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Proposed SNDCF for use with Asynchronous Transfer Mode (ATM) Networks

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SUMMARY

This document proposes a specification for an Subnetwork Dependent Convergence Function (SNDCF) for use with Asynchronous Transfer Mode (ATM) networks. Its adoption will permit a standardised mechanism for the use of such networks by ATN compliant systems.

In the second edition, the specification has been amended to include the use of VBR services over PVCs. This is in recognition of the fact that many early ATM services available from public service providers are limited to provision of Constant Bit Rate (CBR) and Variable Bit Rate (VBR) services over Permanent Virtual Circuits only. Examples of such services include those provide by France Telecom and British Telecom.

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1. Introduction

1.1 Scope

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1.2 Purpose of Document

This document has been prepared as a proposal to ATNP/WG2.

1.3 References

1.	ISO/IEC 8473-1:1994	Information technology – Protocol for providing the connectionless-mode network service: Protocol specification
2.	af-uni-0010.002	ATM Forum - User to Network Interface specification version 3.1

2. Summary

This paper provides a proposed SNDCF for use over ATM networks. The bulk of the paper is concerned with analysis of ATM networks and the requirements for an ATM SNDCF. This should form the basis of later guidance material. The specification itself is straightforward and has the following features:

- User data is sent using ATM Adaptation Layer 5 (AAL5)
- Data Compression Procedures are optionally available for use, and follow those specified for the Mobile SNDCF
- The specification makes use of Available Bit Rate (ABR) services and also permits the use of Unspecified Bit Rate (UBR) services for low priority data.
- Both PVC and SVC services are supported.
- The specification also includes a specification of the interim use of VBR PVCs.
- The analysis leads to the conclusion that optimisations specified for IP over ATM, such as IP Switching, will not give a significant advantage in an ATN context and there is thus no need to consider a requirement for tighter integration between ATN and ATM environments.

The most significant new concepts involved in the specification are the traffic management procedures used to limit data transfer rates over ABR circuits that also carry safety related data. This is because once the traffic rate exceeds the available bit rate, data loss is likely and no guarantee can be offered that safety related data will not be discarded. In order to permit the transfer of lower priority data when the ABR is devoted to high priority data, procedures are also specified to transfer lower priority data over separate ABR circuits without traffic rate limitation, or over UBR circuits.

In the interim use of VBR circuits, VBR will be more complex to implement than ABR, and more expensive than an ABR service should be. However, its use will be necessary until ABR services become available.

3. ATM Backgrounder

3.1 About ATM

An Asynchronous Transfer Mode (ATM) network provides a high speed cell switched wide area communications service. User data is sent over the network as a continuous series of fixed length cells. Each cell is 53 octets long comprising a 5 octet header and 48 octets of user data. The header identifies the destination of the cell, in the form of a Virtual Path Identifier, provides an integrity check (for the header alone) and includes other information that is used for the cell switching process.

The cell switched nature of ATM gives it both flexibility and speed. Fixed sized cells can be switched rapidly without the statistical variations that affect the forwarding of variable sized packets in (e.g.) Frame Relay networks, and with the switching software optimised to give constant real time transit delays. Furthermore, transmission lines can be used in a highly flexible manner. The cells could be assigned to specific data flows in a periodic manner to give a result equivalent to Time Division Multiplexing (TDM). In such a scenario, a proportion of the available bandwidth can be readily provided to each user with constant timing relationships.

However, ATM is much more flexible than simple TDM as, while some users can be given an essentially TDM type service, others can compete for access to the communications path. Some may be guaranteed a set number of cells in a period, but without guaranteeing a constant timing relationship, whilst others may only be guaranteed a minimum number of cells in a period but with the possibility of sending more - if other users do not use their minimum allocation. Furthermore, while some data flows may be symmetric, others will have asymmetric Quality of Service requirements, while others will be unidirectional. ATM can reflect this in different cell allocation strategies for the different data flow directions.

This flexible nature of ATM allows a given communications path to be shared between applications such as High Definition Video and process control that may require guaranteed bandwidth and constant timing relationships, applications such as voice, which are less sensitive to timing delays, and low priority data transfers.

