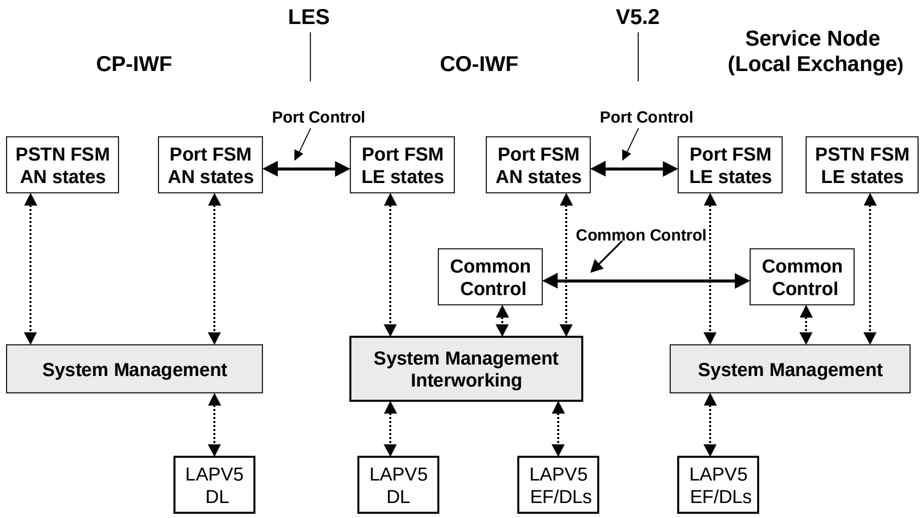
The following figure shows the conceptual model for the various protocol state machines in the CO-IWF when ELCP is present at the LES interface and V5 is present at the Service Node interface.

In this model, the CO-IWF acts as the "AN side" at the V5 interface and as the "LE side" on the LES interface towards the CP-IWF.

The FSMs (Finite State Machines) shown in the figure refer to the FSMs described in ITU-T G.964/G.965 and ETSI EN 300 324/347.

Coordination of the states in the PSTN FSM and the Port FSM for PSN user ports is under responsibility of the respective System management.

It must be noted that this is a conceptual model only to help describe the interactions and does not prescribe a particular architecture for an implementation.



ELCP Port Control to V5 Control Interworking: Conceptual Model

In this model, Port Control messages received by the CO-IWF at one side are handled by the System Management in the CO-IWF and translated to the corresponding messages at the other side.

On both sides, the CO-IWF keeps track of port states.

C.3.2 Handling of V5 PSTN Restart

If the CO-IWF receives a COMMON CONTROL message over the V5 interface with the Control function ID set to "Restart request" it shall

1) respond with a COMMON CONTROL ACK message

2) perform a block/unblock sequence for all affected PSTN user ports

3) send a COMMON CONTROL message over the V5 interface with the Control function ID set to "Restart complete"

C.3.3 Handling of ELCP System Restart

According to section 5.4.4.2 ELCP system restart is initiated when either of the following conditions applies:

a) Reception of Release-Indication of LAPV5_DL

b) ELCP channel allocation/deallocation procedure failure

c) Under request by the Management System (OS)

In this situation, the CO-IWF shall initiate blocking of all affected user ports by sending a PORT CONTROL message over the V5 interface with the Control function element set to "204 = block" for these ports. After restart, these ports will be unblocked again by sending a PORT CONTROL message over the V5 interface with the Control function element set to "202 = unblock".

C.3.4 Interworking of ELCP Activation and V5 BCC protocol

If the CO-IWF receives a BCC protocol ALLOCATION message over the V5.2 interface, the CO-IWF shall invoke the Allocation procedure according to section 5.3.1.1.2 for the corresponding AAL2 channel if necessary. If, for some reason, the channel cannot be activated, the CO-IWF shall respond with a ALLOCATION REJECT message over the V5.2 interface.

If the CO-IWF receives a BCC protocol DE-ALLOCATION message over the V5.2 interface, the CO-IWF shall invoke the De-Allocation procedure according to section 5.3.1.1.2 for the corresponding AAL2 channel, if necessary. If, for some reason, the channel cannot be de-activated, the CO-IWF shall respond with a DE-ALLOCATION REJECT message over the V5.2 interface.

C.3.5 Interworking of ELCP Allocation and V5.1

As mentioned in section C.2.4, there is no BCC protocol termination at the CO-IWF, if V5.1 is used at the SNI.

In the case of interworking with V5.1 it is recommended to include the activation of user channels in the system startup procedures.

More specifically:

At system startup and system restart all PSTN bearer channels and all ISDN B-channels shall be activated.

The procedures described in 5.4.4.1 "Normal Procedures, item d) Post-processing" are augmented as follows:

Between steps 1) and 2) insert step 1a):

1a) The CO-IWF shall activate all AAL2 channels associated with relevant PSTN user ports and all AAL2 channels associated with relevant ISDN B-channels using the ELCP channel activation procedure.

