The ATM Forum
Technical Committee

Voice and Telephony Over ATM - ATM Trunking using AAL1 for Narrowband Services Version 1.0

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1   Introduction

1.1   Background

The ATM Forum's Circuit Emulation Service Interoperability Specification Version 2.0 (af-vtoa-0078.000) is limited to structured DS1, E1, N x 64 kbit/s, and J2 service and to unstructured DS1, E1, DS3 and E3 service. It is based on the establishment of a facility with a fixed number of circuits (channels) between two end points. There are market needs, especially in the enterprise networking environment, to extend these capabilities to provide additional efficiency in the use of ATM backbone and narrowband access resources.

1.2   Scope of the Document

This specification provides those extensions by defining capabilities to allow:

1. allocation of resources on an as-needed basis, which may be based on expected or actual traffic loading.
2. traffic from/to multiple end points (PBXs) to share those allocated facilities
3. calls to be routed to the desired destination facilities, which eliminates the need to dedicate specific narrowband channels to every destination.

ITU-T Recommendation I.580 identifies the following three interworking scenarios for ATM networks and Narrowband networks as depicted Figure 1.2-1:

1. Interconnection of an ATM terminal/network and a Narrowband terminal/network
2. Interconnection of two Narrowband networks via an ATM network
3. Interconnection of two ATM networks via a Narrowband network.
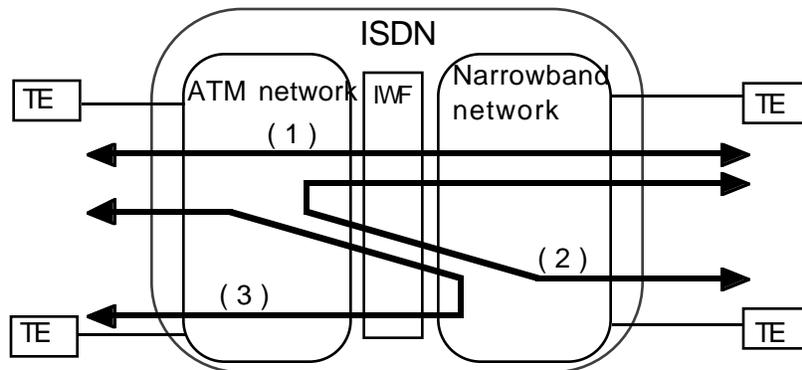
 Figure 1.2-1: Communication Scenarios in Interworking between ATM Networks and Narowband Networks

This specification addresses scenario 2, in which the user interfaces and services are the same as those which are currently provided by the narrowband network. It does not address scenarios 1 and 3 identified in I.580 since they are not directly related to ATM Trunking.

This specification utilizes and builds upon existing standards of recognized standards organisations such as the ITU-T. It does not include any new speech coding methods, but rather, specifies how the existing coded speech is mapped into the ATM cells.

This specification defines the capabilities of the Interworking Function (IWF) to provide a means for the interconnection of two Narrowband networks through an ATM network via ATM trunks. An ATM trunk is defined here as one or more ATM Virtual Connections that carry a number of 64 kbit/s Narrowband channels and associated signalling between a pair of IWFs. The only constraint placed on the number of Narrowband channels per Virtual Connection, the number of Virtual Connections per ATM trunk, and the number of ATM trunks per IWF is the addressing mechanisms inherent in the ATM signalling upon which this capability is built.

The IWFs provide the necessary adaptation functions to interconnect Narrowband equipment to the ATM network. It should be noted that the IWF described here may be either a stand alone device with physical interfaces to the ATM network and the Narrowband network or it may be integrated into either the ATM network equipment of the Narrowband network equipment. This specification defines the IWF as a logical function which communicates with a peer IWF on the other side of the ATM network.

This specification is limited to Network interworking functions. The IWF terminates the narrowband signalling protocol in order to perform routing on a per call basis for the 64 kbit/s channels to the appropriate destination IWF. The IWF transfers the service information, including the identity of the called user, transparently through the ATM connection. This specification cites UNI 3.1, however UNI 4.0 may be used as well.

Service interworking is outside the scope of this specification. Transport of compressed voice with optional activity detection is not addressed and may be the subject of future revisions.

1.3   Service Requirements

In support of the market needs, the following service requirements are identified:

- Call-by-call routing: An ability to route calls on a per call basis to make more effective use of the transmission and switching capabilities of the ATM network. This allows integration into one physical narrowband interface of multiple access circuits carrying calls destined for different far ends. In this way, it reduces the need for tandem circuit switches. To provide this function, the IWF should be able to understand the signalling messages for call set-up and call clearing and be able to establish ATM Trunks to more than one remote IWF.

- Bandwidth on demand: An ability to allocate the bandwidth only when needed. The IWF provides this capability by allowing the establishment of facilities (VCCs) either based on predetermined traffic patterns or when a new call set-up requires it.

- Bandwidth sharing: An ability to share the bandwidth with other types of service (e.g., data or other PBX). The IWF provides the flexibility for efficient use of bandwidth by freeing up unneeded bandwidth for use by other services.

- Support of DS1/E1 with signalling: An ability to support DS1/E1 interfaces with PSS1, DSS1, and E&M (CAS) with DTMF signalling is required.

Not all of the signalling options described in this specification (DSS1, PSS1, CAS) need to be implemented in order to be compliant with this specification. If any of these signalling options is implemented in accordance with this specification, that implementation is deemed to be compliant.

1.4   Network Interconnection Configurations

Figure 1.4-1 shows the potential network interconnection configurations of ATM trunking using AAL1 for Narrowband services.

In Figure 1.4-1, six types of network interconnection configurations for ATM trunking services are presented.

(I)   Concatenation of private Narrowband networks via private ATM networks
(II)   Concatenation of private Narrowband networks via public ATM networks
(III)   Concatenation of public Narrowband networks via public ATM networks
(IV)   Concatenation of private Narrowband network and public Narrowband network via both private ATM networks and public ATM networks
(V)   Concatenation of private Narrowband networks via both private ATM networks and public ATM networks
(VI)   Concatenation of public Narrowband network and private Narrowband network via public ATM networks.

This specification addresses only configurations I, II, and V.
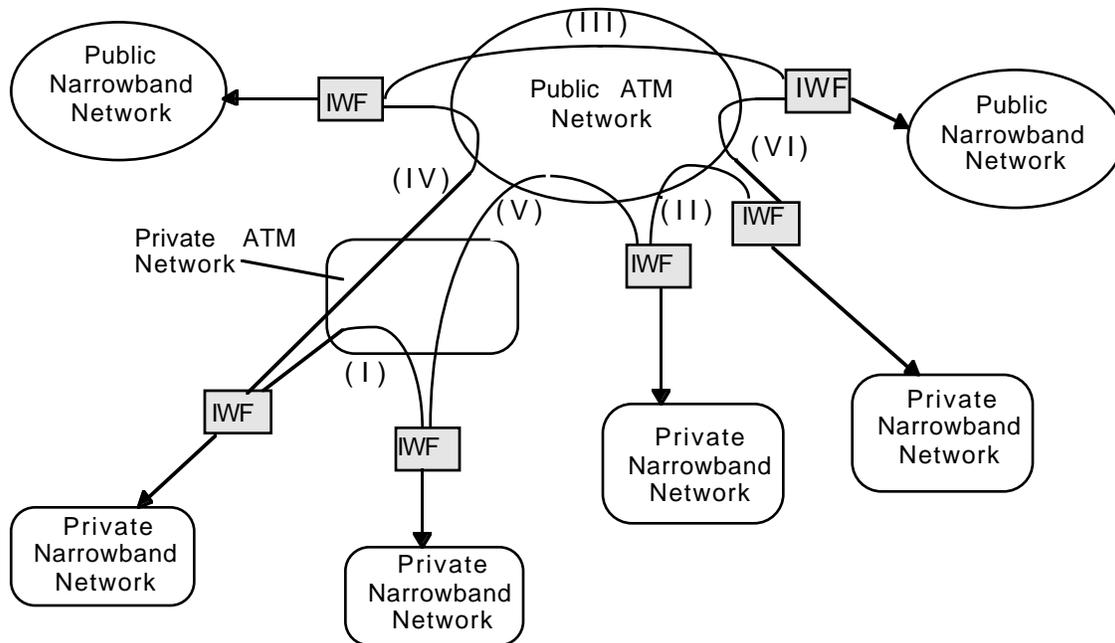
Figure 1.4-1: Network Interconnection Configurations of ATM Trunking using AAL1 for Narrowband Services

The ATM Trunking narrowband network to ATM Network interworking scenario can only be supported in private ISDN network to private ATM network interworking (configuration I) or private narrowband network to a public ATM network which supports the DSS2 message flows between IWFs described in Section 2.2.3 (configurations II & V). Further study is needed to determine how public narrowband networks interworking with either public or private ATM networks would support ATM Trunking (configurations III, IV, and VI).

1.5   Traffic Characterization

The traffic carried by the trunking described in this document includes speech and voice-band telephony services such as FAX and voiceband modem services and the narrowband signalling associated with these services.

This service may provide support for both 64 kbit/s bearer channels and N x 64 kbit/s channels. No specific requirements are described in this specification for the support of N x 64 kbit/s by the IWF such as the procedures for maintaining time-slot integrity of the channels between the narrowband network..

1.6   References

1.6.1 Normative

- af-nm-0020.000, M4 Interface Requirements and Logical MIB: Network Element Views (October 1994)

- af-uni-0010.002, UNI 3.1 - ATM Forum "User Network Interface Specification" version 3.1 (September 1994)

- af-vtoa-0078.000, Circuit Emulation Service Interoperability Specification Version 2.0 (January 1997)

- I.363.1-1996, B-ISDN ATM Adaptation Layer (AAL) Specification, Type 1 and 2

- I.363.5-1996, B-ISDN ATM Adaptation Layer (AAL) Specification, Type 5

- I.371-1996, Traffic Control and Congestion Control in B-ISDN

- I.431-1993, Primary rate User Network Interface - Layer 1 specification

- I.432.1-1996, B-ISDN User-Network Interface: Physical layer specification - General characteristics

- I.432.2-1996, B-ISDN User-Network Interface: Physical layer specification for 155 520 kbit/s and 622 080 kbit/s

- I.432.3-1996, B-ISDN User-Network Interface: Physical layer specification for 1 544 kbit/s and 2 048 kbit/s

- I.432.4-1996, B-ISDN User-Network Interface: Physical layer specification for 51 840 kbit/s

- I.580-1995, General arrangement for Interworking between B-ISDN and 64 kbit/s ISDN

- I.610-1995, B-ISDN operation and maintenance principles and functions

- Q.931-1993, Digital Subscriber Signalling System Number 1 (DSS1) ISDN User Network Interface Layer 3 specification for basic call control

- Q.2931-1995, Broadband Integrated Services Digital Network (B-ISDN); Digital Subscriber Signalling System Number 2 (DSS2) B-ISDN User-Network Interface Layer 3 specification for basic call/connection control

- ANSI/TIA/EIA-464-B, 1996, Requirements for Private Branch Exchange Switching Equipment

- ANSI T1.102-1993, Digital Hierarchy - Formats Specifications

- ISO/IEC 11572:1994, Information technology - Telecommunications and information exchange between systems - Private Integrated Services Network - Circuit mode bearer services - Inter-exchange signalling procedures and protocol

1.6.2 Informative

- G.114-1993, One-way transmission time

- G.826-1993, Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate

- I.555-1993, Frame relaying bearer service interworking

- T1.401-1993, Interface Between Carriers and Customer Installations - Analog Voicegrade Switched Access Lines Using Loop-start and Ground-start Signaling

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

- RFC 1573, Evolution of the Interfaces Group of MIB-II (January 20, 1994)

- RFC 1902, Structure of Management Information for Version 2 of Simple Network Management Protocol (SNMP v2) (January 1996) (revision of RFC1442)

- RFC 2037, Entity MIB using SMIv2 (October 1996)

- RFC 2127, ISDN Management Information Base using SMIv2 (March 1997)

- RFC 2128, Dial Control Management Information Base using SMIv2 (March 1997)

- RFC (TBD) (draft), Definition of Managed Objects for the DS0 and DS0 Bundle Interface Type (draft−ietf−trunkmib−ds0−mib−03.txt)

- RFC (TBD) (draft revision of RFC1406), Definition of Managed Objects for the DS1/E1 Interface Type (draft−ietf−trunkmib−ds1−mib−05.txt)

- RFC (TBD) (draft revision of RFC1407), Definition of Managed Objects for the DS3/E3 Interface Type (draft−ietf−trunkmib−ds3−mib−04.txt)

2   Switched Trunking Options for 64 kbit/s Channels

2.1   Overview

This section discusses the mechanisms identified for the transport of 64 kbit/s narrowband channels across an ATM network with network interworking functions.