The virtual path information contained in a cell’s header identifies the “data stream” with which the cell is associated. A virtual path has to be set up through the network by a network manager before any data can be sent and, each cell switch in the path configured so that each cell sent on such a data stream is switched to its correct destination. An ATM network can thus be considered to be (virtual) circuit oriented. ATM virtual circuits can be point-to-point or point-to-multipoint.

The most basic model of communication through an ATM network is that of the Permanent Virtual Circuit (PVC). PVCs are set up by a network manager who configures the appropriate virtual path identifier and also the “Traffic Management” characteristics e.g. whether the cells are switched with a constant timing relationship, the actual or minimum number of cells of cells assigned to that virtual path in a given period, etc.

Switched Virtual Circuits (SVCs) are also possible. However, these are managed in a very different way to X.25 SVCs. Instead of using an in-band protocol - that is control packets mixed in with user data packets, ATM SVCs are managed by an out-of-band management protocol sent over a PVC between the service user and the service provider that was established for this purpose.

Finally, it should be noted that most applications do not provide their data in ATM friendly 48 octet cells. User data has to be fragmented and reassembled in a suitable manner for transport by ATM. This functionality is performed end-to-end by a so called ATM Adaptation Layer (AAL), and different AALs may be provided for different types of data stream. An example is AAL5 which provides for the fragmentation and re-assembly of variable length data packets.

3.2 ATM Architecture

The ATM protocol layer model is illustrated in Figure 3-1, and is specified in ITU Recommendation I.321.

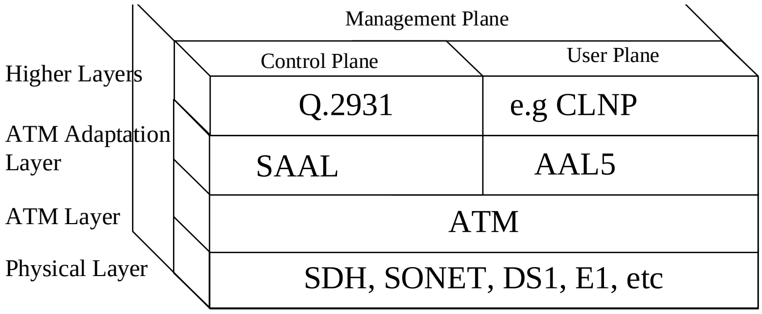

Figure 3-1 Example of ATM Protocol Placement

3.2.1 ATM Physical Layer

In the Physical layer, ATM networks may use a variety of (typically high speed) data links. Examples include common digital bearer networks such as T1/E1 and the Synchronous Optical Network (SONET). The actual data link used depends upon User Preference, service availability and the service provider.

3.2.2 The ATM Layer

The ATM Layer is specified in ITU Recommendation I.361. This specifies the structure of the ATM Cell and how the header fields are used by cell switches. Industry standards such as the ATM Forum's User Network Interface Specification provide guidance on the use of I.361 over various types of data links.

The Cell Header provides the following fields:

- **Generic Flow Control**: This is of local significant only (i.e. not carried end-to-end) and can be used to provide feedback to Layer Management for use in influencing local Traffic Management policy

- **Virtual Path/Virtual Circuit Identifier**: Together, these fields identify a virtual circuit. Note that where multiple virtual circuit share a common route or part of a route between their end-point, this structured identifier enables them to be bundled together into a common virtual path over each shared route segment.

- **Payload Type**: which is used to distinguish between user and management cells and to indicate congestion experienced.

- **Cell Loss Priority**: which enables the sender to indicate which cells are less sensitive to loss in the even of congestion i.e. which should be discarded first.

- **Header Error Check:** which is used to detect cell header corruption.

Above the ATM Layer, the ATM Protocol Model is divided into three different “planes”: the Control Plane, the User Plane and the Management Plane. Each represents a different type of interaction with the ATM network.

In the User Plane, virtual circuits are used for end-to-end communications. In the Control Plane, virtual circuits are used to communicate between the service user and the service provider in order to control the service provided e.g. for virtual circuit management. In the Management Plane, management information may be communicated on a per virtual circuit or virtual path basis, or at the physical layer when management services are available there. Management information may be used for (e.g.) fault management to indicate circuit loss, Performance Management, loopback testing, etc.