Appendix D: Mapping of North American Analog Signaling to PSTN Messages

D.1 Purpose

This informative appendix defines the use and coding of ETSI EN 300 324-1 PSTN Protocol Cadenced Ringing, Steady Signal and Digit-Signal information elements for analog loop services in North America. For exact electrical characteristics, see TR-NWT-000057.

D.2 Information Elements used in the direction CO-IWF to CP-IWF

The following information elements are transmitted by the CO-IWF toward the CP-IWF to indicate various loop conditions that are to be applied by the CP-IWF to the analog loop:

D.2.1 Cadenced Ringing

The following values apply to Loop Start, Ground Start, and Coin (both Dial-tone First and Coin First) loops:

Cadenced Ringing Type =	0	Continuous application of normal ringing voltage superimposed on normal loop current
	All other Values	Reserved for autonomous cadenced ringing application

D.2.2 Steady Signal

Upon receipt of any Steady Signal information element, ringing voltage, if any, is removed from the line.

The following values apply to Loop Start, Ground Start, and Coin (both Dial-tone First and Coin First) loops:

Signal Type =	0	Loop Current Feed (LCF)
	1	Reverse Loop Current Feed (RLCF)
	11	Loop Current Feed Open (LCFO)

The following values apply to Coin (both Dial-tone First and Coin First) loops:

Signal Type =	7	Positive Coin Check
	12	Negative Coin Check
	21	Positive Coin Control
	8	Negative Coin Control

The following values apply to Loop Reverse Battery loops:

Signal Type =	4	Loop Closed (LC)
	5	Loop Open (LO)

D.2.3 Digit-Signal

If a CP-IWF is equipped to support pulse dialing on a Loop Reverse Battery port, it will respond to a Digit-Signal information element by outpulsing the corresponding sequence of Loop Open and Loop Closed states. Timing specifics are per TR-NWT-000057. A CO-IWF that supports pulse dialing on Loop Reverse Battery ports will interwork the Digit-Signal IE from the narrowband interface.

D.3 Information Elements used in the direction CP-IWF to CO-IWF

The following information elements are transmitted by the CP-IWF toward the CO-IWF to indicate various loop conditions detected at the CP-IWF:

D.3.1 Steady Signal

The following values apply to Loop Start, Ground Start, and Coin (both Dial-tone First and Coin First) loops:

Signal Type =	4	Loop Closed (LC)
	5	Loop Open (LO)

The following value applies to Ground Start loops:

Signal Type =	7	Ring Ground

The following values apply to Loop Reverse Battery loops:

Signal Type =	0	Loop Current Feed (LCF)
	1	Reverse Loop Current Feed (RLCF)
	11	Loop Current Feed Open (LCFO)

D.3.2 Digit-Signal

If a CP-IWF is equipped to support pulse dialing on one or more of its analog ports, it should, for each digit, accumulate the pulses and transmit the corresponding digit value using the Digit-Signal information element. This requires that, during an active call, the CP-IWF delay the transmission of loop state changes toward the CO-IWF until it can distinguish between a dial pulse (requiring the Digit-Signal IE) and an on-hook or flash condition (requiring the Steady-Signal IE). To maintain proper timing, the delay must be consistent for both Open-to-Closed and Closed-to-Open transitions. Timing specifics are per TR-NWT-000057. A CO-IWF that supports Dial Pulse loops will interwork the Digit-Signal IE toward the narrowband interface.

Appendix E: Example Parameters for CP-IWF Configuration

This informative Appendix identifies parameters that may have to be configured at the CP-IWF for inter-operation with a CO-IWF, and offers example values for these parameters.

Parameter Name	**Parameter Value**
AAL2 Bearer Channel Virtual Circuit	VPI = 0, VCI = 40_{10}
AAL2 AppID	0x0000000A
AAL2 CPS parameter values	--
Max CPS-SDU size	45_{10}
Max number of multiplexed channels	112_{10}
CID range for AAL2 user channels	16..127
SSCS parameter values	--
SSCS type	I.366.2
Audio Service	Enabled
Circuit Mode Data	Disabled
Frame Mode Data	Disabled
Fax Demodulation/Remodulation	Disabled
CAS (Channel Associated Signaling)	Enabled
DTMF Dialed Digits	Disabled
MF-R1 Dialed Digits	Disabled
MF-R2 Dialed Digits	Disabled
PCM Encoding	Generic PCM encoded as μ law
Max length frame mode data	65535_{10}
Profile source	Other predefined profile
Predefined profile identifier	7
OUI Profile Source	$00A03E_{16}$
Broadband Bearer Capability	--
Bearer Class	10000_2
ATM Transfer Capability	0001001_2
ATM Traffic Descriptors	
Forward PCR CLP=0+1	Dependent on services offered
Backward PCR CLP=0+1	Dependent on services offered
Forward SCR CLP=0+1	Dependent on services offered
Backward SCR CLP=0+1	Dependent on services offered
Forward MBS CLP=0+1	Dependent on services offered
Backward MBS CLP=0+1	Dependent on services offered

Table E-1: CP-IWF configuration parameters