Figure 2.1-1 describes the two different ATM trunking mechanisms which are identified for the stated purpose.
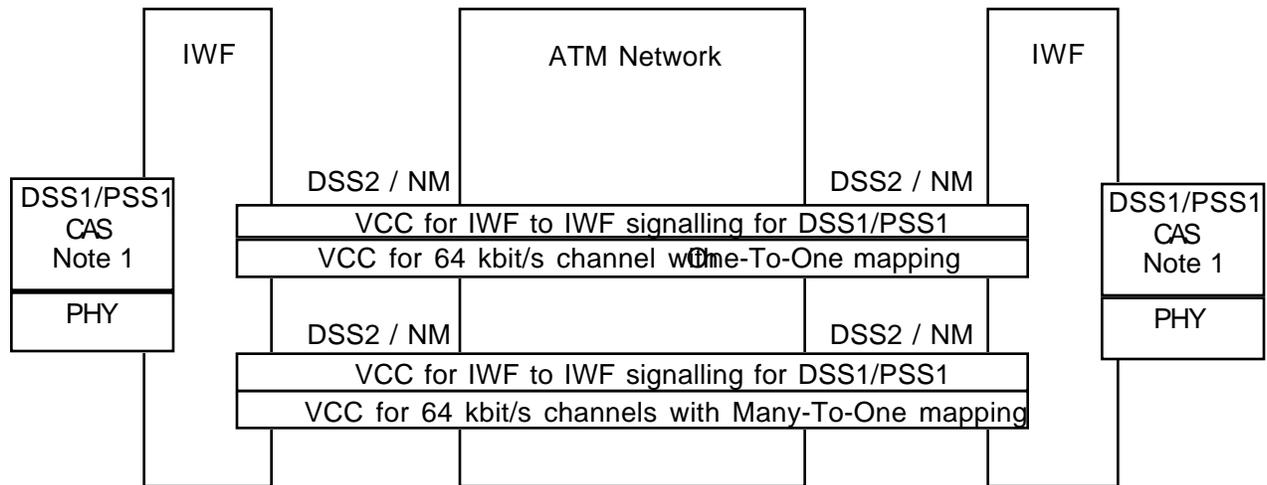
Note 1: The narrowband signalling protocols at the two narrowband interfaces must be the same, i.e., DSS1, PSS1, or E&M (CAS) signalling. The IWF does not support any signalling protocol conversion.

Figure 2.1-1: ATM Trunking Mechanisms

Both mechanisms use one IWF to IWF signalling connection to transport narrowband DSS1 or PSS1 signalling messages between two IWFs within an SSCF-UNI/SSCOP/AAL5 cell stream. For Channel Associated Signalling, the IWF to IWF signalling is performed inband using DTMF and ABCD bit mapping onto AAL1 according to af-vtoa-0078.000 and is carried in the same VCC as the 64 kbit/s channels.

The first mechanism is called One-to-One mapping. It is represented in the upper portion of Figure 2.1-1, and is described in Section 2.3. Each 64 kbit/s channel is mapped into one ATM VCC.

The second mechanism is called Many-to-One mapping. It is represented in the lower portion of Figure 2.1-1, and is described in Section 2.4. Multiple 64 kbit/s channels are mapped into one ATM VCC.

The functions which are common to both mechanisms are described in Section 2.2.

2.2   Common Functions

2.2.1 Service Description

2.2.1.1 Reference Configuration

Figure 2.2.-1 shows the reference configuration for ATM Trunking for Narrowband Services. Private or public narrowband networks are shown connected to Interworking Functions (IWFs), which in turn are connected to either public or private ATM networks via physical interfaces defined in Section 2.2.1.2. The narrowband networks connect to the IWFs over E1 or DS1 facilities.

An arbitrarily large number of IWFs can be connected to an ATM network, although for reasons of clarity and simplicity, the figure shows only two IWFs. The purpose of the IWFs is to adapt the incoming signals from the narrowband networks into a suitable format for carriage over the ATM networks and vice versa. ATM connections are set up over the ATM networks between appropriate IWFs to support the desired number of adapted 64 kbit/s narrowband channels.
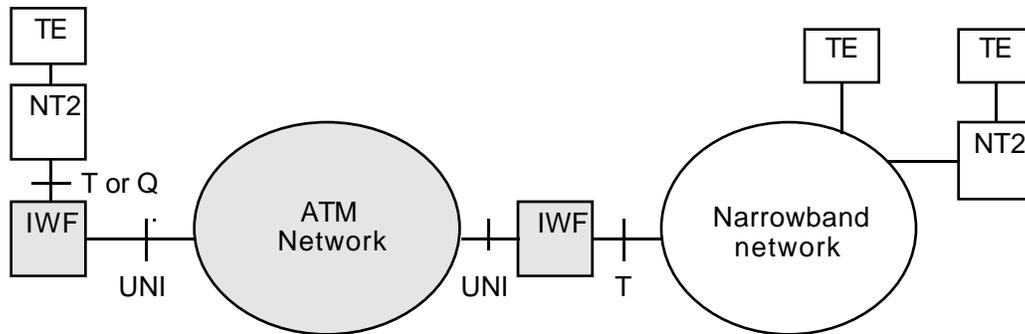
Figure 2.2-1: Reference Configuration for Network Interworking

The IWF for ATM trunking using AAL1 provides a call by call switched service to the Narrowband Network as shown in Figure 2.2-2. For the support of N-ISDN (out-of-band) signalling, the IWF terminates the Narrowband Signalling and transports all Narrowband messages in a signalling connection set up with the remote IWF. For the support of Channel Associated Signalling, the IWF terminates the narrowband signalling and signalling information is transported in the same ATM virtual connection that carries the voice information. The services available to the Narrowband network are independent of their availability in the ATM network.
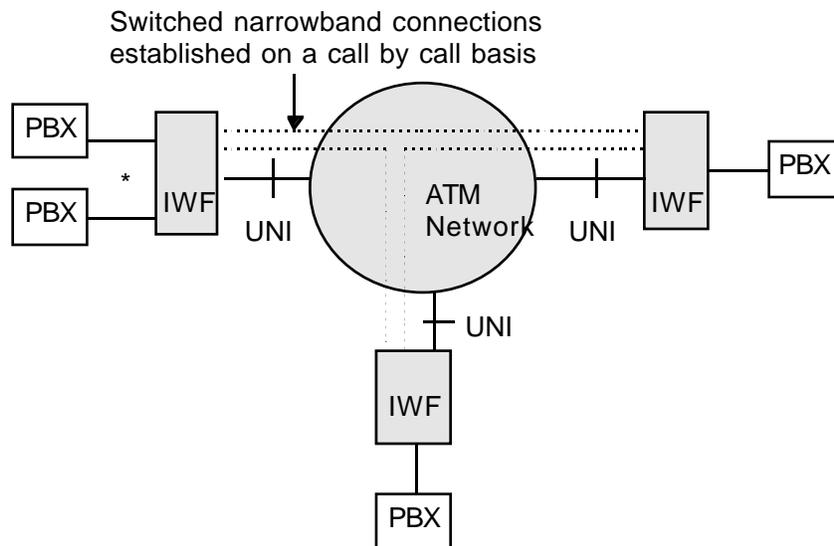
*Note: Some IWF implementations may support more than one narrowband system, e.g., PBXs. However, local switching between PBXs within an IWF implementation is out of the scope of this specification.

Figure 2.2-2: Example of Switched Service Configuration

2.2.1.2 Physical Layer Interfaces

For the support of N-ISDN (out-of-band) signalling, the interface between the N-ISDN network and the IWF is defined in I.431 (ISDN Primary Rate Interface).

For the support of Channel Associated Signalling, the interface between the narrowband network and the IWF may be E1 as defined in G.703 or DS1 as defined in Section 3 of ANSI/TIA/EIA-464-B.

The interfaces between the IWF and the ATM network can be any one or more ATM interfaces defined by the ATM Forum, or by the ITU-T I.432.x series of UNI recommendations.

2.2.1.3 Performance Parameters

Delay:

ATM trunking for narrowband services introduces some additional delay to that encountered for the transport over the ATM network. This is primarily associated with buffering to accommodate Cell Delay Variation introduced by the ATM network, and cell construction delay.

Appropriate echo control measures are recommended on all speech connections where end-end delay exceeds that specified in G.131.

Error Performance:

The error performance of trunked narrowband channels is impacted by cell errors, cell loss, and cell misinsertion in the ATM network. Appropriate cell loss compensation is required in the IWF.

End-to-end Delay:

End-to-end delay requirements are application-dependent. End-to-end delay requirements are beyond the scope of this specification. ITU-T Recommendation G.114 provides considerable guidance on the subject of delay.

Error Ratios:

Bit Error Ratio (BER) is the ratio of the number of bit errors to the total number of bits transmitted in a given time interval. There are no specific bit-error ratio requirements for 64 kbit/s service other than those implied by the errored second and severely-errored second requirements that follow. (Source: ANSI T1.510-1994)

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

2.2.2 Functionality of the IWF

The functionality of the IWF described in this specification is depicted in Figure 2.2-3. (For sake of illustration, Figure 2.2-3 shows PBXs as the narrowband network and depicts specific functional components and an architecture of the IWF. Other configurations of narrowband networks are possible, and the IWF may be implemented in other ways than depicted.)