3.2.3 The ATM Adaptation Layer

Several ATM Adaptation Layers have been specified by the ITU for different purposes:

- AAL 1 has been defined to support applications requiring a constant bit rate service;
- AAL 2 has been defined to support variable bit rate applications where a defined timing relationship is needed between source and destination.
- AAL 5 provides a simple framework for the transport of packet oriented data communications over ATM networks,

AAL 3 and 4 do exist, however, they are not widely used, if at all. Originally, AAL 3 was intended for variable bit rate connection oriented applications and AAL 4 for message mode or stream mode services. However, their specifications have been combined and now referred to as AAL 3/4.

In the User Plane, the adaptation layer typically supports a higher layer protocol. For example, AAL 5 could be used to support the transport of CLNP packets, and AAL 1 could support high definition video. Note that (e.g.) AAL 1 and AAL 5 cannot be used concurrently over the same virtual circuit, and a virtual circuit is also set up to support a specific ATM Adaptation Layer in terms of the bit rate and Quality of Service provided.

AAL 5 is generally used for data transfer over ATM and is itself structured into three sublayers:

- The Segmentation and Reassembly (SAR) sublayer makes direct use of the ATM layer and segments packets (that must be exact multiples of 48 octets) into ATM cells and reassembles the packet on arrival. The payload type field is used to indicate which cell contains the last part of the packet.
- The Common Part Convergence Sublayer (CPCS) defines a simple trailer for each packet containing user to user information, the actual length of the packet and a CRC. The CPCS also pads out a user data packet to an integral multiple of 48 octets for later segmentation into ATM cells.
- The Service Specific Convergence Sublayer (SSCS), which varies between applications and can be null.

In the Control Plane, the Higher Layer protocols are also defined by ITU standards as these are used to communicate between the user and the service provider. This protocol is specified by ITU Recommendation Q.2931 and is used for SVC connection control.

Q.2931 requires a reliable packet mode communications service which is provided by the Signalling ATM Adaptation Layer (SAAL). The SAAL is itself composed of two sublayers - the AAL Common Part (AAL CP) and the service specific part. The service specific part is itself subdivided into a Service Specific Co-ordination Function (SSCF) and a Service

Specific Connection Oriented Protocol (SSCOP) specified in ITU recommendation Q.2110. The SSCF maps the SSCOP on to the needs of different services. The SSCF needed by Q.2931 is specified in ITU Recommendation Q.2931.

AAL 5 is used as the AAL common part in support of Q.2931 and provides for packet transmission over ATM and detection of corrupt packets.

3.2.4 ATM Addressing

For the purposes of virtual circuit establishment, ATM Networks use the OSI NSAP Addressing scheme in order to identify ATM users. However, while such addresses are allocated from the same Address Space as (e.g.) ATN NSAP Addresses, they do not identify the same class of objects as do the NSAP Addresses used as CLNP Destination Addresses. ATN NSAP Addresses cannot therefore be used as ATM Addresses.

3.3 ATM Quality of Service and Throughput

Both PVCs and SVCs can be established with differential Quality of Service (QoS) and throughput requirements. Furthermore, the QoS can be different (asymmetric) for each direction of data transfer.

Throughput requirements are expressed in terms of cell rates in each direction. For a constant bit rate service, the cell rate is naturally fixed at the level needed to maintain that bit rate. However, for a Variable Bit Rate (VBR) service, the cell rate is expressed as:

- Peak Cell Rate (cells/second)
- Sustainable Cell Rate (cells/second)
- Maximum Burst Size (cells)

where the sustainable cell rate is the typical rate, while bursts at the peak cell rate of no more than the maximum burst size will be tolerated. It is also possible to have an Available Bit Rate (ABR) service where only a minimum cell rate is guaranteed, and an Unspecified Bit Rate (UBR) service where no minimum throughput is guaranteed.

