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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Network Aspects (NA).

The present document describes the requirements for the transport of 64 kbit/s narrowband channels between narrowband public networks across a public Asynchronous Transfer Mode (ATM) based Broadband Integrated Services Digital Network (B-ISDN).

Introduction

With the introduction of ATM backbone infrastructures into public telecommunications networks, the provision of a range of broadband services, e.g. high speed LAN interconnect and virtual private networking, is being enabled. These broadband services are targeted initially at the business user, but with the proliferation of broadband terminals and the accompanying economies of scale they will ultimately become available to the residential user as well. Nevertheless, it is well recognized that for many years to come, the present generation of 64 kbit/s narrowband public networks will need to co-exist and interwork with the evolving B-ISDN.

The present document concentrates on the provision of one of the narrowband/broadband interworking requirements, namely ATM trunking for the support of 64 kbit/s narrowband channels. An ATM trunk is defined here as one or more ATM virtual connections that carries a number of 64 kbit/s narrowband channels and the associated narrowband signalling. No constraints are placed on the number N of narrowband channels transported in an ATM trunk, so that N may vary from 1 to some arbitrarily large number, depending on the application being served and the chosen trunking method.

A general objective for ATM trunking is the efficient use of B-ISDN resources in the support of 64 kbit/s narrowband channels. The use of ATM trunking in support of services employing, e.g. low bit rate coding and silence suppression techniques, in which the number of user channels supported may vary dynamically, is for further study.

Reference configuration

Figure 1 shows the reference configuration for ATM trunking of narrowband channels.

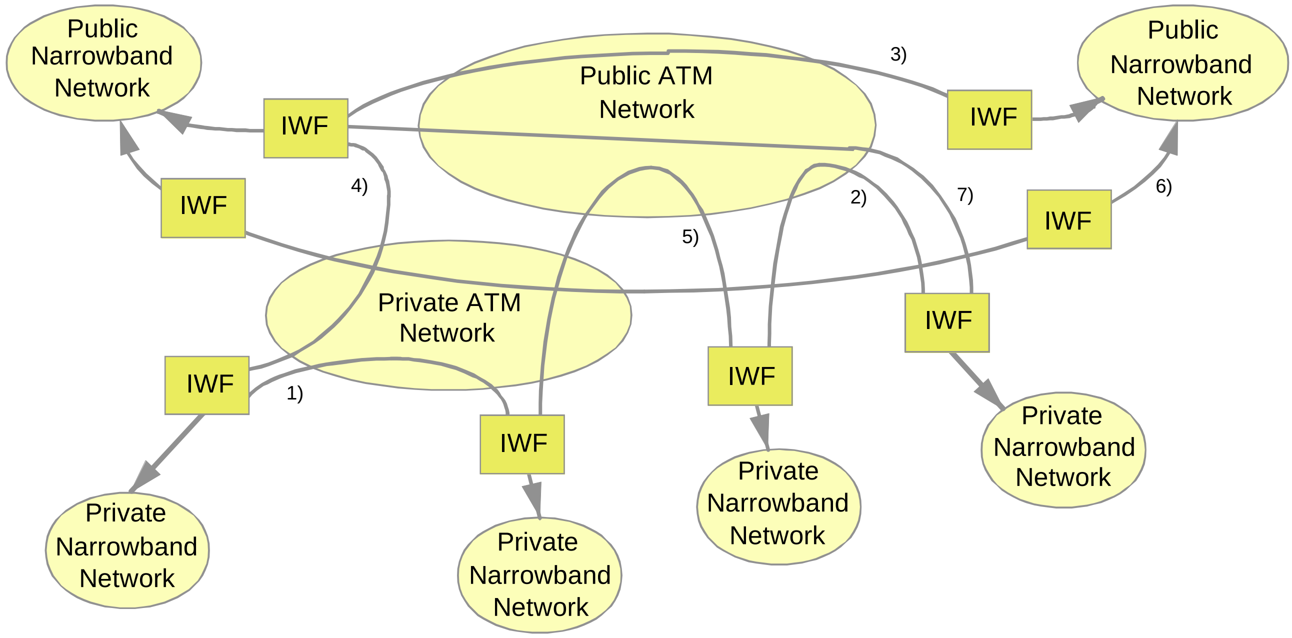

Figure 1: Reference Configuration for ATM Trunking

In the above reference configuration, 7 types of trunking services are represented:

1) ATM trunking between private narrowband networks across a private ATM network;

2) ATM trunking between private narrowband networks across a public ATM network;

3) ATM trunking between public narrowband networks across a public ATM network;

4) ATM trunking between private and public narrowband networks across a private ATM network;

5) ATM trunking between private narrowband networks across concatenated private and public ATM networks;

6) ATM trunking between public narrowband networks across a private ATM network;

7) ATM trunking between private and public narrowband networks across a public ATM network.

The ATM trunking service represented as type 3) in figure 1 is the focus of the present document; consideration of other service types is for further study.

1 Scope

The present document defines the requirements for ATM trunking, which may be used for the transport of 64 kbit/s narrowband channels across an ATM-based B-ISDN. These requirements include:

- the use of switched ATM virtual connections including interworking between N-ISUP and B-ISUP;
- the use of ATM virtual connections, both permanent and switched, including circuit emulation.

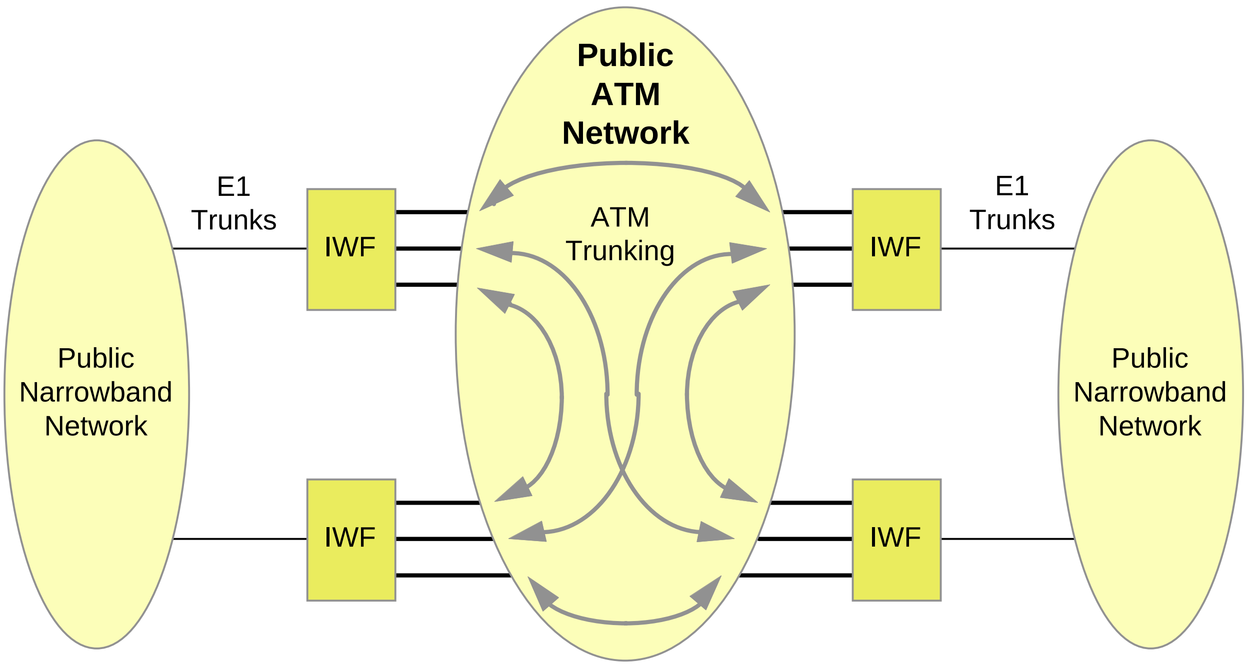

Figure 2: ATM Trunking Scenario

Figure 2, adapted from ITU-T Recommendation I.580 [1], illustrates the scope of the present document.

As shown in the figure, one or more public narrowband networks interfaces with a public broadband network by means of interworking functions (IWFs). ATM trunking is used for the transport of 64 kbit/s narrowband channels between the narrowband networks across the ATM network via the IWFs. In the present document, only "static" trunking is defined, in which the ATM trunk supports a fixed number of narrowband channels.

For reasons of clarity and simplicity, figure 2 shows only a restricted number of IWFs, although any number may be connected between the narrowband network(s) and the ATM network commensurate with the overall network architectural requirements and policy.