The IWF includes the following functions:
- Signalling termination, to extract signalling from and insert signalling into the narrowband interface.
- Call Handling, to interpret the call setup and release signals from the connected narrowband equipment including selection of the destination for each call
- Switching, to allow any combination of channels from the narrowband side to be connected, on a call-by-call basis, to any combination of ATM trunks. This consists of copying of the data octets from individual time-slots from the DS1/E1 side into the desired channel positions on the ATM side and vice versa.
- Multiplexing, to combine channels from multiple sources from the narrowband side towards ATM trunks to the ATM network
- Mapping and adaption, to insert the 64 kbit/s channels into the allocated channel positions in the VCC according to af-vtoa-0078.000.
- VCC management, to allocate and deallocate VCCs to distant PBXs as needed to support the traffic.
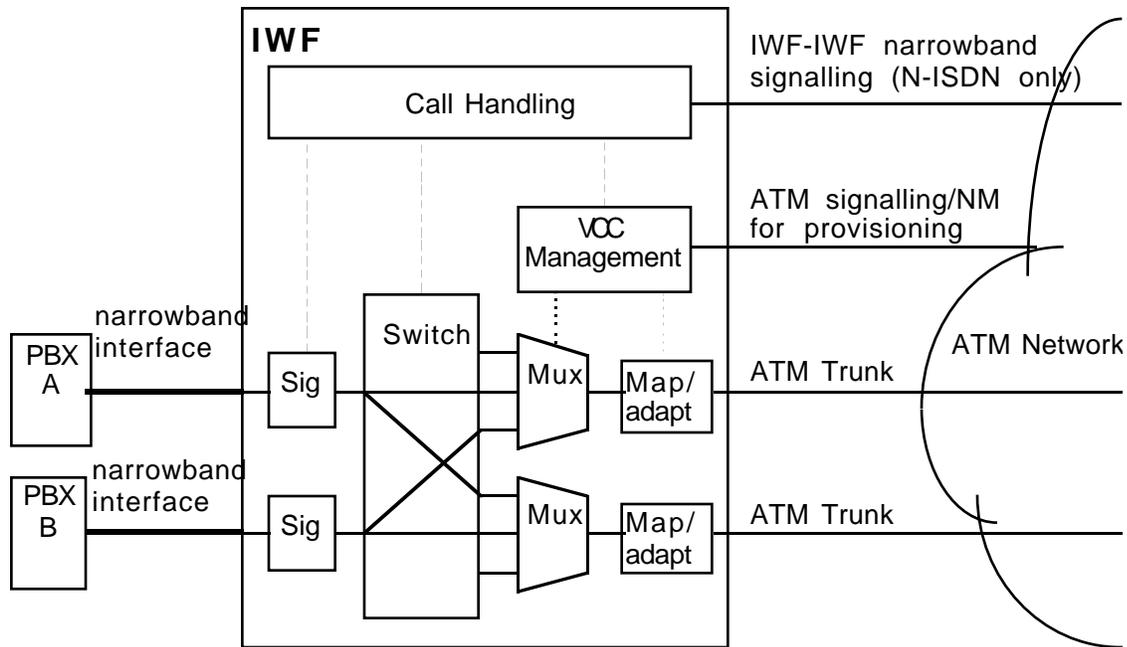
Figure 2.2-3: IWF Functionality for ATM Trunking

2.2.2.1 IWF Functionality with N-ISDN Signalling

The functionality of the IWF located at the interface between a Narrowband ISDN and a Broadband network, is described as follows:

Trunks on E1 or DS1 facilities, with their associated out-of-band signalling channels, terminate on a Narrowband switch function, which routes the 64 kbit/s channels from the incoming trunks so that channels which need to use the same path across the ATM network may be grouped. Multiple outputs are multiplexed together and presented to a mapping function, where the octets belonging to individual 64 kbit/s channels are mapped into the payload of AAL1 ATM cells belonging to a given VCC. These ATM cells are carried by the VCCs connecting IWFs across the ATM network.

The out-of-band signalling channels are also presented to the call handling function so that the call handling function can control the Narrowband switch function. The call handling function uses the services of SAAL and AAL 5 to transfer the Narrowband signalling messages across the ATM network to a peer IWF in a separate VCC.

If the VCCs to carry Narrowband signalling messages and 64 kbit/s channels are controlled by the IWF, then the Call Handling function also generates messages as defined in UNI 3.1 for setting up these VCCs. Otherwise, the VCCs are established by network management procedures.

The Call Handling of the IWF is limited to setup and release of point-to-point connections and shall not include other services such as supplementary services.

2.2.2.2 IWF Functionality with Channel Associated Signalling

The functionality of the IWF located at the interface between a Narrowband network and a Broadband network and utilizing CAS, is described as follows:

Trunks with CAS for supervisory signalling and DTMF for address signalling on E1 or DS1 facilities terminate on a Narrowband switch function, which routes the 64 kbit/s channels from the incoming trunks so that channels which need to use the same path across the ATM network may be grouped. Multiple outputs are multiplexed together and presented to a mapping function, where the octets belonging to individual 64 kbit/s channels are mapped into the payload of AAL1 ATM cells belonging to a given VCC. These ATM cells are carried by the VCCs connecting IWFs across the ATM network.

The narrowband switch function also presents the narrowband signalling (supervisory and address signalling) to a call handling function. This call handling function controls the narrowband switch function in order to route the individual 64 kbit/s channels to the correct VCC. The narrowband signalling information is transported in the same ATM VCC as the associated speech information.

If the VCCs to carry 64 kbit/s channels are controlled by the IWF, then the Call Handling function also generates messages as defined in UNI 3.1 for setting up these VCCs. Otherwise, the VCCs are established by network management procedures.

2.2.3 Signalling

The signalling required includes signalling on the narrowband interface, IWF-IWF signalling, and IWF to ATM network signalling as described in the following sections.

2.2.3.1 Signalling for Narrowband Interface

The signalling between the IWF and the narrowband network may be via either DS1 or E1 at the physical layer with either narrowband ISDN or CAS signalling.

2.2.3.1.1 N-ISDN signalling

The N-ISDN signalling may be either DSS1 as defined in Q.931 or PSS1.

2.2.3.1.2 Channel Associated Signalling

G.704 defines the framing structure for the Channel Associated Signalling bits for E1 and DS1. The interpretation of the signalling bits for E1 is not defined by this specification. The Channel Associated Signalling for DS1 is E&M supervisory signalling and DTMF address signalling as specified in Sections 4.2 and 6 of ANSI/TIA/EIA-464-B. Dial pulse address signalling is not supported.

2.2.3.2 IWF-IWF Signalling

The signalling protocols between the IWFs can be one of the following and shall be the same as that used between the connected narrowband equipment and the IWF:

- DSS1 ISDN (Annex D, Q.931)
- PSS1 at the Q reference point for QSIG Transit Private Integrated Network Exchange (PINX)
- Channel associated signalling (E&M with wink start and DTMF according to ANSI/TIA/EIA-464-B)

2.2.3.2.1 Signalling for N-ISDN

Figure 2.2-4 shows the Protocol Reference Model for DSS1 or PSS1, which is useful to understand the signalling requirements in the Interworking Function to interface Narrowband and ATM networks.
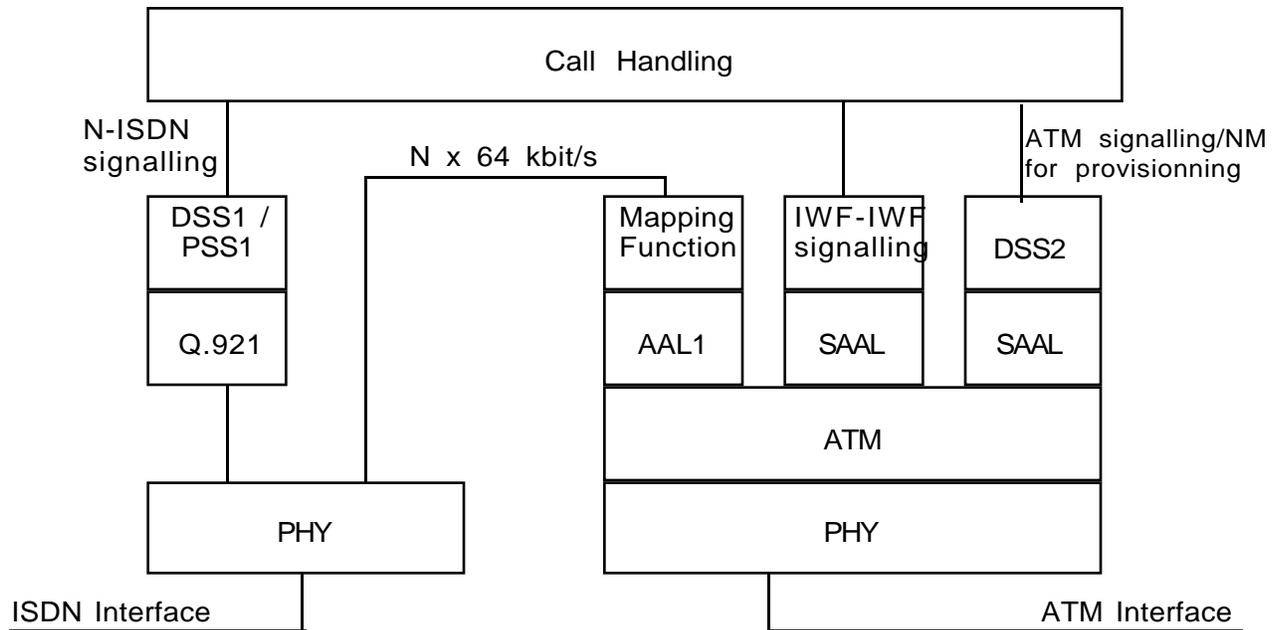
Figure 2.2-4: IWF Reference Model for DSS1/PSS1

Signalling associated with 64 kbit/s channels carried between two IWFs is transported across the ATM network in an SAAL cell stream within a separate VCC. It allows the signalling for Narrowband ISDN 64 kbit/s calls to remain in the Narrowband domain from end-to-end. This separate VCC may be established as a PVC or as an SVC as shown in Figure 2.2-5.

A single ATM VCC is required between a pair of IWFs to carry the IWF-IWF signalling as long as an ATM VCC to carry one or more 64 kbit/s channels exists between this pair of IWFs.

In order to correlate the circuit connections that are established using narrowband signalling with the established resources at the ATM layer using ATM signalling or ATM management, a Virtual Circuit Connection Identifier (VCCI), is defined. This VCCI is carried with the ATM (or through management) as low layer information and with the narrowband signalling as the interface identifier.

These VCCI values are assigned by the IWF that originates the ATM VCC. These values are unique to the originating IWF only between a pair of IWFs. The VCCI is assigned at the beginning of an ATM VCC and remains fixed for the lifetime of the VCC. After the VCC is disconnected, the associated VCCI value may be reassigned to a later VCC. Two identical VCCI values may be used when each value pertains to a VCC originated at opposite ends of the IWF-IWF connections.

Two octets (14 bits) are used for this VCCI between each pair of IWFs, including an identifier flag. The identifier flag can take the values "0" or "1". The flag is used to identify which end of the IWF-IWF connection originated the identifier. The origination side always sets the flag to "0". The destination side always sets the flag to "1". The flag is used to resolve simultaneous attempts to allocate the same identifier value.

Figures 2.2-5 and 2.2-6 show information flows among PBXs, IWFs, and the ATM network. Figure 2.2-5 shows information flows when there are no existing ATM VCCs to carry the IWF-IWF signalling or the narrowband call. Figure 2.2-6 shows information flows when VCCs already exist to carry the signalling and the narrowband call.

The following rules apply when the IWF-IWF signalling connection is an SVC. and only one is desired:

• Either IWF, as needed, may set up a signalling connection to the other. An IWF shall not issue a setup to the same ATM address if an earlier setup is still pending of if a signalling connection is already established.

• On receipt of an incoming setup for a signalling connection: If a signalling connection is already established with the same ATM address, an IWF shall reject the setup; otherwise, accept it.