QoS requirements are again expressed in each direction and in terms of:

- Cell Error Ratio
- Severely-Errored Cell Block Ratio
- Cell Loss Ratio
- Cell Mis-insertion Rate
- Cell Transfer Delay
- Mean Cell Transfer Delay
- Cell Delay Variation

However, although ATM standards may be extended to support the selection of individual QoS parameter values on a per virtual circuit basis, currently they are bundled as QoS classes provided by a service provider for:

- Service Class A: Circuit Emulation, Constant Bit Rate
- Service Class B: Variable Bit Rate Audio and Video
- Service Class C: Connection-oriented data transfer
- Service Class D: Connectionless data transfer

Of the latter classes, class C is intended for services such as Frame Relay, whilst class D is intended for switching IP and CLNP traffic. The actual semantics of these classes may also vary between service providers.

The QoS class may also be “unspecified” which may be a default or “best efforts” QoS.

3.4 ATM Services

In practice, the underlying physical service and the use of the ATM Layer, management and control plane functions will be chosen/specified when connecting to an ATM Service Provider or installing a private ATM Network. There may be variations between different services. However, the ATM Forum’s User Network Interface (UNI) specification provides an important benchmark for interoperability, and compliance with it will be mandatory in most cases. The main issues left open are:

- The Adaptation Layers used in the User Plane
- The Quality of Service class and cell rates specified for each PVC and SVC
- Use of Congestion Notification information (this is added to an ATM cell by a Cell Switch).

3.5 ATM and Internetworking

ATM has already been used to support a number of internetworking services, these include LAN Emulation (LANE), and supporting IP internetworks.

3.5.1 LAN Emulation (LANE)

LANE aims to use ATM services to form a “virtual LAN” that appears as a set of logical shared medium LANs interconnected via routers. A shared LAN is emulated by setting up an ATM multicast group between all of the nodes that belong to the same logical LAN. For data transfer between nodes, an address resolution server is used to translate MAC address to an ATM address and then a point-to-point virtual channel is established between the nodes. Main disadvantages of this solution are the use of routers for transferring data within same physical ATM LAN and servers being single point of failures. There is also no opportunity to vary the QoS for different data streams within the emulated LAN.

An extension to LANE has also been proposed by ATM Forum. This is Multi-Protocol Over ATM (MPOA) MPOA uses a “Next Hop Resolution Protocol” (NHRP) to resolve the ATM address of an exit point closest to destination and provide direct layer 3 connectivity across an ATM fabric. It also includes protocols to replicate servers and distribute the database for reasons of capacity and availability.

3.5.2 IP and ATM

IETF RFC 1483 provides a baseline for the use of ATM in IP internetworks and a generic multi-protocol encapsulation scheme for use with other protocols such as CLNP. IETF RFC 1577 builds upon this to propose an IP over ATM (IPOA) approach to using an ATN as an IP subnetwork.

RFC 1483 specifies the use of AAL 5 with a null SSCS, and requires that each packet is encapsulated within a modified IEEE 802.2 LLC1 header (i.e. an Ethernet header less the source and destination MAC Addresses). Different values of the LSAP-id fields are used to introduce different packet formats. The RFC defines the encapsulation of OSI protocols, of IP and of LAN protocols.

The scheme is sufficient to transport IP packets over an ATM network. However, it often regarded as inefficient in use as, in a large ATM deployment, a packet may transit the same ATM network several times as it is passed from Router to Router. To avoid this overhead, several schemes have been proposed such as IP Switching (Ipsilon Networks

Inc.) and Tag Switching (Cisco Systems Inc.). These proprietary schemes involve the ATM switch itself in recognising data flows and routing the packets between different virtual circuits. In the former case, the ATM switches recognise IP packets, make cached routing decisions and then perform routing on further packets on the same data flow without having to perform packet re-assembly. In the latter, the flow recognition is done by external routers which communicate this information to the ATM switches.

4. Requirements Analysis

The basic requirement is to enable ATN End Systems and Routers to exchange CLNP, ES-IS and eventually IS-IS PDUs over an ATM subnetwork. This is primarily in support of the existing single cast connectionless network service, but should be extensible to support a future multicast connectionless network service. This is to be done whilst respecting the prioritisation of ATN PDUs, ATSC Classes and Congestion Avoidance mechanisms.