For a complete definition of ATM trunking requirements, the scope of the present document will include:

- definition of the functionality of the IWF between narrowband and broadband networks;
- description of the relationships between the functions comprising the IWF;
- definition and description of any relevant control plane aspects of ATM trunking;
- definition and description of any relevant management plane aspects of ATM trunking;
- definition of any timing/synchronization requirements specific to ATM trunking.

The above scope is applied to each of the multiple ATM trunking methods documented in the present document. The advantages and drawbacks associated with each of the methods is also discussed in order to give readers an appreciation of the differences in performance that can be expected.

General interworking requirements

A number of general requirements in respect of interworking between narrowband and broadband networks applies, including the following.

- No retrospective requirements shall be placed on existing networks by the ATM trunking mechanism employed.
- Voice and voiceband data (not precluding X.25 and Frame Relay over ISDN) shall be carried transparently in the user plane of the ATM infrastructure.
- Any routeing, switching or signalling requirements of the individual trunking mechanisms will be explicitly defined.

Traffic characterization

ATM trunking can be supported by the Deterministic Bit Rate (DBR) Transfer capability, as defined in draft ITU-T Recommendation I.371 [3]. If 64 kbit/s PCM samples are directly encoded into ATM cells with no low rate encoding or silence suppression, then a Constant Bit Rate (CBR) connection is used. If low rate encoding or silence suppression is used, then an on-demand-bandwidth connection is required; this type of capability is for further study.

2 References

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case the latest version applies.

A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] ITU-T Recommendation I.580: "General arrangement for interworking between B-ISDN and 64 kbit/s ISDN".

[2] ITU-T Recommendation I.363.1: "B-ISDN ATM Adaptation Layer (AAL) Specification, Type 1 and 2".

[3] ITU-T Recommendation I.371: "Traffic Control and Congestion Control in B-ISDN".

[4] ITU-T Recommendation Q.2963: "B-ISDN DSS 2 Connection modification".

[5] ITU-T Recommendation G.711: "Pulse Code Modulation (PCM) of voice frequencies".

[6] ITU-T Recommendation I.751: "Asynchronous Transfer Mode Management of the Network Element View".

[7] TCR-TR 044: "Vocabulary for B-ISDN".

[8] ITU-T Recommendation I.610: "B-ISDN operation and maintenance principles and functions".

[9] ETR 263: "Broadband Integrated Services Digital Network (B-ISDN); Specific interworking functionalities with B-ISDN".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the definitions given in ETSI TCR-TR 044 [7] apply.

3.2 Symbols and abbreviations

For the purposes of the present document, the following symbols and abbreviations apply:

AAL	ATM Adaptation Layer
AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
B-ISDN	Broadband Integrated Services Digital Network
B-ISUP	Broadband Integrated Services User Part
CBR	Constant Bit Rate
CDV	Cell Delay Variation
CES	Circuit Emulation Service
DBR	Deterministic Bit Rate
GPS	Global Positioning by Satellite
ID	Identifier
IWF	Interworking Function
LAN	Local Area Network
MIB	Management Information Base
MTP	Message Transfer Part
N-ISDN	Narrowband Integrated Services Digital Network
N-ISUP	Narrowband Integrated Services User Part
OAM	Operation And Maintenance
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PDH	Plesiochronous Digital Hierarchy
PHY	Physical Layer
PRS	Primary Reference Source
PSTN	Public Service Telephone Network
PVC	Permanent Virtual Connection
QoS	Quality of Service
RDI	Remote Defect Indication
SAAL	Signalling ATM Adaptation Layer
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical Network
SRTS	Synchronous Real Time Stamp
SVC	Switched Virtual Connection
TDM	Time Division Multiplex
TMN	Telecommunications Management Network
UNI	User Network Interface
VC	Virtual Channel
VCC	Virtual Channel Connection
VTG	Virtual Trunk Group

4 ATM trunking mechanisms

This clause discusses the ATM trunking mechanisms identified for inclusion in the present document for the transport of 64 kbit/s narrowband channels across a public B-ISDN.

Currently, three types of ATM trunking have been identified and these are:

- switched trunking;
- CES trunking;
- trunking based on service interworking.

For switched trunking and CES trunking, which are all variants of network interworking, either B-ISDN signalling or TMN procedures are used in order to set up the ATM connection(s) that carry the narrowband traffic channels, depending on whether the connections are PVCs or SVCs, respectively.

For switched trunking, three mechanisms are available as identified in figure 3.

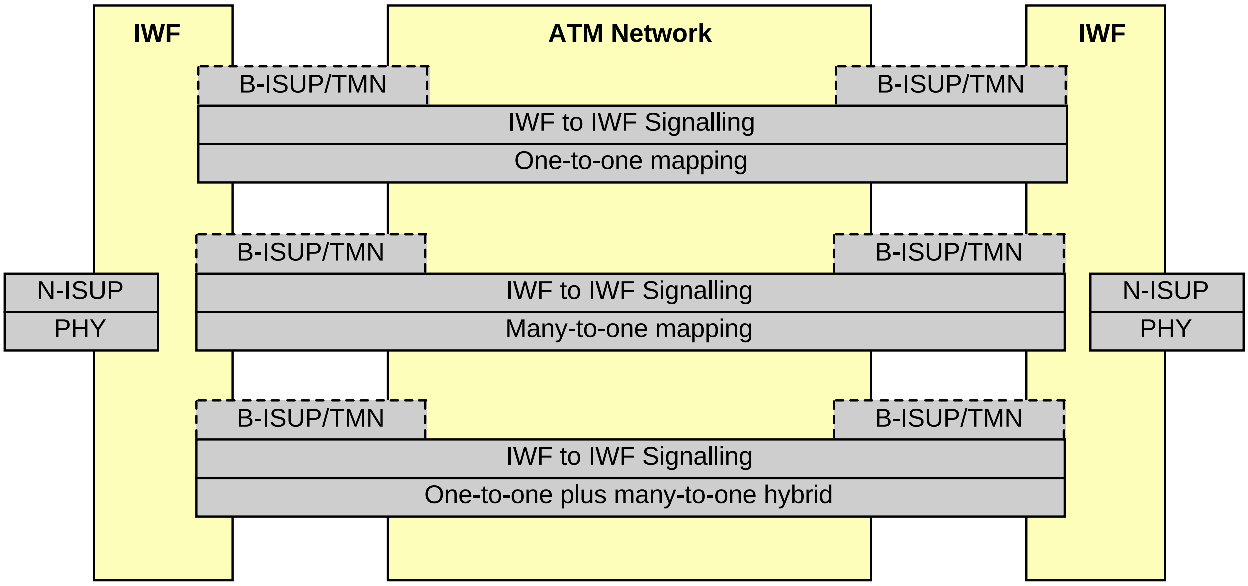

Figure 3: ATM Trunking Mechanisms

The three switched trunking variants are described in clause 3. Note that each variant uses a single ATM connection carrying an AAL5 cell stream for the transparent transport between IWFs of the signalling associated with the narrowband calls.

- Subclause 3.2 describes the one-to-one mapping approach, in which a single 64 kbit/s narrowband channel is transported across a B-ISDN in a single ATM VC. This mechanism avoids the N-ISUP/B-ISUP signalling translation that is necessary for Service Interworking.
- Subclause 3.3 describes a many-to-one approach based on the mapping of multiple 64 kbit/s narrowband channels in a single ATM VC.
- Subclause 3.4 describes a hybrid approach based on one-to one mapping plus many-to-one mapping.

Clause 4 describes trunking based on the Circuit Emulation Service (CES), in which a fixed number of 64 kbit/s narrowband channels is mapped in a fixed manner into a single ATM VC.

Clause 5 then describes a mechanism based on service interworking, in which a single 64 kbit/s narrowband channel is transported across an ATM network in a single, switched ATM VC. Service interworking requires the translation of the N-ISUP signalling associated with the narrowband calls into B-ISUP signalling in order to effect SVC set-up between IWFs.

5 Switched trunking

In the following subclauses, the three switched trunking mechanisms identified in the previous clause are described in detail.

5.1 Common functions

A number of functions have been identified as being common to all of the switched trunking variants belonging to network interworking. These are itemized and described below.

5.1.1 Reference configuration

The reference configuration for ATM trunking for narrowband services specifies the concatenation of public narrowband networks via public ATM networks as one of 7 types of ATM trunking services. The interworking function is located between the public narrowband network and the public ATM network. A network element belonging to the public narrowband network or the public ATM network may provide the Interworking Function (IWF). The IWF carries out interactions in the user and in the control plane; interworking is performed for on-demand 64 kbit/s CBR Service. Figure 4 reproduces the relevant reference configuration as extracted from figure 2.