- If two signalling connections become established between the same pair of ATM addresses, an IWF shall send messages only on the one that was set up by the numerically lower ATM address. It shall still accept messages arriving on the other. An IWF shall release the signalling connection that was set up by the numerically higher ATM address after an interval of 2 seconds has passed with no messages received.
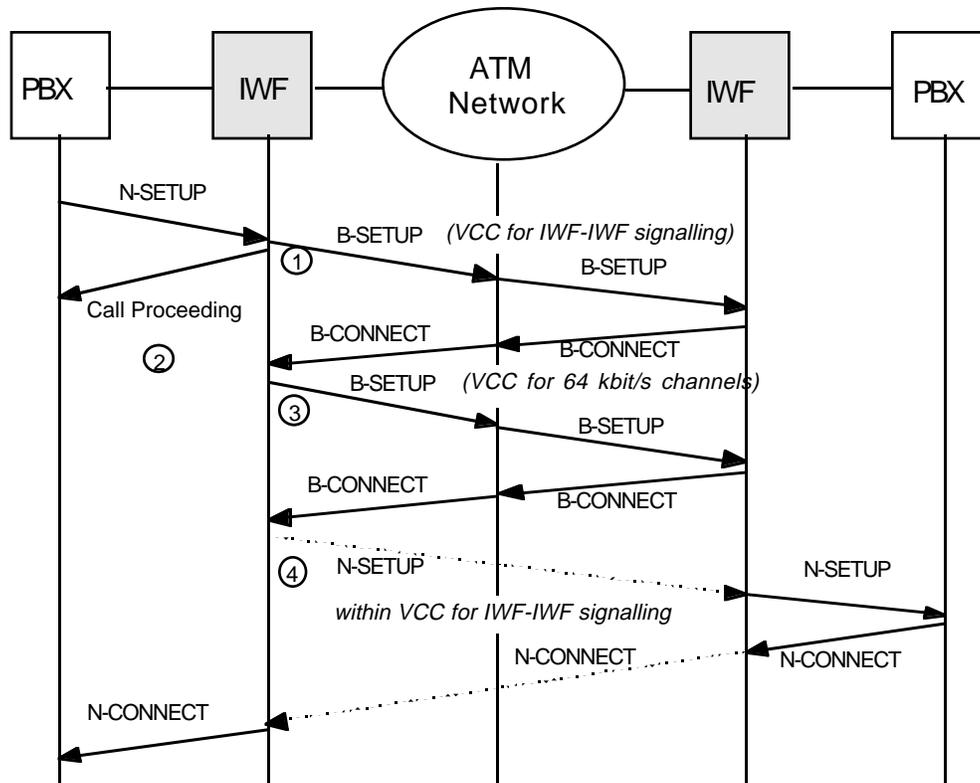
Note 1: Based on the Called Party number in the N-ISDN Setup message, the IWF finds the ATM address of the destination IWF. If the VCC for the IWF-IWF signalling does not already exist, the IWF sets up a VCC for the IWF-IWF signalling.

Note 2: Depending on the time to set up the VCCs, it may be necessary to send a call proceeding message in order to avoid failures due to expiring timer.

Note 3: The IWF sets up a VCC for the 64 kbit/s channel(s) using Broadband Setup message with B-LLI IE to identify the VCC.

Note 4: After the VCC to carry the narrowband call is established, the IWF sends a Narrowband Setup message to the destination IWF over the IWF-IWF signalling connection. This N-SETUP contains the VCCI value from the B-LLI IE of the B-SETUP. For Many-to-one mapping, it also contains the number of the selected channel in the identified VCC.

Figure 2.2-5: Information Flows When VCCs Do Not Exist
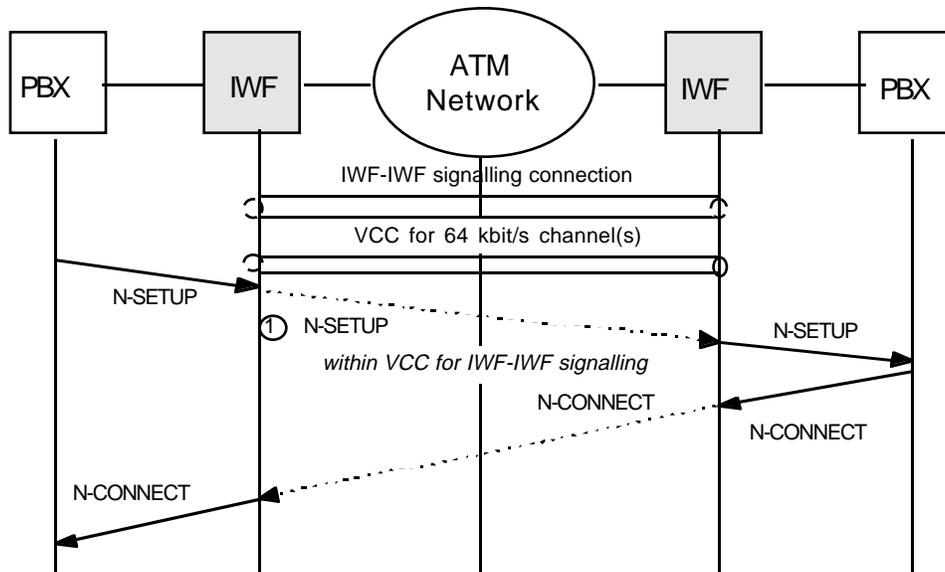
Note 1: Based on the Called Party number in the N-ISDN Setup message, the IWF finds the destination IWF and the IWF-IWF signalling VCC. The IWF sends Narrowband Setup message to the destination IWF over the IWF-IWF signalling connection.

Figure 2.2-6: Information Flows When VCCs Already Exist

2.2.3.2.2 Signalling for Channel Associated Signalling

Figure 2.2-7 shows the protocol reference model for the support of Channel Associated Signalling. The IWF terminates narrowband CAS supervisory signalling and DTMF address signalling.
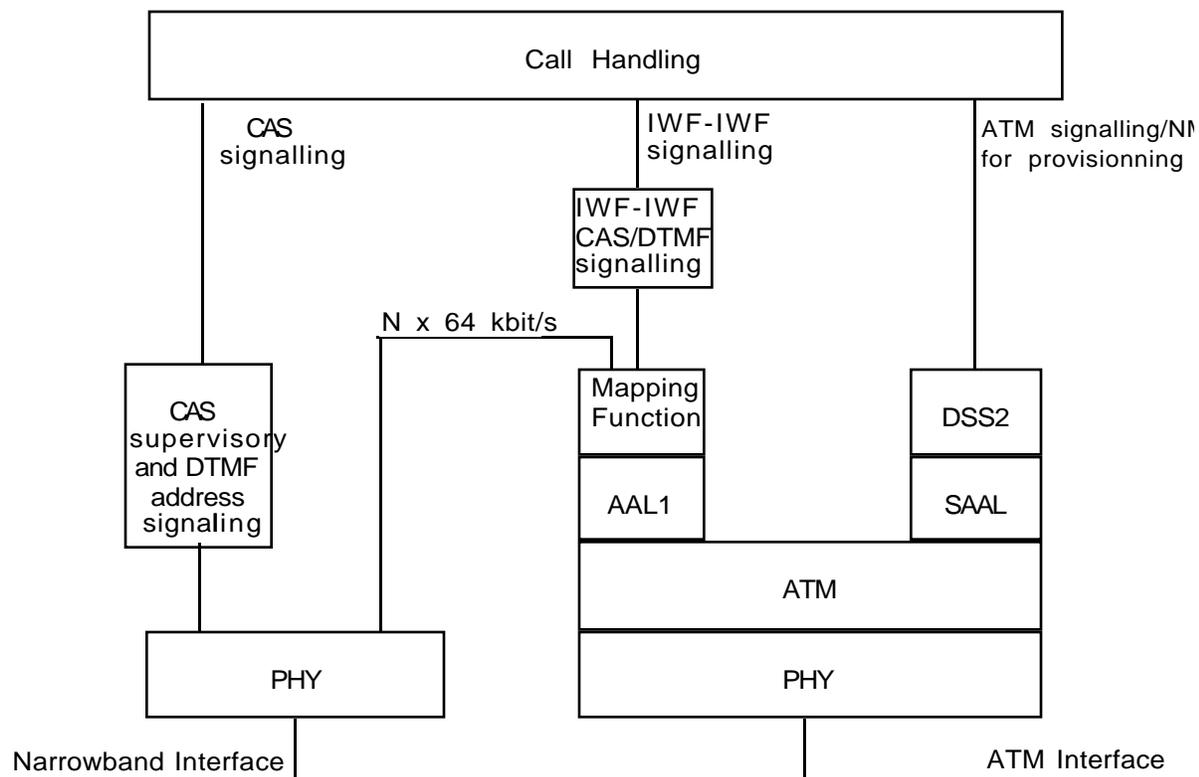
Figure 2.2-7: IWF Reference Model to Support Channel Associated Signalling

When a narrowband channel becomes active, the IWF, based on the called party number, finds the ATM address of the destination IWF. If there is no ATM VCC to the destination IWF available to carry the call, the IWF sets up an ATM VCC to carry the call. This is shown in Figure 2.2-8. If there is an ATM VCC to carry the call to the destination IWF, the 64 kbit/s channel is mapped into the VCC. This is shown in Figure 2.2-9.

IWF-IWF signalling is also through Channel Associated Signalling. For DS1 applications, the address signalling between IWFs is DTMF as specified in ANSI/TIA/EIA-464-B. Supervision signalling between IWFs is E&M with wink start as specified in ANSI/TIA/EIA-464-B. Dial Pulse addressing signalling is not supported. Flash signals are not transported between IWFs.

A separate VCC for IWF to IWF signalling is not required since the narrowband signalling information is transported in the same ATM VCC as the associated speech information. The mapping is according to Section 2.3.1.2 of af-vtoa-0078.000, however, the limit of 24 or 31 channels for DS1 and E1 systems, respectively, shall not apply. The number of channels per VCC is limited to 128. Speech information and DTMF tones are carried by the payload portion of the AAL1 block. The Channel Associated Signalling bits are carried by the signalling portion of the AAL1 block.
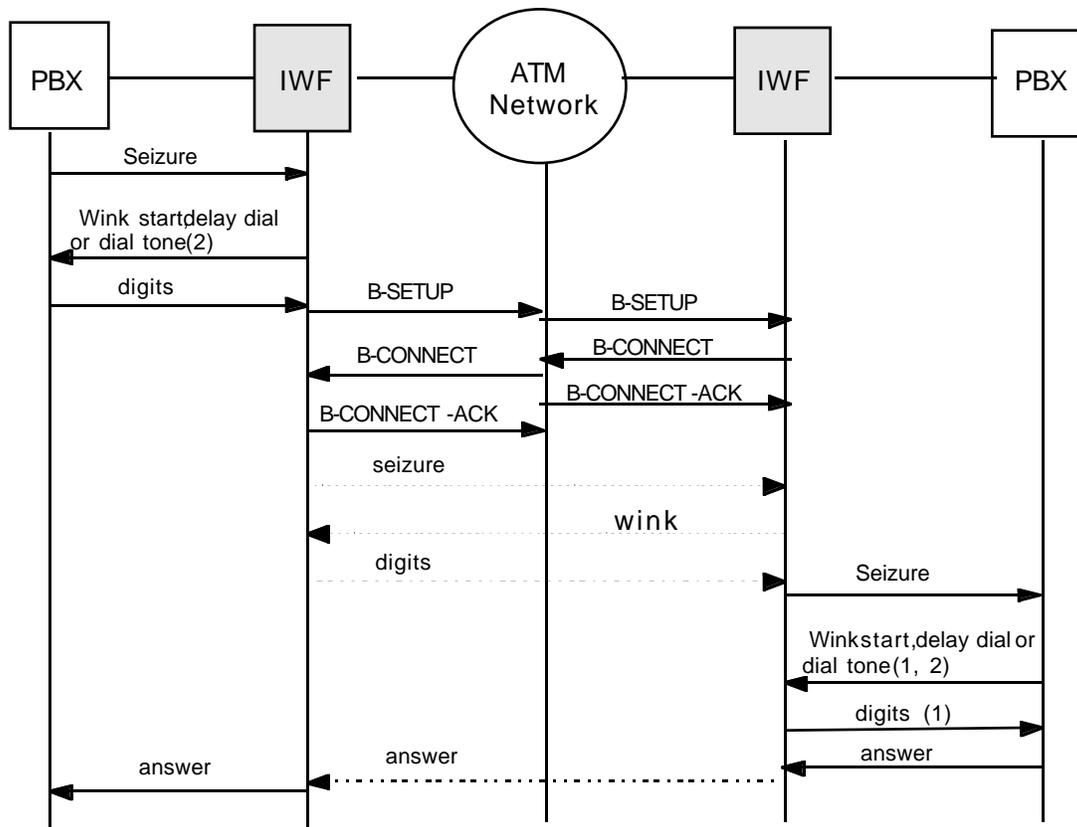
Note 1: Not used for attendant-completing trunk circuits
Note 2: Not used for immediate-start trunk circuits