LAN Emulation could provide a “low cost” and straightforward way to achieve this, without having to add any ATM support to ATN Systems (the existing LAN interface is used). However, this gives no scope for QoS management, for recognising data priority or for Congestion Avoidance. Mixing ATN and non-ATN data could give rise to undesirable effects with non-ATN data being transported at the expense of ATN data for purely statistical reasons. LAN Emulation is thus ruled out for ATN use.

IETF RFC 1483 appears to offer a useful starting point for ATN use of ATM, with the AAL5 Common Part being used to transport CLNP, ES-IS and IS-IS PDUs over an ATN virtual circuit. In fact AAL5 alone is probably sufficient. RFC 1483 proposes an additional five octet multiple protocol encapsulation header. However, CLNP, ES-IS and IS-IS PDUs are all distinguishable from each other by inspection of the initial octet - a Network Layer Protocol Identifier, and there are unlikely to be any circumstances under which ATN data is required to share the same ATM virtual circuit with non-ATN data using a non-ATN protocol (the purpose of the additional header). There would seem to be little benefit in development of the traffic management algorithms needed to do this in order to give ATN data a higher priority. By not including such encapsulation in the specification, it is explicitly ruled out and avoids the risk of ATN and non-ATN data sharing the same virtual circuit by error in system configuration.

4.1 Circuit Type

ATM virtual circuits may be either PVCs or SVCs and both types may be used by the ATN. In practice, the Network Designer will identify the need for virtual circuits and the capacity requirements of each one. As the data flows in the ground ATN internet will be predictable and fairly static, PVCs may be expected to be the dominant type with SVCs mostly being used for perhaps backup purposes or when the tariff does not favour a PVC (e.g. when the load varies significantly during each day).

However, early ATM public networks appear to be limited to PVCs with CBR and VBR as the only grades of service offered. Use of ATM may be limited to such services in the near term.

The relationship between priority and the throughput characteristics of the virtual circuit need to be considered carefully. Variable Bit Rate services are really intended for applications such as voice or compressed video, while Available Bit Rate (ABR) services are more appropriate for data transfer. However, under ABR, if traffic load exceeds the guaranteed bit rate, there is a risk of cell loss. This is a problem as, while the outgoing queues can be ordered by priority, the underlying ATM service has no way of determining which cells contain the higher priority data - except through the single but “Cell loss priority” field. This is probably too limited to express the ATN priority requirement.

Instead, an approach that performs traffic management using packet priority is foreseen. An ABR virtual circuit may be established between two ATN Systems with sufficient capacity to handle the foreseen load from safety related applications. However, as long as that load is not exceeded that circuit may be used for all priorities with the outgoing queue priority ordered. Indeed, the sending system should limit the transmission rate to ensure that the guaranteed bit rate is never exceeded.

This may result in the queue becoming arbitrarily long if the actual load (due to non-safety data) exceeds the ABR. To avoid the excessive delay that this implies, the low priority messages should, in such a situation, be diverted to another circuit between the same pair of systems. This may be a PVC or an SVC brought into use when the queue reached a certain length. It may be an ABR circuit - or even an Unspecified Bit Rate (UBR) circuit in order to keep costs down. Only low priority data will use this circuit and therefore data loss can be tolerated.

ABR can thus be effectively used for ATN services and ought to be the most cost effective use of ATM for ATN. However, as early ATM services will often be limited to CBR and VBR PVCs, interim use of these services must also be considered.

CBR services are likely to be costly in comparison to ABR but may still be less expensive than a leased line of a similar capacity. The CBR characteristic will be very similar to a leased line. However, the service provider will expect a constant rate of cell transmission and this could be difficult to arrange without specialised hardware. CBR is thus not considered further.

VBR services should be less costly than CBR and it should be possible to use them without specialised hardware. They are thus preferred for interim use. Cell transmission rate monitoring and limiting will be necessary, as with ABR. However, unlike ABR, the "sustainable cell rate" is not a limit that should not be exceeded, and it will be acceptable for the transmission rate to exceed the sustained rate as long as it does not exceed the peak rate and the burst of cells above the sustained call rate does not exceed the maximum burst.