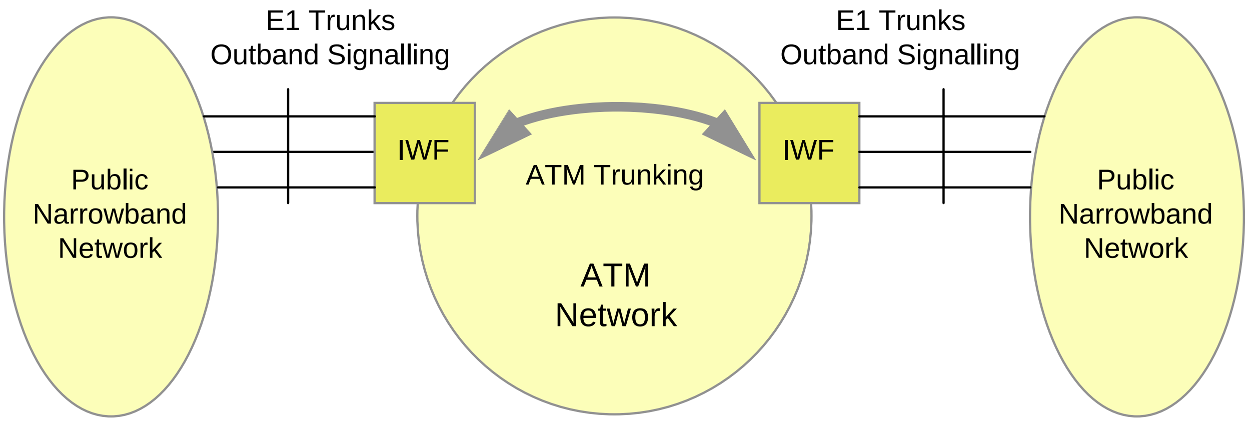

Figure 4: Reference configuration for public narrowband trunking

The narrowband networks connect to the IWFs over standard E1 narrowband trunks. Outband signalling system No. 7 is assumed.

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.

The IWF terminates the outband narrowband No. 7 Signalling and places all narrowband messages on a signalling connection set up with the remote IWF. This approach ensures that the services available to the narrowband networks are independent of their availability in the ATM network.

The ATM trunks that carry the narrowband traffic channels are set up between IWF pairs either by B-ISDN signalling or by TMN procedures.

5.1.2 Functionality of the Interworking Function (IWF)

The functionality of the IWF, located at the interface between the narrowband and broadband networks, is illustrated in figure 5.

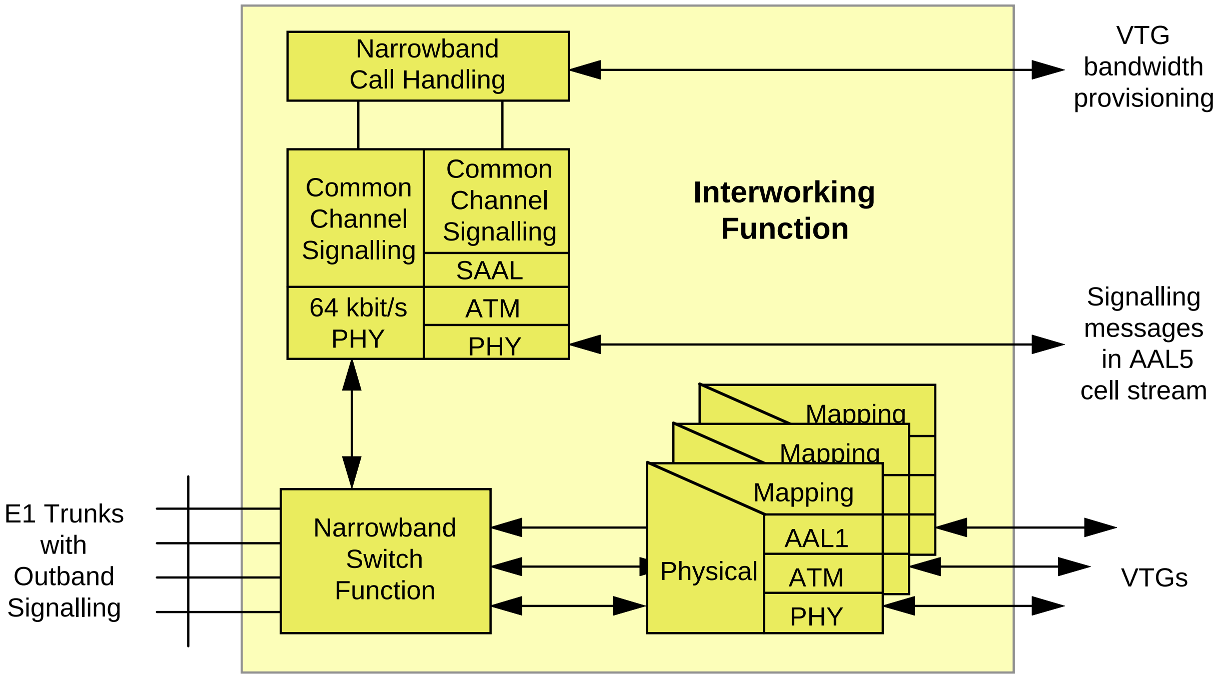

Figure 5: IWF functionality

As shown in figure 5, E1 trunks and the associated outband signalling channels, terminate on a narrowband switch function. Here, in the direction from narrowband network towards ATM network, the 64 kbit/s channels from the incoming trunks are sorted so that channels which need to use the same path across the ATM network appear on the same port from the switch function. The switch function outputs are then presented to a mapping and AAL1 adaptation function, where the octets belonging to individual 64 kbit/s channels are simply mapped into the payload of ATM cells belonging to a given VC. These ATM cells are carried by the VCCs - the so-called Virtual trunk groups (VTGs) - connecting IWFs across the ATM network.

The narrowband switch function also presents the outband signalling channels to a call handling function. This recovers the signalling messages so that the call handling function can control the narrowband switch function in order to associate the individual 64 kbit/s channels with the correct VCC. The call handling function also converts the narrowband signalling messages into an equivalent AAL5 cell stream. The AAL5 Message cells accompany the VCC across the ATM network in a separate VC.

In the opposite direction from ATM network towards narrowband network, an exactly inverse set of operations to the above is performed.

VTG bandwidth provisioning entails the control of both the ATM connections between IWFs and the amount of bandwidth available on those connections. These processes are performed in conjunction with the narrowband call handling function and involve B-ISDN signalling and/or TMN procedures either to create/release complete ATM connections or to modify the amount of bandwidth available on existing connections.

5.1.3 IWF reference model

Figure 6 shows in a layering context the functionality required in the Interworking Function at the interface between narrowband and ATM networks.

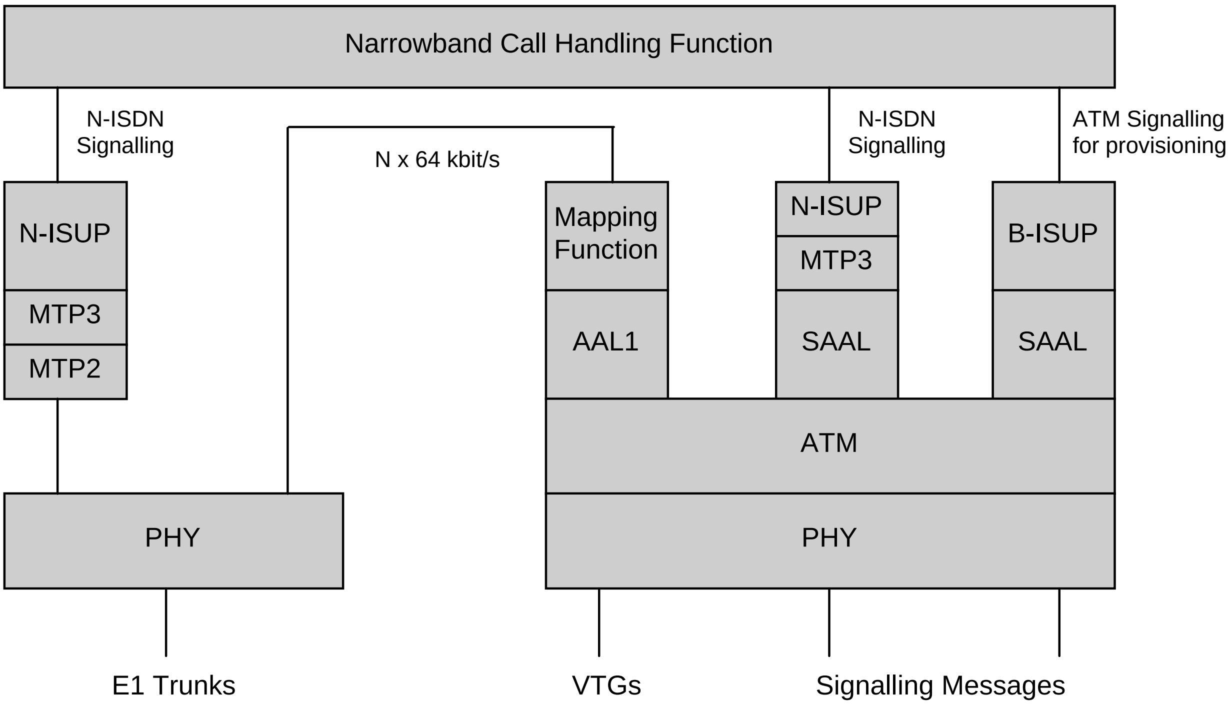

Figure 6: IWF reference model

5.1.4 Signalling

The narrowband signalling associated with the narrowband calls being transported across the ATM network is completely independent from the broadband signalling used for ATM bandwidth provisioning

5.1.4.1 N-ISDN signalling

The N-ISDN signalling protocols carried on the TDM trunks between the IWF and the narrowband network are based on Signalling System No. 7.