Figure 2.2-8: Information Flows When No VCC Exists for 64 kbit/s Channel
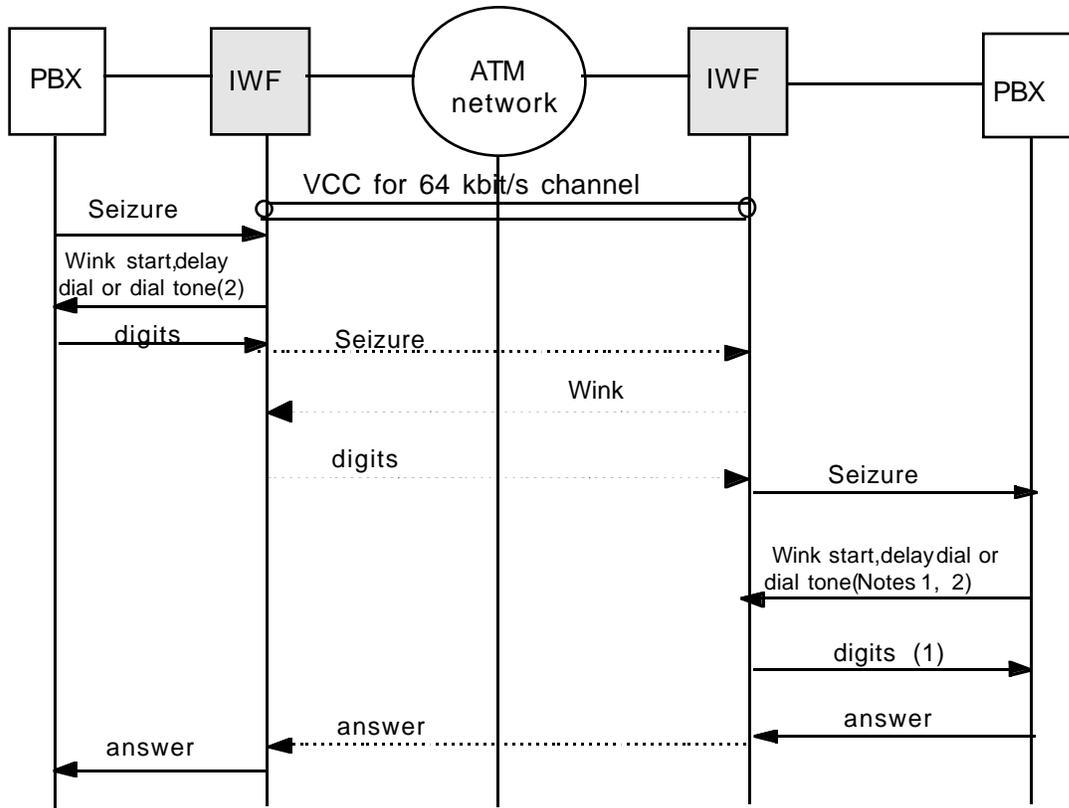
Note 1: Not used for attendant-completing trunk circuits
Note 2: Not used for immediate-start trunk circuits

Figure 2.2-9: Information Flows When a VCC Already Exists

2.2.3.2.3 Glare Resolution

Glare is the condition that occurs when two IWFs seize the same allocated channel position ("slot")of the same ATM VCC at about the same time such that the IWF-IWF signalling setup indications cross. For N-ISDN, this occurs when both sides generate a N-SETUP message at about the same time. For Channel Associated Signalling, glare is detected when the return offhook in the wink lasts beyond 350 ms. The IWF that had initiated the establishment of the ATM VCC (for the 64 kbit/s channels) controls all the channel positions of the VCC. When glare is detected by an IWF, the following apply:

- The controlling IWF should ignore the incoming narrowband call from the other IWF

- The non controlling side IWF should back out by giving priority to the incoming call fromn the other IWF and by retrying the outgoing call on another channel. If no other channel is available, the non-controlling IFW should clear the call.

2.2.3.3 ATM Signalling

ATM signalling is used between the IWF and the ATM network to set up:

- SVCs for IWF-IWF signalling (for the case of N-ISDN signalling only)
- SVCs for the 64 kbit/s channels across the ATM network.

The call/connection control procedures of UNI 3.1 apply. The following sections detail the content of the setup message. ATM signalling for the IWFs places no explicit constraints on other signalling messages.

Addresses and Identifiers for Switched Virtual Channels (SVCs)

All SVCs are point-to-point. As with all SVCs, the endpoints must be identified during call setup with an ATM address which may be of any of the three formats identified in Section 5.1.3 of the UNI 3.1 Specification, that is, DCC, ICD, or E.164 format. Additional identifiers in the Broadband Low Layer Information (B-LLI) information element (IE) distinguish the particular type of SVC being set up.

SETUP Message Contents

Section 5.3.1.7 of af-uni-0010.002, UNI 3.1 Specification, lists the mandatory and optional information elements in the SETUP message. This specification specifies values of certain fields in the following mandatory and optional information elements:

1. ATM Adaptation Layer Parameters (optional)
2. ATM Traffic Descriptor (required)
3. Broadband Bearer Capability (required)
4. Broadband Low Layer Information (optional)
5. Quality of Service Parameter (required)

Annex C lists the contents of these information elements both for setup of the IWF-IWF signalling channel and setup of the SVC for 64 kbit/s channels. Note that in Annex C the fixed information element header fields and field identifiers have been omitted from this specification. These must be included in the appropriate place in the information elements.

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

2.2.3.4 Handling of Error Conditions

2.2.3.4.1 VCC Fault on the VCC Used for IWF-IWF Signalling

Whenever an IWF (or "Q.931" entity in an IWF) is notified that a VCC used for signalling declares VC-AIS or VC-RDI state, the following procedures apply:

- Any calls associated with the IWF-to-IWF signalling VCC and not in the Active state shall be cleared internally. Cause #41 "temporary failure" may be indicated.

- For any call associated with the IWF-to-IWF signalling VCC and in the Active state, a timer T309 shall be started. If timer T309 is already running when the VCC declares VC-AIS or VC-RDI state, the IWF shall stop timer T309 and clear the call internally.

When VC-AIS or VC-RDI state is released, the IWF shalll stop timer T309 and either:

- the IWF shall send a STATUS message with cause #31 "normal, unspecified" to report the current state to the peer IWF; or

- the IWF shall perform the status enquiry procedure according to subclause 5.8.10 of ITU-T Q.931 to verify the call state of the peer IWF. (Note: Q.931 and Q.SIG as specified by ISO/IEC 11572 use the same status enquiry procedure.)

If timer T309 expires prior to the release of VC-AIS or VC-RDI state, the IWF shall clear the mapping of the call to its associated voiceband VCC, release the call reference, and enter the Null state.

2.2.3.4.2 VCC Fault on a VCC Used for 64 kbit/s Channel(s)

Whenever an IWF is notified that a VCC used for 64 kbit/s channel(s) declares VC-AIS or VC-RDI state, the following procedures apply:

For CCS:

- For any call mapped to the VCC and in the disestablishment phase, no action shall be taken.

- For any call mapped to the VCC and not in the disestablishment phase, the IWF shall clear the call to its peer IWF with cause #31, "normal, unspecified", clear the mapping of the call to its associated voiceband VCC, release the call reference, and enter the Null state.

For Channel Associated Signalling:

- For any call mapped to the VCC and in the disconnect phase, no action shall be taken.

- For any call mapped to the VCC and not in the disconnect phase, the IWF shall clear the call toward the connected PBX with which the call is associated.

2.2.4 OAM

2.2.4.1 ATM OAM Messages to be Supported

For VCCs used for IWF-IWF signalling, the IWF shall support VC-AIS and VC-RDI defect indications, VCC continuity check, and VC loopback capability as defined in I.610. Support for VC performance management and VC system management defined in I.610 is for further study.

For VCCs used for 64 kbit/s channels, the IWF shall support VC-AIS and VC-RDI defect indications as defined in I.610. Support for other VCC (F5 flow) OAM functions defined in I.610 is for further study.

Support for VPC (F4 flow) OAM functions defined in I.610 is for further study.

2.2.4.2 OAM Signals Supported for Narrowband Trunks

The IWF shall support the DS1/E1 alarm detection and reporting functions of the interfaces between the narrowband network and the IWF defined in Section 2.2.1.2.

2.2.4.3 Mapping between OAM Signals and Messages at the Interconnecting Point

No mapping between OAM signals and messages in the IWF is specified.

2.2.5 ATM Adaptation Layer

For the transport of IWF-IWF signalling to support N-ISDN (out-of-band) signalling, AAL type 5 shall be used.

For the user plane, AAL1 shall be used with the cell coding method described in the following.

AAL1 as specified in ITU-T recommendation I.363.1 has the capability to delineate repetitive, fixed-size "blocks" of data, each block being an integral number of octets in size. This capability is used to carry multiple DS0 timeslots organized into blocks.

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

For a block size greater than one octet, AAL1 uses a pointer mechanism to indicate the start of a structure block. The pointer operation shall be as described in ITU-T Recommendation I.363.1 which requires the pointer to be inserted at the first opportunity in a cycle of eight cells, as delimited by the AAL1 header sequence number 0 through 7.

2.2.5.1 N-ISDN (out-of-band) Signalling

For the support of connections using N-ISDN (out-of-band) signalling, to encode multiple 64 kbit/s channels into the AAL1 SDT, a block is created by collecting N octets - one from each N number of 64 kbit/s channels - and grouping them in sequence. See Figure 2.2-10 for an example which shows the block structure for three 64 kbit/s channels. The block size for Nx64 channels is always N octets.

AAL1 Pointer →

Octet from the first timeslot in current frame
Octet from the second timeslot in current frame
Octet from the third timeslot in current frame
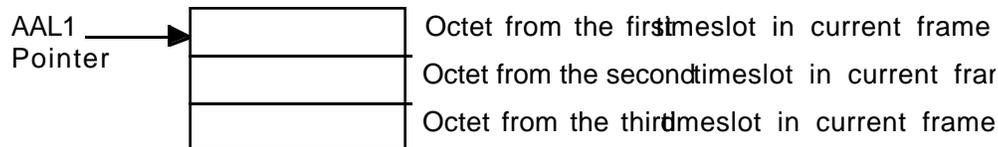
Figure 2.2-10: Example Structure Format for 3x64 kbit/s

For the Many-to-One Mapping, the Channel number in the Channel Id IE corresponds to the position number in the SDT frame, i.e., the first channel is in the first octet in the SDT frame, the second channel is in the second octet, etc.