The simplest strategy for VBR use is to regard the "sustained cell rate" as the same as the ABR available bit rate. However, the sustained cell rate is meant to be the typical cell rate and the user could then easily end up paying for capacity that is not used. The sustained cell rate should really reflect the average cell rate, with the peak cell rate being the genuine peak rate - which must not be exceeded.

The implementation will thus need to monitor the outgoing cell rate to ensure that the peak cell rate is not exceeded and that the burst above the sustained cell rate does not exceed the contracted maximum burst size. If the data load exceeds these limits then flow rate limitation will have to be applied, as with ABR. A key difference will be that there is no opportunity to open up new circuits as it is assumed that only PVCs are available.

Circuit QoS is another issue and may be related to the ATSC Class requirement. Currently, ATM offers limited QoS choices and the practical choice is between service classes C or D. A Network Designer will need to look at the QoS offered by these classes from a service provider and make an appropriate mapping to ATSC Class. This may result in two ABR circuits between a pair of ATN Systems, each capable of supporting high priority data but made available to traffic belonging to different ATSC Classes.

4.2 Intra-domain Use of ATM

Within a Routing Domain, an ATM network may be used in conjunction with both ES-IS and IS-IS Routing Information Exchange Protocols.

When End Systems communicate with each other and a Router using an ATM subnetwork, they will need to know *a priori* the ATM location of at least one Router. This may be accessed over a PVC or via an SVC to a known ATM Address. ES-IS Configuration information may be used in such a scenario to perform confirmation of identification. However, it has no other role. On the other hand, ES-IS Redirection Information may be usefully used when an End System sends an NPDU to the Router and the destination is another End System on the same ATM Network. In such a case, the Router may forward the NPDU but also inform the sender of the actual ATM Address of the destination End System. An SVC can then be opened for direct communication with that system or an existing circuit utilised. Redirection Information may similarly be used to redirect an End System to another Router on the same ATM network that offers a more direct route to the destination.

With IS-IS, the ATM scenario need be no different from X.25. ATM VCs are set up between Routers as "Static circuits" for both routing information and user data exchange, and other circuits may be brought into use as "dynamic circuits".

4.3 Inter-Domain use of ATM

In the Inter-Domain environment, BISs may be readily interconnected by ATM virtual circuits and exchange routing information in such a manner. Furthermore, when several such Routers are interconnected over the same ATM Network, "next hop" information may also be exchanged between routers so that data PDUs may take the most optimal route through the network with the BISs operating as Route Servers.

This is a very likely scenario for the ATN. Routers belonging to several Administrations and Service Providers may be connected to the same ATM Network with adjacencies limited to Administration to Service Provider only i.e. no BIS-BIS connections between Administrations. However, when the Service Providers relay routes, each route to a given destination on the same ATM network contains the "next hop" i.e. the ATM Address of the Administration's BIS. This permits data PDUs to be sent direct (Administration to Administration) over an existing PVC or an SVC established for this purpose.

4.4 Optimisation

The IP has seen the need to optimise the use of ATM through technologies such as "IP Switching". Is such an optimisation appropriate or needed for ATN?

The IP environment is noticeably different to the ATN environment. The data flows in IP are not necessarily predictable and can vary enormously depending on who wants to communicate with whom. There is also less opportunity in many of the IP Routing Protocols for redirection (as in ES-IS). On the other hand, in the ATN, traffic flows are and need to be predictable. Virtual circuits can therefore be established to represent most required and direct data flows. Furthermore, the Redirection mechanisms in ES-IS and the Route Server concept in IDRP can be used to ensure that direct virtual circuits are used, if necessary bypassing Routers altogether.

However, IS-IS has not got a suitable mechanism to convey Inter-Domain "Next_Hop" information to the intra-domain, or between Level 1 and Level 2 Routing Areas. Thus, when the systems in a Routing Domain are interconnected by ATM, IS-IS is used, and the same ATN network is used by other Routing Domains, NPDUs must still transit through the BIS when passing between Routing Domains. However, this can be avoided if, in such cases, IS-IS is not used and ES-IS is used by End Systems to communicate with BISs directly. In such a scenario this should be adequate.