5.1.4.2 ATM signalling

ATM signalling for provisioning specifies the procedures between the IWF and the ATM network to set up signalling and N x 64 kbit/s Virtual Connections across the ATM network. It also supports the basic capabilities to increase and decrease the bandwidth of the VCs.

The ATM signalling protocols can be :

- UNI PVC;
- UNI SVC for data.

5.1.4.3 IWF-IWF signalling

Signalling associated with N x 64 kbit/s channels carried between two IWFs is transported across the ATM network in a SAAL cell stream within a separate VC. It allows the signalling for narrowband 64 kbit/s calls to remain in the narrowband domain from end-to-end. Note that the channel ID information Element available in signalling system No. 7 may be used to relate the data belonging to a given 64 kbit/s call to its location within the AAL1 cell stream.

5.1.5 OAM

For VCs used for IWF-IWF signalling, the IWF supports VC-AIS and VC-RDI indications, VC continuity check and VC loopback capability as defined in ITU-T Recommendation I.610 [8]. VC performance management and VC system management as defined in ITU-T Recommendation I.610 [8] may also be supported.

For VCs used for 64 kbit/s calls, the IWF supports VC-AIS and VC-RDI indications as defined in ITU-T Recommendation I.610 [8]. Other OAM functions may also be supported.

The possible requirements for other flows (concerned with a single AAL1 VC carrying a multiplex of 64 kbit/s calls and concerned with individual connections within an AAL1 multiplex) are for further study.

5.1.6 ATM Adaptation Layer (AAL)

For the transport of IWF-IWF signalling associated with the 64 kbit/s calls, AAL type 5 shall be used.

For the transport of narrowband traffic, AAL1 shall be used. ITU-T Recommendation I.363.1 [2] specifies how 64 kbit/s timeslots may be organized into blocks, each an integral number of octets in size, and carried within an AAL1 cell stream. A pointer mechanism is provided to indicate the start of a structure block and so delineate the individual call timeslots within the cell stream.

5.1.7 Timing

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

5.1.7.1 Timing scenarios

The requirements for timing depend very much on how a legacy network like a PBX is connected to its neighbouring networks. 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 the existing PSTN can accept. All entities that are interconnected using existing transmission equipment are therefore also bound by the requirements of this transmission equipment. From the service aspect viewpoint, however, the elasticity of ATM can be generally accepted.

The following scenarios are considered.

A Single IWF Supporting a Single Legacy Network.5

It is here assumed that the legacy network (PBX) has no interface to the PSTN other than the one offered by the IWF over ATM. See figure 7.

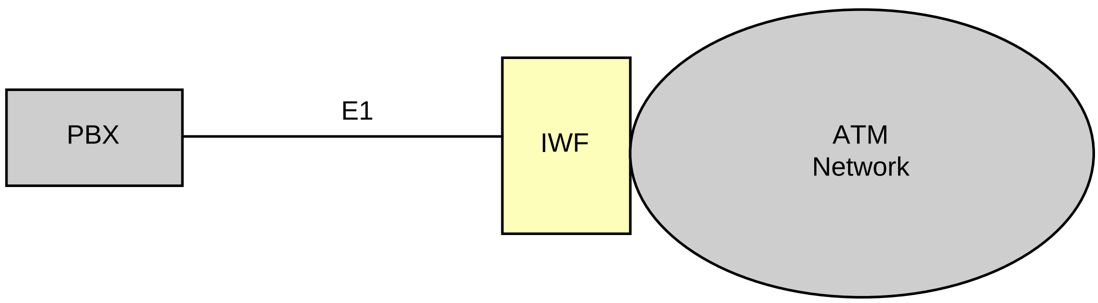

Figure 7: Single IWF supporting a single PBX

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

A Single IWF Supporting Multiple Legacy Networks

This scenario includes the group of legacy networks without parallel interfaces to the PSTN other than the one offered by the IWF. See figure 8.

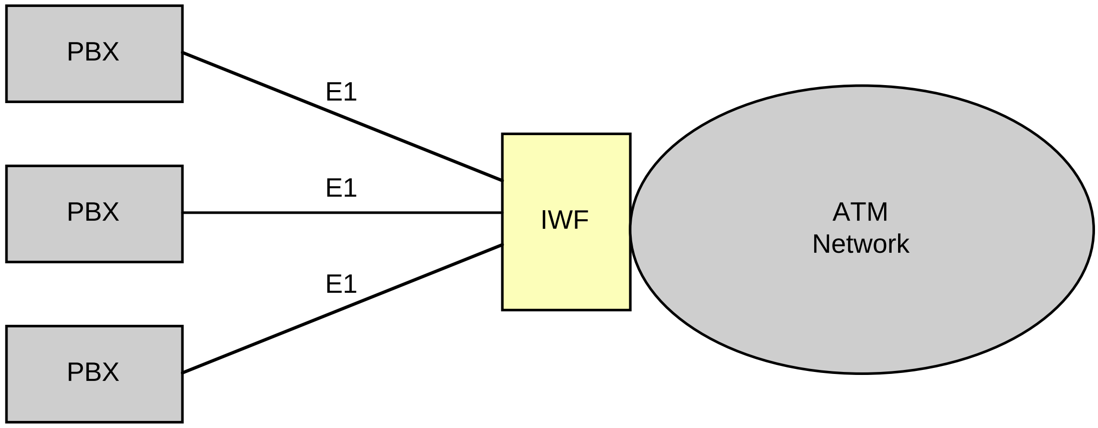

Figure 8: Single IWF supporting multiple PBXs

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 is only possible in the one to one mapping case.

An IWF Supporting Legacy Networks With Parallel Connections to a PSTN

The legacy network may have parallel interfaces to a PSTN. See figure 9.

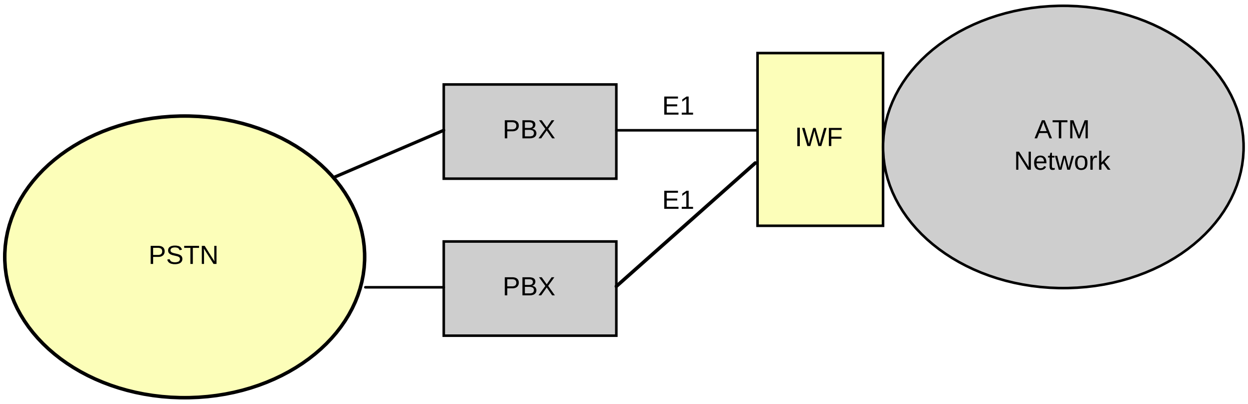

Figure 9: Single IWF supporting PBXs connected to a PSTN

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.

An IWF Supporting an Interface to a PSTN.