2.2.5.2 Channel Associated Signalling

For the support of connections using Channel Associated Signalling, the AAL1 block structure specified in Section 2.3.1.2 of af-vtoa-0078.000 shall be used; however, the limit of 24 or 31 channels for DS1 and E1 based systems, respectively, shall not apply. The number of channels per VCC is limited to 128.

Speech information and DTMF tones are carried by the payload portion of the AAL1 block. The Channel Associated Signalling bits are carried by the signalling portion of the AAL1 block.

2.2.6 Timing

All Narrowband 64 kbit/s channels are carried in AAL1 ATM cells using the synchronous mode of operation. In this mode, the constant bit rate sources are frequency locked to the network clock. Thus, the Interworking Units must be supplied with a clock traceable to a Primary Reference Source (PRS).

The basic clock required at the IWF is an 8 kHz clock. This is used for aligning the octets from the 64 kbit/s channels for packing into ATM cells, and for the inverse operation on received ATM cells.

The technique used for the provision of the PRS at IWFs is beyond the scope of this specification.

2.2.7 Management

An ATM Trunking Interworking Function (TRK IWF) provides the necessary adaptation function to connect Narrowband equipment with ATM equipment. Thus, the TRK IWF has a Narrowband side and an ATM side. In general, the Narrowband side is implemented in equipment that supports one or more CBR interfaces (typically DS1 and/or E1 ports). Likewise, the ATM side is supported by ATM ports. The ATM Forum's specification atm-nm-0020.000 specifies the management of the ATM equipment (the "ATM side") by providing a MIB for ATM Layer resources. Existing specifications do not address management aspects pertaining to the Service Interface and interworking entities:

1. The DS1, E1, JT2, DS3 or E3 Service Interfaces,
2. Narrowband switching function (Call control),
3. The AAL1 entities, and
4. SAAL entities.

Annex A provides the Management Information Base (MIB) for the ATM Trunking using AAL1. (To be added by addendum.)

2.3 One-to-One Mapping

For the support of N-ISDN (out-of-band) signalling, an ATM VCC is required between a pair of IWFs for the transport of IWF-IWF signalling. For the support of Channel Associated Signalling, the narrowband signalling information is transported with the same ATM VCC that carries voice information.

In either case, for the user plane, an ATM VCC is required for each 64 kbit/s channel. This VCC can either be set-up and released individually for each voice call or it can be reused for a number of consecutive voice calls. The number of such VCCs between a pair of IWFs is limited by the connection identifier used in the B-LLI Information Element, which can identify up to 8192 different connections for each direction.

The network configuration is described by Figure 2.3-1.
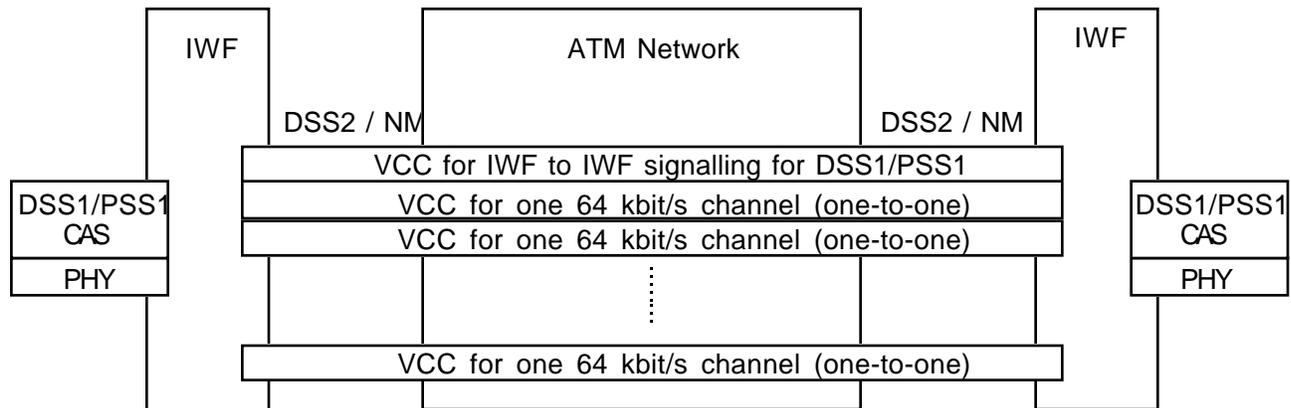
Figure 2.3-1: One-to-one Mapping Configuration

Since the individual 64 kbit/s calls are mapped on to separate ATM VCCs, the IWF does not require a switching functionality.

The cell assembly delay is 5.875 msec.

This alternative is most appropriate for small trunk groups that sometimes even may be empty. It also offers the full bandwidth efficiency for larger trunk groups.

For One-to-One Mapping using N-ISDN (out-of-band) signalling, the Channel Id IE in the IWF-IWF signalling shall be coded as shown in Annex C.

2.4 Many-to-One Mapping

For the support of N-ISDN (out-of-band) signalling, an ATM VCC is required between a pair of IWFs for the transport of IWF-IWF signalling.

For the support of Channel Associated Signalling, the narrowband signalling information is transported on the same ATM VCC that carries voice information.

For either case, for the user plane, an ATM VCC is required to carry multiple 64 kbit/s channels. The network configuration is described in Figure 2.4-1.
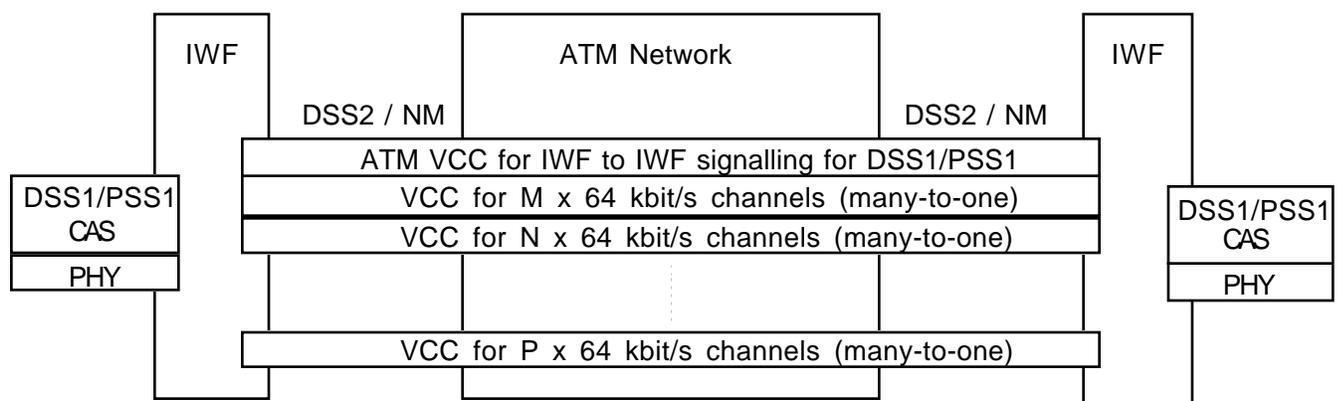
Figure 2.4-1: Many-to-One Mapping Configuration

The IWF establishes an appropriate number of Many-to-One mapping connections between two IWFs. The establishment can be done through ATM signalling, as the figure indicates, or through management. The number of

VCCs between a pair of IWFs to carry the 64 kbit/s channels is limited by the connection identifier used in the B-LLI Information Element, which can identify up to 8192 different connections for each direction. The number of 64 kbit/s channels within each VCC is limited to 128.

This alternative is best for large trunks with a predictable traffic pattern, e.g., time of day traffic pattern. The IWF adjusts the trunk capacity by activating and deactivating (establishing and releasing) ATM links of multiple 64 kbit/s capacity to meet the need. The capacity not required by the N-ISDN may be released in the B-ISDN. When sufficient surplus broadband capacity exists in the network, the IWF identifies a VCC to be released to reduce surplus capacity. It then blocks access to all unused 64 kbit/s circuits on this VCC. When all 64 kbit/s circuits on this VCC are blocked (upon the release of the last 64 kbit/s call on the VCC), the ATM VCC can be released through signalling or through management. The mechanism for blocking access to unused 64 kbit/s circuits on a particular VCC between two IWFs is for further study. See Figure 2.4-2.
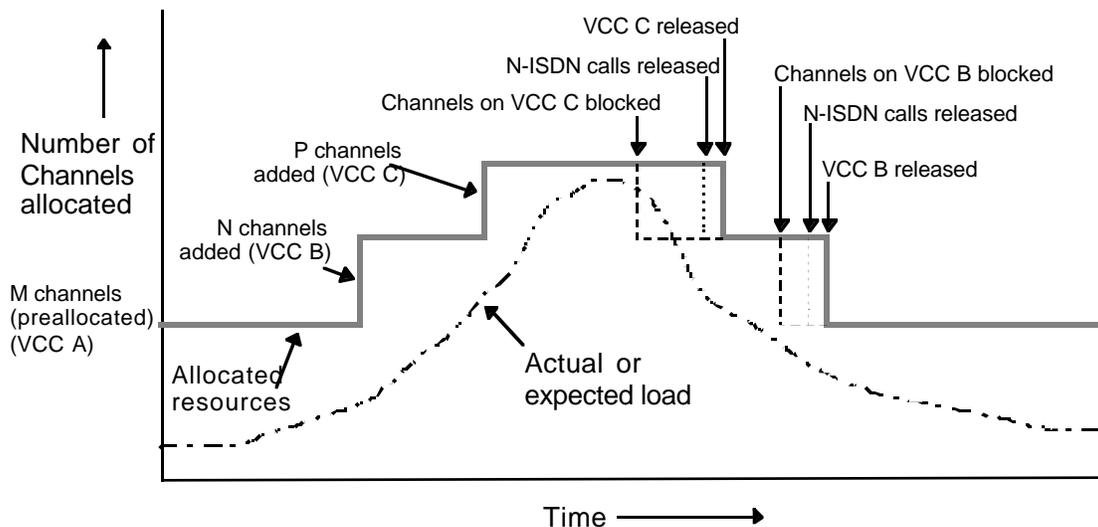
Figure 2.4-2: Capacity Allocation

For Many-to-One Mapping, the Channel Id IE in the IWF-IWF signalling shall be coded as shown in Annex C.

ANNEX A: Management Information Base for VTOA Trunking using AAL1

The Management Information Base (MIBs) will be added by addendum following additional study by the ATM Forum.

ANNEX B: Acronyms

AAL   ATM Adaptation Layer

CAS   Channel Associated Signalling

DSS1   Digital Subscriber Signalling System Number 1 (Narrow-Band ISDN)

DSS2   Digital Subscriber Signalling System Number 2 (Broadband-ISDN)

DTMF   Dual Tone Multifrequency

IWF   Interworking Function

PRS   Primary Reference Source

SDT   Structured Data Transfer

VCC   Virtual Channel Connection

VCCI   Virtual Channel Connection Identifier

ANNEX C: Information Element Contents

This Annex describes the contents of the information elements of the SETUP messages between the IWF and the ATM network for the establishment of the VCCs for the IWF-IWF signalling and for the 64 kbit/s channels. These information elements are as defined in af-uni-0010.002, UNI 3.1.

C.1   Signalling to Establish VCC for IWF-IWF Signalling

The following information elements are used in the SETUP to establish the VCC for IWF-IWF signalling.

C.1.1 ATM Adaptation Layer Parameters

The format of the ATM Adaptation Layer Parameters Information Element shall be as shown in Section 5.4.5.5 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.1.1.