The IWF is connected to a PSTN. See figure 10.

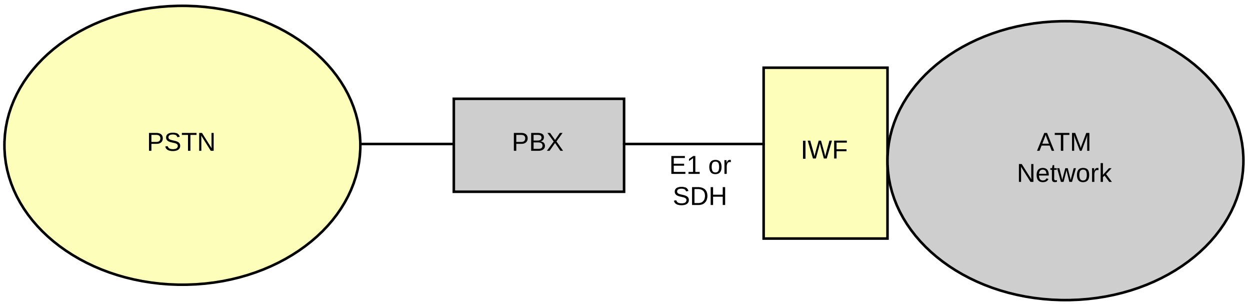

Figure 10: Single IWF with direct connection to a PSTN

The timing requirements are here defined by the PSTN.

5.1.7.2 Timing requirements

The requirements below are limited to an end system at customer premises. Core systems have to meet the full requirements in respect of existing PSTNs. The requirements only apply to the narrowband side of the IWF.

Elastic Timing

When elastic timing applies it can reduce the timing requirements for the IWF and the connected legacy network. See the scenarios of figures 7 and 8.

- It is suggested that for timing elasticity, an accumulated phase error of 2 ms should be allowed which matches *the maximum CDV*. This will however increase the transmission delay correspondingly.
- 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 e.g. voice and video is even more relaxed (e.g. compared with the hi-fi standard of 100 ppm).
- The bit error rate is defined by existing PSTN.
- The slip rate is defined by existing PSTN.

Non Elastic Timing

This corresponds to the requirement of 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 µs.
- 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 e.g. 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 existing PSTN.
- The slip rate is defined by existing PSTN.

5.1.7.3 Timing options

The following options depicted in figure 11 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 described by the following figure indicating three possible clock references and two locations where slip may occur.

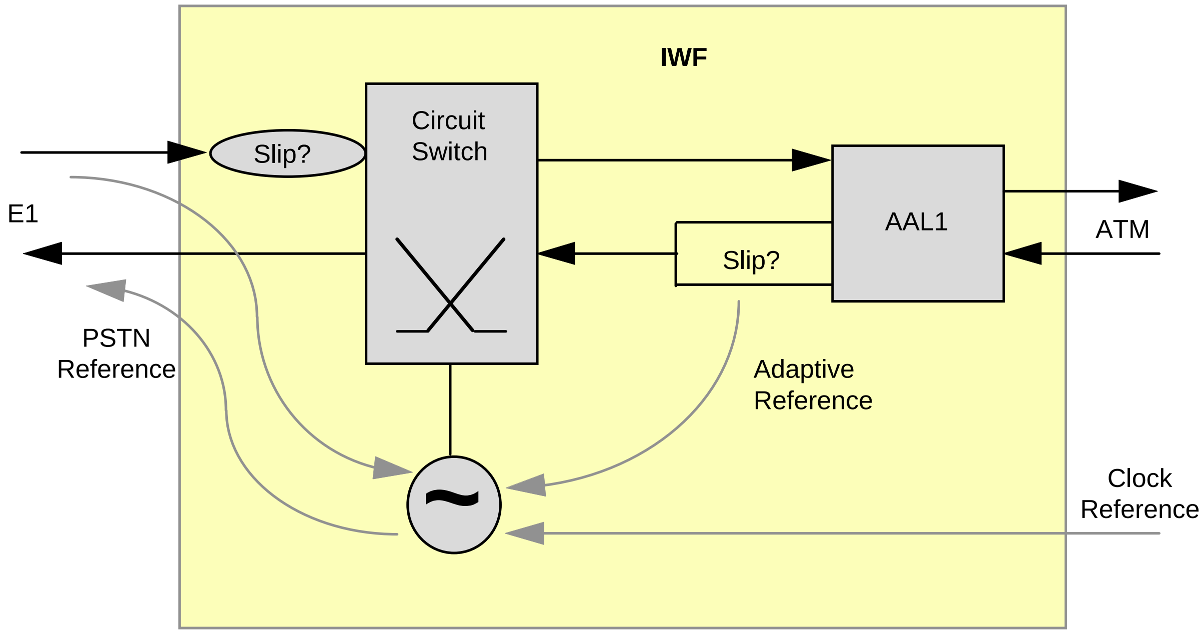

Figure 11: Clocking of the IWF

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 like GPS. The clock reference has to be PRS traceable to meet the PSTN requirement.

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 by the IWF because the connected entities may not use the same clock reference.

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

SRTS

When a clock reference is available the SRTS mechanism can be used to retrieve timing from a remote IWF for clock distribution purposes. This requires 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 suggested.

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 the larger buffer is located. Slip of more than just single octets may be considered in order to reduce the slip rate.

The Use of a Free Running Clock.

If the requirement on slip rate is relaxed the use of a free-running clock in the IWF might be realistic. For example, a Stratum 3 clock requires an accuracy of 4.6 parts in 10^6 and this would lead to one 125 µs slip every minute on average. However, while this may be acceptable for speech it may not be acceptable for PSTN services in general.

The Use of Adaptive Timing

The adaptive mechanism is only available when the IWF (using ATM to connect to the PSTN) represents the only connection to the PSTN and thereby allows for elastic timing. See the scenarios of figures 9 and 10. The adaptive mechanism does not work unless the acceptable elasticity is in 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, with the given assumptions, it can meet the PSTN service related requirements (e.g. slip).

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

5.1.8 Management

The IWF has a narrowband side and an ATM side and provides the functionality to connect the narrowband equipment with the ATM equipment. In general, the narrowband side is implemented in equipment that supports one or more CBR interfaces (E1 ports). Likewise, the ATM side is supported by ATM ports. The ITU-T Recommendation I.751 [6] specifies the management of ATM equipment (the ATM side) by providing a MIB for ATM Layer resources. Existing specifications do not address management aspects concerned with the service interface and the IWF entities:

- the E1 service interface;
- narrowband switching function;
- call handling function;
- mapping and AAL1 functions;
- SAAL functions.

The need for a Management Information Base for ATM Trunking is for further study.

5.2 Trunking based on one-to-one mapping

One ATM VCC is established between two IWFs for the transport of narrowband signalling. One ATM VCC is also established for each 64 kbit/s channel to be transported across the ATM network. A VCC can either be set-up individually for each voice call or it can be used for a larger number of consecutive voice calls. This will be possible since the voice call is handled through the IWF to IWF signalling channel and the IWF to ATM signalling is only used for provisioning of ATM resources. The network configuration is described by figure 12.

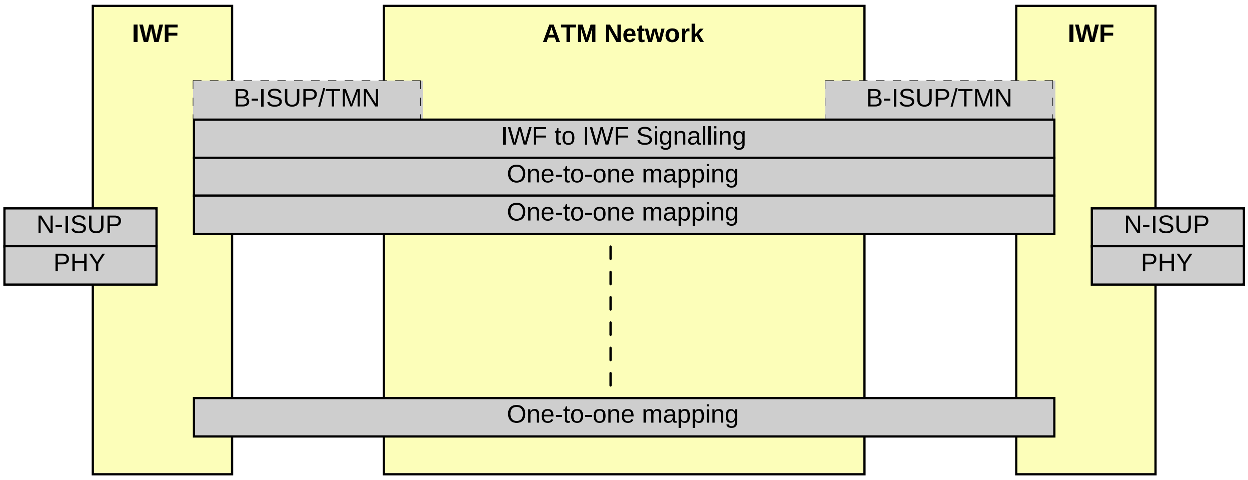

Figure 12: One-to-one mapping configuration

Note that since the individual 64 kbit/s circuits are mapped on separate ATM VCs it is possible to replace the circuit switching functionality of the IWF with ATM switching.

The cell assembly delay is 6 ms.

This alternative fits best to small trunks that are sometimes empty. It also offers the full bandwidth efficiency for larger trunks.

5.2.1 AAL

For the transport of narrowband channels, AAL type 1 with unstructured data transfer shall be used.

For the transport of IWF-IWF signalling associated with the narrowband channels, AAL type 5 shall be used.

5.3 Trunking based on many-to-one mapping

One ATM VCC is established between two IWFs for the transport of narrowband signalling. One ATM VCC is established for multiple 64 kbit/s channels. The network configuration can be described by figure 13.

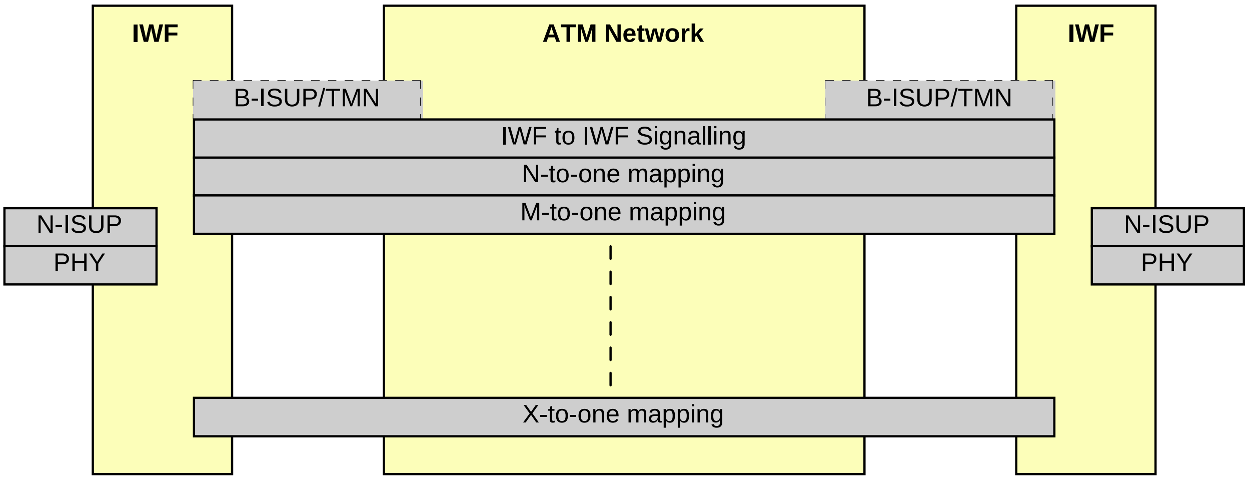

Figure 13: Many-to-one mapping configuration

The IWF establishes an appropriate number of VCs between two IWFs. Each VC carries N (or M or X, according to traffic demand) 64 kbit/s narrowband channels. The establishment of VCs can be performed either through the signalling plane or through the management plane. In principal the number of VCs and the number of 2 Mbit/s narrowband links terminating on the IWF are both unrestricted.

The interconnection capability is restricted to those bandwidths defined in relevant specifications. These are currently N x 64 kbit/s, 2048 kbit/s; 34 Mbit/s is expected to be available soon.

Each VC has a predefined capacity with the limitation defined by the capabilities of the AAL1 MIBs for the ATM network.

5.3.1 AAL

For the transport of narrowband channels, AAL type 1 with structured data transfer shall be used.

For the transport of IWF-IWF signalling associated with the narrowband channels, AAL type 5 shall be used.

5.4 Trunking based on hybrid multiplexing

In order to support dynamic allocation of bandwidth in situations where the requirements are for flexibility together with efficient use of resources, the one-to-one mapping plus the many-to-one mapping methods may be combined into a "Hybrid" solution. The network configuration can be described by figure 14.

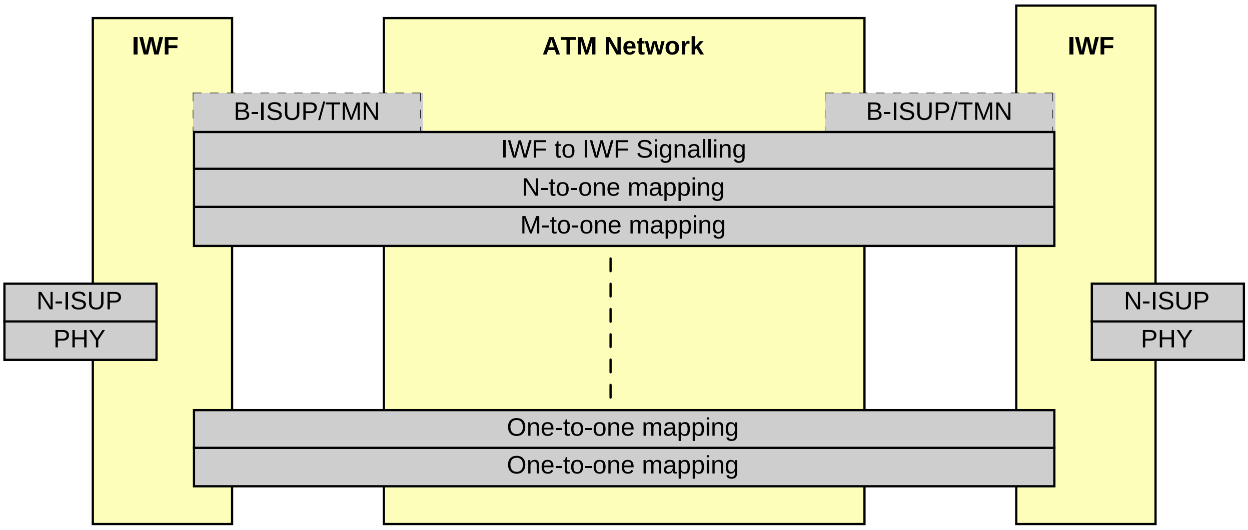

Figure 14: Hybrid multiplexing configuration

An appropriate number of VCs is established between the two IWFs, including a VC for IWF to IWF signalling plus one or more VCs for many-to-one mapping, in order to carry the initial traffic load.

As the traffic load increases (or as per predetermined schedules) further many-to-one VCs may be added to meet demand.

For fine tuning purposes, VCs for one-to-one mapping are then set up. As user traffic demand fluctuates about some (perhaps temporary) mean value, so the one-to-one VCs may be added or deleted to follow the demand.

Thus, the Hybrid solution offers the ability 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, to ensure an optimal match between the available ATM resources and the prevailing traffic load.

5.4.1 AAL

For the transport of narrowband channels, AAL type 1 shall be used with structured data transfer for the many-to-one VCs and with unstructured data transfer for the one-to-one Vcs.

For the transport of IWF-IWF signalling associated with the narrowband channels, AAL type 5 shall be used.

6 CES Trunking

6.1 Functional requirements

6.1.1 Definition of the interface point

The Circuit Emulation Service Interoperability Specification (CES-IS) specifies the ATM Forum's interoperability agreement for supporting CBR traffic over ATM networks. This specification covers two types of CBR services: structured DS1/E1 N x 64 kbit/s Service and unstructured DS1/E1 Service. Figure 15 shows the reference configuration for trunking of N-ISDNs including the network management entities (NMs).

In this scenario a B-ISDN consisting only of standard ATM multiplexers and cross-connects can be utilized.

In this case the trunks (2 Mbit/s or N x 64 kbit/s) originating from the N-ISDNs are transparently connected with each other. The co-ordinated provisioning of capacity at the B-ISDN and the N-ISDN is performed by the network management.