Field	Value
AAL Type (octet 5)	'0000 0101' AAL type 5
SSCS Type (octet 8.1)	'0000 0011' ITU-T Q.2110 (SSCOP assured operation) with UNI SSCF Q.2130 (value to be confirmed by ITU-T SG11 for inclusion in Q.2931)

Table C.1.1: AAL Parameters IE Field Values
for Establishment of IWF-IWF Signalling ATM VCCs

C.1 2 ATM Traffic Descriptors

The format of the ATM Traffic Descriptor Information Element shall be as shown in Section 5.4.5.6 of af-uni-0010.002 and the forward and backward peak cell rates shall be included. The values of the rates are application specific.

C.1.3 Broadband Bearer Capability

The format of the Broadband Bearer Capability Information Element shall be as shown in Section 5.4.5.7 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.1.3.

Field	Value
Bearer Class (octet 5)	'10000' BCOB-X
Traffic class (octet 5a)	'010' Variable bit rate
Timing requirements (octet 5a)	'10' End-to-end timing not required
User plane connection configuration (octet 6)	'00' Point-to-point

Table C.1.3: Broadband Bearer Capability IE Field Values
for Establishment of IWF-IWF Signalling ATM VCCs

C.1.4 Broadband Low layer Information Element

The format of the Broadband Low Layer Information Information Element shall be as shown in Section 5.4.5.9 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.1.4.

Field	Value
User Information Layer 3 Protocol (octet 7)	'01011' ISO/IEC TR 9577
ISO/IEC TR 9577 Initial Protocol Identifier (IPI) (octet 7a, 7b)	'1000 000' IEEE 802.1 SNAP (octet 7a = 0100 0000 octet 7b = 1000 0000)
Organizational Unit Identifier (OUI) (octets 8.1-8.3)	x'00 A0 3E' ATM Forum OUI
Protocol Identifier (PID) (octets 8.4-8.5)	x'00 0C' VTOA ATM trunking

Table C.1.4: Broadband Low Layer Information IE Field Values
for Establishment of IWF-IWF Signalling ATM VCCs

C.1.5 Quality of Service Parameters

The format of the Quality of Service Parametes Information Element shall be as shown in Section 5.4.5.18 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.1.5a when operating over networks that are compliant with the ATM Forum specifications and as shown in Table C.1.5b when operating over networks that are ITU conformant but not ATM Forum compliant.

Field	Value
Coding standard (octet 2)	'11' Standard defined for the network
QoS Class Forward (octet 5)	'0000 0011' QoS Class 3 - Connection oriented protocol
QoS Class Backward (octet 6)	'0000 0011' QoS Class 3 - Connection oriented protocol

Table C.1.5a: QoS Parameter IE Field Values for IWF-IWF Signalling ATM VCCs
(ATM Forum Compliant Network)

.Field	Value
Coding standard (octet 2)	'00' ITU standard
QoS Class Forward (octet 5)	'0000 0000' QoS Class 0 - Unspecified QoS class
QoS Class Backward (octet 6)	'0000 0000' QoS Class 0 - Unspecified QoS class

Table C.1.5b: QoS Parameter IE Field Values for IWF-IWF Signalling ATM VCCs
(Non-ATM Forum Compliant Network)

C.2   Signalling to Establish VCC for 64 kbit/s Channels

The following information elements are used to establish the SVC for the 64 kbit/s channels for ATM trunking.

C.2.1 ATM Adaptation Layer Parameters

The format of the ATM Adaptation Layer Parameters Information Element shall be as shown in Section 5.4.5.5 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.2.1.

If the called party does not accept these parameters, it should release the call with cause 93 (AAL Parameters not Supported).

Field	Value
AAL Type (octet 5)	'0000 0001' AAL Type 1
Subtype (octet 6.1)	'0000 0010' Circuit Transport
CBR rate (octet 7.1)	'0000 0001' 64 kbit/s '0100 0000' Nx64 kbit/s, N>1
Multiplier (Octets 8.1 and 8.2)	The value 'N' for Nx64 kbit/s. Omit field for 64 kbit/s case.
Structured Data Transfer Blocksize (Octets 11.1 and 11.2)	Size in octets
Partially filled cells method (octet 12.1)	K, the number of AAL-user octets filled per cell. Omit field if partial cell fill is not used

Table C.2.1: AAL Parameters IE Field Values
for Establishment of Nx64 ATM Trunking SVCs

C.2.2 ATM Traffic Descriptor

The format of the ATM Traffic Descriptor Information Element shall be as shown in Section 5.4.5.6 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.2.2.

Field	Value
Forward peak cell rate CLP=0+1 (Octets 7.1, 7.2, 7.3)	Must be provided
Backward peak cell rate CLP=0+1 (Octets 8.1, 8.2, 8.3)	Must be provided
Best effort indicator (Octet 17)	Must be omitted
Traffic management options identifier (Octet 18)	Must be omitted

Note: It is recommend that other fields shown in Section 5.4.5.6 of af-uni-0010.002 be omitted.

Table C.2.2 ATM Traffic Descriptors IE Field Values
for Establishment of ATM Trunking SVCs

C.2.3 Broadband Bearer Capability Information Element

The format of the Broadband Bearer Capability Information Element shall be as shown in Section 5.4.5.7 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.2.3.

Field	Value
Bearer Class (octet 5)	'10000' BCOB-X
Traffic Type (octet 5a)	'001' Constant bit rate
Timing Requirements (octet 5a)	'01' End-to-end timing required
Susceptibility to clipping (octet 6)	'00' Not susceptible to clipping
User Plane Connection Configuration (octet 6)	'00' Point-to-point

Table C.2.3: Broadband Bearer Capability IE Field Values
for Establishment of ATM Trunking SVCs

C.2.4 Broadband Low Layer Information

The format of the Broadband Low Layer Information Information Element shall be as shown in Section 5.4.5.9 of af-uni-0010.002 with the addition of octets 5a and 5b as indicated by the use of the extension bit of octet 5 being "0". The contents shall be encoded as shown in Table C.2.4.

This information element identifies that the signalling entities are ATM Forum ATM Trunking AAL User Entities as specified in this ATM Trunking-Interoperability Specification. It also identifies the specific service and coding approach for Nx64 kbit/s service.

Field	Value
User Information Layer 1 Protocol (octet 5)	'00001' VTOA Trunking Interface Identifier
User Information Layer 1 Protocol (octet 5a)	'1Fxxxxxx' where: F(lag)=0: message is sent from side that originates the VCCI F(lag)=1: message is sent to side that originates the VCCI 'xxxxxx' the most significant bits of the VCCI
User Information Layer 1 Protocol (octet 5b)	'xxxxxxx' the least significant bits of the VCCI (Note 1)
User Information Layer 3 Protocol (octet 7)	'01011' ISO/IEC TR 9577 (Protocol Identification in the Network Layer)
ISO/IEC TR 9577 Initial Protocol Identifier (IPI) (octet 7a, 7b)	'1000 000' IEEE 802.1 SNAP (octet 7a = 0100 0000 octet 7b = 1000 0000)
SNAP ID (octet 8)	"00"

Organizational Unit Identifier (OUI) (octets 8.1-8.3)	x'00 A0 3E' ATM Forum OUI
Protocol Identifier (PID) (octets 8.4-8.5)	x'00 0D' E1 w/CAS x'00 0E' DS1 SF w/CAS x'00 0F' DS1 ESF w/CAS x'00 10' CCS (N-ISDN)

Note 1: The number of bits used for the VCCI is 14, which includes the flag.

Table C.2.4: Broadband Low Layer Information IE Field Values
for Establisment of ATM Trunking SVCs

C.2.5 Quality of Service Parameter

The format of the Quality of Service Parametes Information Element shall be as shown in Section 5.4.5.18 of af-uni-0010.002 and the contents shall be encoded as shown in Table C.2.5a when operating over networks that are compliant with the ATM Forum specifications and as shown in Table C.2.5b when operating over networks that are ITU conformant but not ATM Forum compliant.

Field	Value
Coding Standard (octet 2)	'11' Standard defined for the network
QoS Class Forward (octet 5)	'0000 0001' QoS Class 1
QoS Class Backward (octet 6)	'0000 0001' QoS Class 1

Table C.2.5a: QoS Parameter IE Field Values for ATM Trunking SVCs
(ATM Forum Compliant Network)

Field	Value
Coding Standard (octet 2)	'00' ITU standard
QoS Class Forward (octet 5)	'0000 0000' QoS Class 0 - Unspecified QoS Class
QoS Class Backward (octet 6)	'0000 0000' QoS Class 0 - Unspecified QoS Class

Table C.2.5b: QoS Parameter IE Field Values for ATM Trunking SVCs
(Non-ATM Forum Compliant Network)

C.3   IWF-IWF Signalling

When DSS1 or PSS1 signalling is being used, the Channel ID information element as defined in Q.931, Section 4.5.13 is used in the IWF-IWF signalling VCC to identify a channel for a new call. Since the channel negotiation procedures do not apply, octet 3 shall be coded to indicate "Exclusive".

C.3.1 Channel Id Information Element for One-to-one Mapping

For one-to-one mapping, the contents of the Channel ID IE shall be as listed in Table C.3.1.

Field	Value
(octet 3)	'11101001'
Interface ID (octet 3.1)	VCCI from B-LLI IE (see Table C.2.4 octet 5a) (ext bit=0 + flag + upper 6 bits)
Interface ID (octet 3.1 +)	VCCI from B-LLI IE (see Table C.2.4 octet 5b) (ext bit=1 + lower 7 bits)
Coding Standard (octet 3.2)	'11' (standard defined for the network)
Channel Type (octet 3.2)	'1011' ATM VCC

Table C.3.1: Channel Id IE Field Values for One-to-one Mapping

C.3.2 Channel Id Information Element for Many-to-oneMapping

For many-to-one mapping, the format of the Channel Number field listed in Table C.3.2 is in accordance with the conventions defined in Q.931. The first channel of a VCC is numbered "0" for both DS1 and E1 based systems, with the extension bit as defined in Q.931 (always "1"). The use of the "slot map" format in octet 3.3 is not supported.

Field	Value
(octet 3)	'11101001'
Interface ID (octet 3.1)	VCCI from B-LLI IE (see Table C.2.4 octet 5a) (ext bit=0 + flag + upper 6 bits)
Interface ID octet 3.1 +)	VCCI from B-LLI IE (see Table C.2.4 octet 5b) (ext bit=1 + lower 7 bits)
Coding Standard (octet 3.2)	'11 standard defined for the network
Channel Type (octet 3.2)	'1011' ATM VCC
Channel Number (octet 3.3)	Ext bit="1" + 7 bit binary value to identify the position in the AAL1 structure

Table C.3.2: Channel Id IE Field Values for Many-to-one Mapping

ANNEX D: (Informative) Timing Related to ATM Trunking using AAL1 for Narrowband Services

Timing is an essential function when supporting voice and especially when interworking with synchronous legacy networks as in the case of voice trunking.

D.1   Timing requirement

The requirement depends very much on how a legacy network like a PBX is connected to its surrounding. A connection over ATM can accept an "elastic" timing scheme allowing relatively large accumulated phase error between interconnected entities. The elasticity over ATM is much larger than what the existing PSTN can accept. All entities that are interconnected using existing transmission equipment are therefore also bound by the requirement of these transmission equipment. From the service aspect however, the elasticity of ATM can be generally accepted.

The following scenarios are considered.