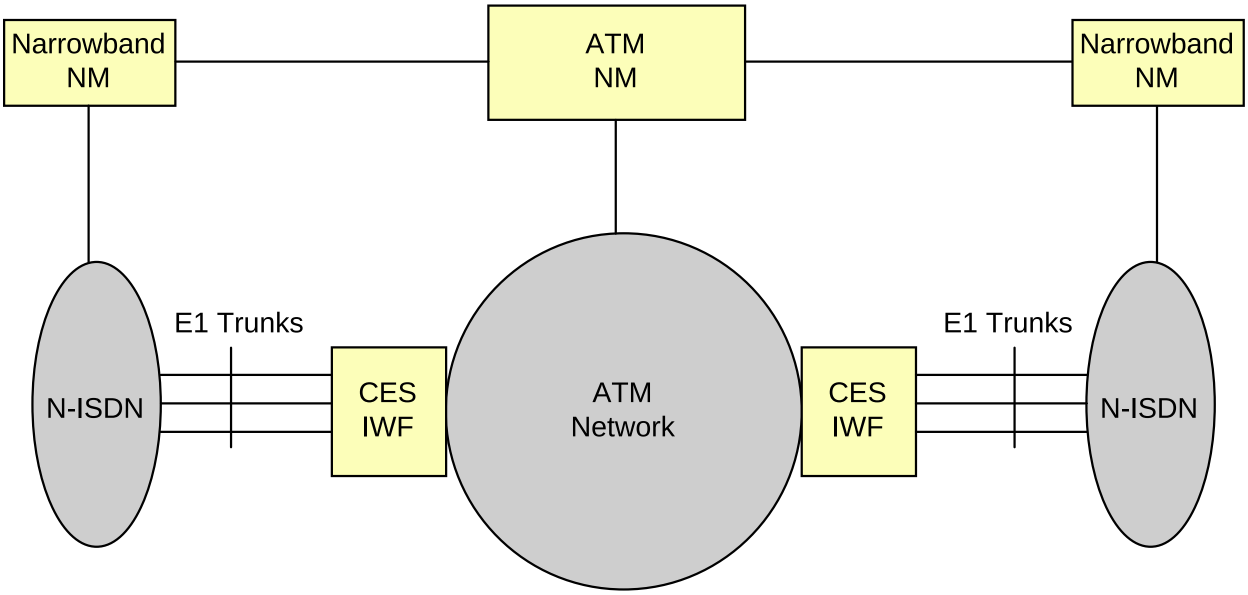

Figure 15: CES reference configuration

6.1.2 Interconnection capability at IWF

The interconnection capability is restricted to those bandwidths defined in relevant specifications. These are currently N x 64 kbit/s, 2 048 kbit/s; 34 Mbit/s will be available soon according to progress in the CES group of ATM Forum.

6.1.3 Functional allocation

There is a clear functional split between the IWF and the B-ISDN, i.e. the functionality of the IWF is mainly concerned with the mapping between PCM link and ATM. The IWF is totally transparent for signalling information.

In principal the number of VCs and the number of N x 64 kbit/s or 2 Mbit/s links are both unrestricted. But in order to enable a smooth transition in network capacity as described below it is favourable to map individual links or groups of 64 kbit/s channels into individual VCs.

The B-ISDN then connects the IWFs via PVCs carrying CBR service. The capacity and routeing is controlled via network management.

The N-ISDN signalling contained in one of the 64 kbit/s timeslots within one of the trunks is treated like each other 64 kbit/s timeslot and transported transparently through the B-ISDN.

6.1.4 Applicability and limits

This scenario, like any other PVC-based scenario, is applicable to networks with a limited, rather low number of N-ISDNs and IWFs. The main reason for this limitation is that no signalling based routeing is performed within the B-ISDN. As a consequence, the IWFs have to be fully meshed. This would result in uncomfortably high numbers of connections and low capacities in the individual directions for large numbers of IWFs. Suitable networks are:

- the core/backbone networks of public networks, i.e. the B-ISDN replaces the highest layer of transit exchanges;
- corporate networks where the B-ISDN is used to interconnect a limited number of sites.

6.2 Signalling requirements

6.2.1 Conversion of signalling

Since no signalling is monitored or processed in the IWFs and the B-ISDN no signalling requirements are given for the IWFs and the B-ISDN network elements.

6.2.2 Bandwidth allocation

The N x 64 kbit/s service provides capabilities for the dynamic configuration of the permanent virtual channel connections in the ATM network. The capacity required in the N-ISDN is varying dependent e.g. on the time of day. Therefore only the capacity required by the N-ISDN will be throughconnected in the B-ISDN. Figure 16 shows the relationship between actual load and capacity provided in the N-ISDN and B-ISDN.

The permanent virtual channel connections will be established via the B-ISDN TMN according to the capacity required by the N-ISDN. This can be accomplished for instance by reserved VCs. The relevant trunks have to be unblocked by the N-ISDN TMN afterwards.

The capacity not required by the N-ISDN may be released in the B-ISDN. The relevant 64 kbit/s channels have to be blocked by the N-ISDN TMN. After the calls have been released, e.g. after hard blocking request from the TMN, the permanent virtual channel connection is released by the B-ISDN TMN.

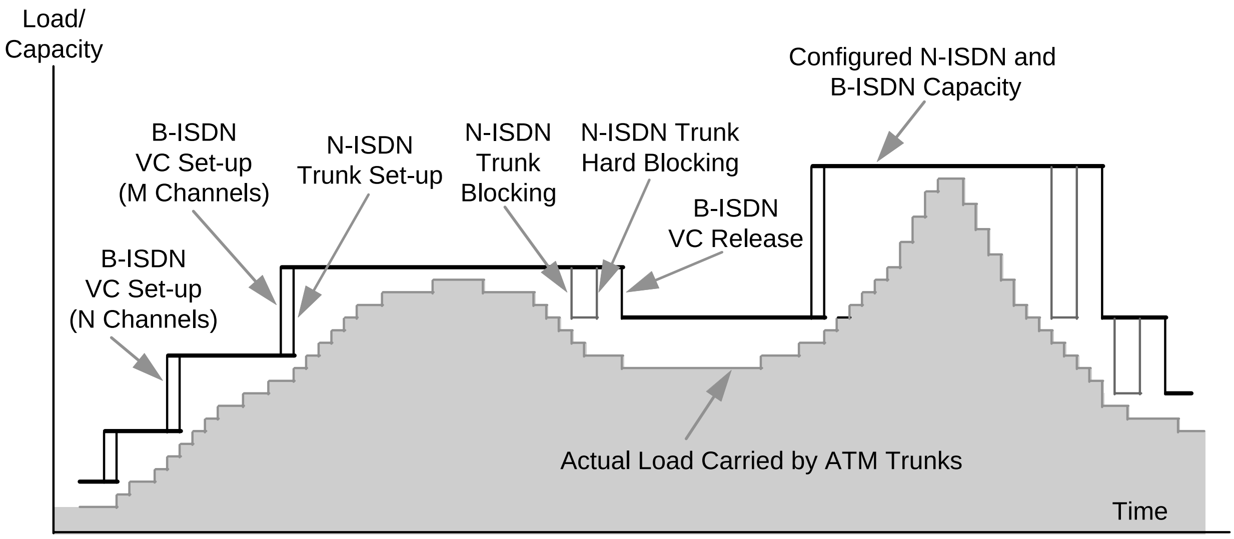

Figure 16: Capacity allocation

6.2.3 Target signalling protocol

The IWF is connected via a UNI to the B-ISDN in the case that the B-ISDN is public and N-ISDN is public or private.

6.3 QoS requirements of the ATM network

6.3.1 Reference configuration

No limitation to capacity exists, neither on the low side with N x 64 kbit/s where N can be kept small, nor on the high side where one or multiple DS-1, DS-3, STM-1, STM-4, STS-1, STS-3c, STS-12c can be utilized.

6.3.2 Performance parameter

Compared to SDH based trunks no significant differences in terms of availability or error rate are expected. Additional delay is introduced by each transition between SDH and ATM through the packetization delay. This delay amounts to t = 6 ms / N (N = number of 64 kbit/s channels) and is irrelevant for N > = 6.

Since no signalling is monitored or processed in the IWFs and the B-ISDN no additional contribution for connection processing delay is introduced.

Consequently in real applications, esp. in the back bone case, no significant deterioration in performance is expected.

6.3.3 Related issues

The packetization/depacketization of the 64 kbit/s PCM channels in the IWF introduces additional delay. The amount of the additional delay is dependent on the number of 64 kbit/s PCM channels packed into one virtual channel connection.

The delay caused by the packetization/depacketization of a single 64 kbit/s channel is 6 ms and may thus require echo compensation. The delay caused by the packetization/depacketization of N 64 kbit/s channels (N > = 6) is < 1 ms and can be ignored: echo compensation is not required. Therefore N channels (N > = 6) should be packed into one virtual channel connection.

The delay originated by ATM network elements, e.g. a cross connect, is comparable to the delay of the SDH network elements. Consequently no additional end-to-end delay occurs. Furthermore, no additional connection processing delay exists since no signalling procedures are involved in this scenario.

6.4 QoS effects on narrowband services

6.4.1 Availability

There is no difference to SDH trunking. Even in the case of broken connections the protection mechanisms in the SDH and ATM layers provide for automatic re-establishment.

6.4.2 Limitations

All N-ISDN services can be conveyed without any restriction.

6.5 OAM

No interworking between the OAM flow at the PCM links and the B-ISDN is performed. This situation is described in ETR 263 [9]. In the case that 2 048 kbit/s CES is used the OAM flow contained in timeslot 0 of the PCM link is transparently transported through the ATM network. The only way of information exchange between N-ISDN and B-ISDN is via the TMN system.

6.6 AAL

For the transport of narrowband channels, AAL type 1 shall be used with structured data transfer as defined in ITU-T Recommendation I.363.1 [2].

6.7 Management

All networks are managed through open Q-interfaces as described in ITU-T Recommendation I.751 [6]. The information flow between the network management systems is performed via X-interfaces.

7 Trunking based on service interworking

Service interworking provides a trunking mechanism in which each single narrowband channel is transported by a single switched ATM VC. This mechanism requires the translation of N-ISUP signalling into B-ISUP signalling in order to set up SVCs between IWFs. This service is described in ITU-T documentation and in particular, the following description is based on the ITU-T Recommendation I.580 [1].

7.1 Functional requirements

7.1.1 Definition of the interface point

The reference configuration of ATM trunking for narrowband services specifies the concatenation of public narrowband networks via public ATM networks as one of the types of ATM trunking services. The interworking function is located between the public narrowband network and the public ATM network. A network element belonging to the public narrowband network and the public ATM network may provide the Interworking Function (IWF). The IWF carries out the interactions in the user and in the control plane. The interworking is performed for on-demand N x 64 kbit/s CBR Service.

In this scenario the public ATM network and the public narrowband network consist of standard switches.

In this case a call/connection (N x 64 kbit/s) originating from the public narrowband network is routed through the public ATM network. The public ATM network provides transparent transport for the services and supplementary services offered by the public narrowband network.

This scenario supports in addition to the concatenation of public narrowband networks via an ATM network the interworking between a subscriber connected to the narrowband network and a subscriber connected to the ATM network.

7.1.2 Interconnection capability at IWF

The interconnection capability is restricted to those bandwidths defined in relevant specifications of the public narrowband network. These are currently N x 64 kbit/s.

7.1.3 Functional allocation

The functionality of the IWF is mainly concerned with the mapping between a PCM link and the ATM interface as well as with the mapping of signalling.

The IWF is connected to the narrowband network via DSS1 interfaces and to the ATM network via ATM interfaces (e.g. SDH/SONET). The IWF provides one-to-one mapping between an N x 64 kbit/s connection in the narrowband network and a virtual channel connection in the ATM network. The N x 64 kbit/s connection is mapped onto an AAL1 connection using the structured data transfer mode in the ATM network. The mapping function is according to the N x 64 basic service specified in the ATM-Forum CES-IS.

7.1.4 Applicability and limits

This scenario is applicable to public narrowband and ATM networks. Suitable networks are the core/backbone networks of public networks, i.e. the B-ISDN replaces the highest layer of transit exchanges.

7.2 Signalling requirements

7.2.1 Conversion of signalling

The IWF resides at the interface between the public narrowband network and the public ATM network. Therefore the IWF supports the signalling system No.7 of both the narrowband and of the broadband network. The following functions are supported by the IWF:

- Message Transfer Part (MTP) of the narrowband signalling system No. 7;
- SAAL and MTP of the broadband signalling system No. 7;
- Narrowband ISDN User Part (N-ISUP);
- Broadband ISDN User Part (B-ISUP).

The interworking at the control plane is provided by the conversion of N-ISUP to B-ISUP and vice versa. The IWF maps the information received from the N-ISUP into the B-ISUP messages and adds ATM specific information, e.g. description of ATM traffic parameters and the AAL parameter (AAL1). The B-ISUP provides transparent transport of N-ISDN specific information.

7.2.2 Bandwidth allocation

Dynamic allocation of bandwidth on a call by call basis is provided. The connections are established via signalling. The capacity per connection required in the ATM network corresponds to N x 64 kbit/s plus the ATM overhead. Therefore only the actual capacity required by the N-ISDN connection will be throughconnected in the B-ISDN. The total capacity required by the ATM network corresponds to the capacity provided by the N-ISDN at the busy hours. Bandwidth not required for the interworking may be used by the ATM network for calls between other ATM users.

7.2.3 Target signalling protocol

The target signalling protocol is the signalling system No.7 for the public narrowband and the public ATM network.

7.3 QoS requirements to the ATM network

7.3.1 Reference configuration

The reference model for circuit emulation services as specified in the ATM-Forum CES-IS applies.

7.3.2 Performance parameter

The IWF should fulfil the requirements for cell transfer delay as specified in CES-IS.

7.3.3 Related issues

The packetization/depacketization of the 64 kbit/s PCM channels in the IWF introduces additional delay. The delay caused by the packetization/depacketization of a single 64 kbit/s channel is 6 ms and may thus require echo compensation dependent on the round trip delay of the connection. The echo compensation may be provided within the narrowband network or within the IWF.

7.4 QoS effects on narrowband services

7.4.1 Availability

There is no difference compared to the trunking via N-ISDN transit switches.

7.4.2 Limitations

All N-ISDN services can be conveyed without any restriction.

7.5 OAM

For VCs used for 64 kbit/s calls, the IWF supports VC-AIS and VC-RDI indications as defined in ITU-T Recommendation I.610 [8]. Other OAM functions may also be supported.

No interworking between the OAM flow at the PCM links and the ATM network is performed.

7.6 AAL

For the transport of narrowband channels, AAL type 1 shall be used as defined in ITU-T Recommendation I.363.1 [2].

7.7 Management

All networks are managed through open Q-interfaces as described in ITU-T Recommendation I.751 [6]. The information flow between the network management systems is performed via X-interfaces.

8 Conclusions

8.1 Circuit emulation service

CES is the simplest trunking option since it involves requirements for neither switching nor signalling handling. However, the resulting trunking capability is inflexible. This characteristic is ameliorated to some extent in the CES mechanism described in clause 4 by introducing suitable system management controls. These are concerned with the blocking and deblocking of N-ISDN trunks as well as B-ISDN VCs and enable a coarse match to be maintained between the demand for ATM resources and the availability of such resources.

8.2 Switched trunking

Switched trunking is more complex than CES. It requires an IWF that provides a switching capability in order to distribute 64 kbit/s channels onto the appropriate ATM VCs. This also entails a narrowband signalling handling function to control the switching, although the signalling capability does not involve narrowband/broadband signalling conversion. Instead, the signalling associated with the 64 kbit/s channels is carried transparently across the ATM network between IWFs. Switched trunking also provides transparency for narrowband service features.

From the viewpoint of the ATM network, switched trunking presents a relatively small number of VCs for transport across the infrastructure. This places a minimal signalling handling requirement on the ATM switches.

From the viewpoint of the TDM network, switched trunking introduces no additional requirements for echo control above those that already exist.

8.3 Service interworking

Service interworking provides the long term solution for trunking, in the sense that in the long term the majority of telecommunications traffic will be ATM based. Service interworking supports trunking by carrying each 64 kbit/s channel in a separately switched VC. It has high bandwidth efficiency (ATM VCs are only set up on demand), provides high QoS for the transported narrowband services and narrowband interfaces do not require fixed assignments of 64 kbit/s channels. Note that service interworking also permits communications between terminals on the broadband network and terminals on the narrowband network, although this capability is outside the scope of the present document.

The flexibility and efficiency of service interworking has a price. This includes the need for IWFs which concentrate E1 trunks into a smaller number of ATM physical bearers for presentation to the ATM switches and also perform narrowband/broadband signalling conversion.

From the viewpoint of the ATM network, service interworking presents a large number of VCs to the ATM switches with a consequential large processing load associated with signalling handling.

From the viewpoint of the TDM network, the extra cell assembly delay resulting from the adaptation of individual 64 kbit/s channels (6 ms.) may introduce the need for echo control devices.

8.4 Summary

CES (static) trunking, as the simplest option, may be seen as the short term solution in the implementation of a narrowband trunking capability.

Switched trunking provides a solution which may be especially suited to ATM networks containing a limited number of large ATM switches at which the IWFs are (logically) co-located. This ensures that the number of such ATM switches that need to be interconnected is relatively small, thus limiting the number of VCs set up for trunking purposes. This option may be seen as a medium to longer term option.

Service interworking is largely independent of the above switched trunking considerations. It is the obvious long term trunking solution.

History

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