D.1.1 One IWF Supporting One and Only One Legacy Network

In this case, it is assumed that the legacy network is without parallel interfaces to the PSTN beside the one offered by the IWF over ATM as shown in Figure D.1.
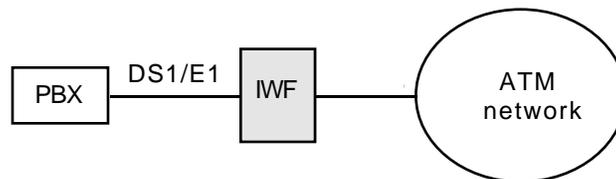

Figure D.1: Single IWF and PBX

Through the ATM network, the IWF with its connected legacy network (PBX) is separated from the PSTN allowing an elastic timing.

D.1.2 One IWF Supporting More Than One Legacy Network

This is a case of a group of legacy networks without parallel interfaces to the PSTN other than the one offered by the IWF and ATM as shown in Figure D.2.
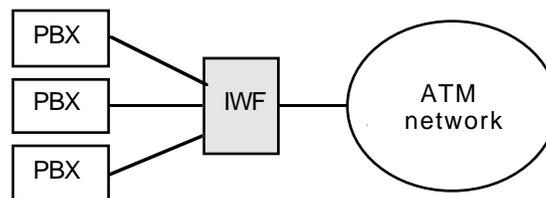

Figure D.2: Single IWF Supporting a Number of PBXs

Through the ATM network, the group of legacy networks (PBXs) is separated from the PSTN allowing an elastic timing of the group. Internally within the group however, the elasticity can not be accepted unless the IWF is using an internal switching fabric based on ATM which only is possible in the one-to-one mapping case.

D.1.3 IWF Supporting Legacy Networks with Parallel Connection to a PSTN

The legacy network may have parallel interfaces to PSTN as shown in Figure D.3.
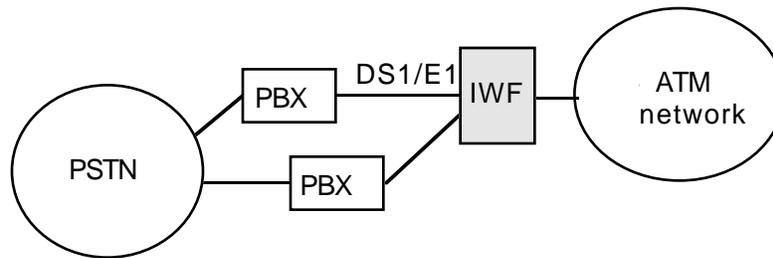
Figure D.3: Single IWF and PBX

In this scenario the timing requirements are defined by the PSTN and the timing elasticity offered by ATM can not be utilized when synchronizing the IWF and connected entities.

D.1.4 IWF Supporting an Interface to PSTN

The IWF is connected to the PSTN as shown in Figure D.4.
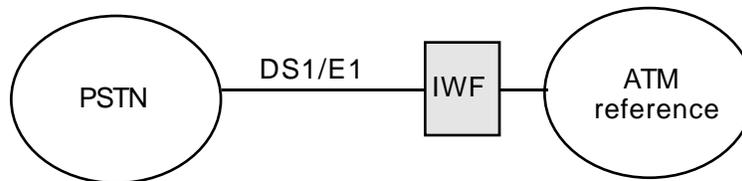
Figure D.4: Single IWF and PSTN

In this case, the timing requirements are defined by the PSTN.

D.2   Timing Requirements

The following requirement is limited to end system at customer premises. Core systems have to meet the full requirement for existing PSTN. The requirement does only apply to the narrowband side of the IWF.

D.2.1 Elastic Timing

When elastic timing applies, it can reduce the timing requirement for the IWF and the connected legacy network. See the scenarios in Sections D.1.1 and D.1.2.

- It is suggested that, for timing elasticity, an accumulated phase error of 2 msec should be allowed, which matches the maximum CDV. This will, however, increase the delay correspondingly.

- The momentary frequency requirement will typically be defined by the transmission link between the IWF and the legacy network which typically means on the order of 50 ppm. The service requirement from voice and video is even more relaxed (e.g., comparing with the Hi-Fi standard of 100 ppm).

- The bit error rate is defined by the existing PSTN (on the order of 10^{-5} or better).

- The slip rate is defined by the existing PSTN (one slip every third day?).

D.2.2 Non Elastic Timing

This corresponds to the requirement for the existing PSTN where the elasticity is limited by existing TDM transmission (with small buffers). For end systems like PBXs, the difference is only in the elasticity; the other requirements are identical.

- Accumulated phase error has to be less then 13 usec.

- The momentary frequency requirement will typically be defined by the transmission link between the IWF and the legacy network which typically means in the order of 50 ppm. The service requirement from voice and video is even more relaxed (e.g., comparing with the Hi-Fi standard of 100 ppm).

- The bit error rate is defined by the existing PSTN (on the order of 10^{-5} or better).

- The slip rate is defined by existing PSTN (one slip every third day?).

D.3   Timing Options

The following options exist for synchronizing the IWF.

The IWF is generally required to distribute timing to connected legacy end systems.

The timing of the IWF can be as described by Figure D.5 which indicates three possible clock references and two locations where slip may occur.
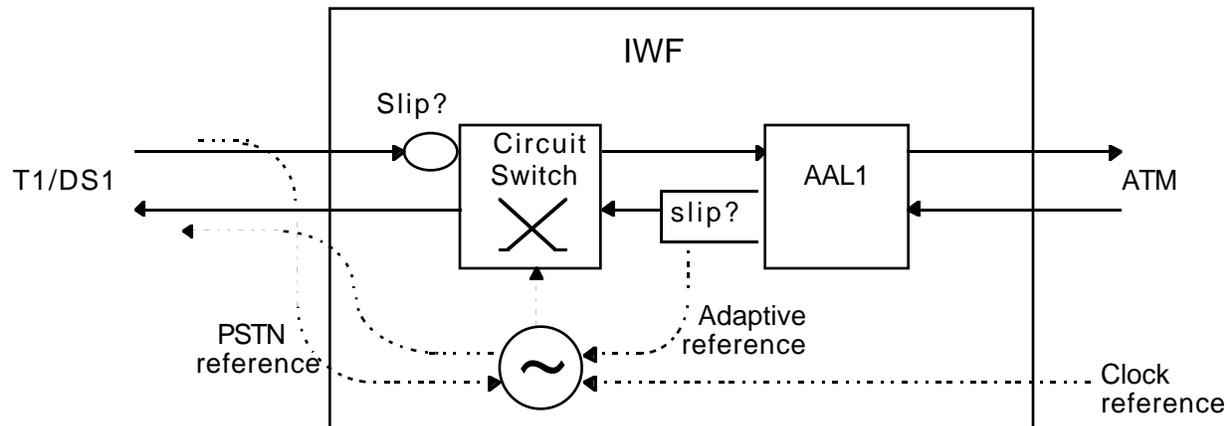

Figure D.5: Clocking of the IWF

D 3.1 The Use of a Clock Reference

In other cases, the clock reference may be derived from the physical layer of the ATM network or a completely separate link such as GPS. The clock reference has to be PRC traceable in order to meet the PSTN requirement.

D.3.1.1 Plesiochronous Mode

The clock reference is directly used by the IWF for internal timing and for clock distribution.

A slip strategy has to be considered for the IWF, considering that connected entities are not using the same clock reference.

Whenever a clock reference is available, this is the preferred option which completely meets the PSTN service requirements.

D.3.1.2 SRTS

When a clock reference is available, the SRTS mechanism can be used to retrieve timing from a remote IWF and to use this for clock distribution. This does require that the ATM connection used to carry timing is permanent.

The SRTS mechanism is, however, not needed in order to meet the PSTN requirement and therefore not recommended.

D.3.2 The Use of PSTN as a Reference

An IWF connected to a PSTN shall preferably use the clock derived from the PSTN.

Slip handling, when required, will thereby be moved from the narrowband side of the IWF to the broadband side where there will likely be the larger buffer. Slip of more than just single octets may be considered in order to reduce the slip rate.

D.3.3 The Use of a Free Running Clock

If the requirement on slip rate is relaxed, the use of free running clock in the IWF might be realistic.

As a reference, it should be noted that 125 usec slips every 10 seconds requires 10^{-5} in clock accuracy and that this may be acceptable for speech but not for PSTN services in general.

D.3.4 The Use of Adaptive Timing

The adaptive mechanism is only available when the IWF (using ATM to connect PSTN) represents the only connection to PSTN and thereby allows for elastic timing. See the scenarios in D.1.1 and D.1.2. The adaptive mechanism does not work unless the acceptable elasticity is on the same order as the CDV. The average delay over an ATM network will be load dependent (within the limit of CDV) and it is therefore unavoidable that regenerated timing will follow the change in average delay.

The adaptive mechanism also requires a permanent (always active) ATM connection to a clock source in order to meet the stated accuracy requirement above.

The main advantage with adaptive timing is that it can meet the PSTN service related requirement (e.g., slip) with the given assumptions.

Adaptive timing is suggested when a separate PRC traceable clock reference is not available.

# ANNEX E: (Informative) Example of the Hybrid Configuration

In order to support dynamic allocation of bandwidth for flexible situations, the one-to-one mapping and the many-to-one mapping may be combined into a "hybrid" solution. The hybrid solution offers the possibility to combine pre-allocated resources, using many-to-one mapping, with on-demand controlled resources, using both many-to-one and one-to-one mapping.

The following is an example of the hybrid solution.

The pre-allocated resources between a pair of IWFs consists of a VCC for many-to-one mapping to carry "M" channels as described in Section 2.4 (PVC or SVC).

At some point, determined either by the actual traffic or on a scheduled basis, a second VCC to carry "N" channels is added, utilizing the same signalling VCC (PVC or SVC).

When the narrowband users' demand exceeds what can be handled by these two VCCs, the one-to-one mapping as described in Section 2.3 is used to add resources for one additional channel at a time (SVC).
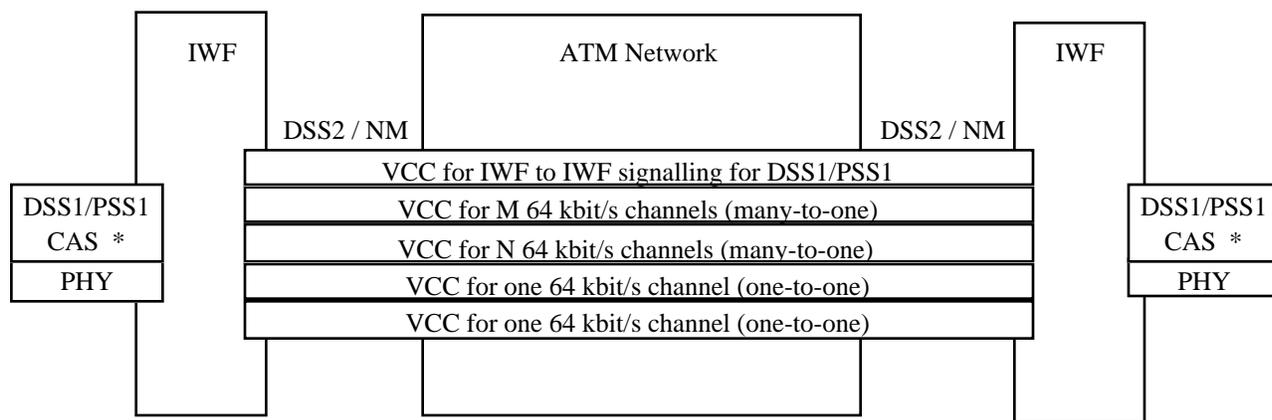
* Signalling the same on both ends.

Figure E.1: The Hybrid Configuration