Therefore, there seems to be few occasions when something like IP Switching would be appropriate to the ATN. Indeed, the complexities of managing ATN Priority as well, would probably make such a scheme even more complex.

4.5 Data Compression

The ATN SARPs have already defined a "Mobile SNDCF" which can negotiate three different data compression algorithms for use over an X.25 virtual circuit. This is primarily in support of Air/Ground Communications over low bandwidth data links. However, it is available for use over ground X.25 circuits as well. The question is should such data compression schemes also be available for use over ATM as well?

The simple answer is why not? Use of compression could translate into substantial bandwidth savings, and the data compression schemes should be available for use if required. This implies that some sort of negotiation is needed over SVCs, when the SVC is established - as is already required for X.25. However, such an exchange of PDUs also necessary to resolve simultaneous attempts by both sides to establish an SVC.

5. Formal Specification

5.1 Overview

Note 1.—This specification is for a Subnetwork Dependent Convergence Function (SNDCF) for use of a Broadband ISDN (B-ISDN) compliant with ITU specifications for the Asynchronous Transfer Mode (ATM).

Note 2.—Such a network provides Permanent Virtual Circuit (PVC) services and, optionally, Switched Virtual Circuit (SVC) services, with limited but deterministic throughput and Quality of Service guarantees.

Note 3.—The architecture for access to an ATM network is illustrated in Figure 3-1, which also illustrates the positioning of the SNDCF within this architecture. The SNDCF is formally positioned as a Higher Layer function in the User Plane i.e. a user of ATM network services, with access to the cell switched ATM network being performed through ATM Adaptation Layer 5, and an appropriate physical layer service. When SVC services are supported, connection management and control is performed in a separate plane - the control plane - i.e. Out-of-Band through an exchange of messages between the ATM Service provider and the user according to ITU-T Recommendation Q.2931. Q.2931 messages are transferred over ATM cell switched services by the Signalling ATM Adaptation Layer (SAAL). Other information related to (e.g.) fault and performance management are exchanged through ATM cells transferred in the Management Plane i.e. out-of-band of both user and control messages.

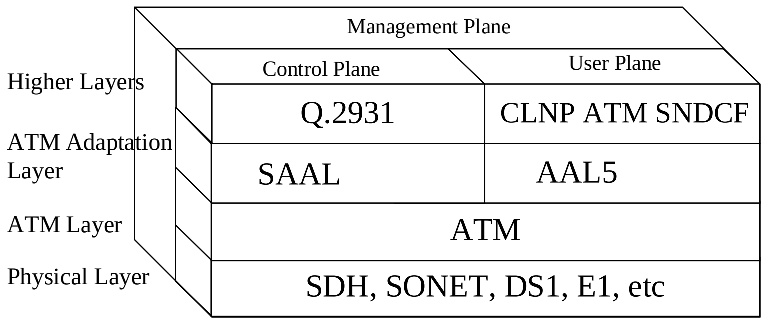

Figure 5-1 ATM Architecture

Note 4.—The ATM Forum's User Network Interface (UNI) Specification provides an industry standard and guidance on access to ATM networks including physical layer services, the control and management planes

Note 5.—Although an Available Bit Rate (ABR) service is the preferred ATM Service for use with the ATN, it is expected that early public ATM Services will be limited to Constant Bit Rate (CBR) and Variable Bit Rate (VBR) services only. For this reason, this specification also defines the use of VBR services..

5.2 The ATN Physical Layer

Note.—The physical layer service is beyond the scope of this specification, and may be any suitable physical layer service.

5.3 The ATM Layer

The ATM Layer shall be in compliance with ITU-T Recommendation I.361.

Note.—ATM Cells exchanged in the context of the Control and Management Planes are beyond the scope of the specification and may vary between different ATM Networks.

5.4 The ATM Adaptation Layer

ATM Adaptation Layer 5 (AAL5) as specified in ITU-T Recommendation I.363 shall be used to transfer SN-Unitdata over an ATM compliant network. The Segmentation and Reassembly Sublayer (SAR) and the AAL5 Common Part Convergence Sublayer (CPCS) shall be as specified in I.363. The Service Specific Convergence Sublayer (SSCS) shall be null.

Note 1.—This means that AAL5 is used to perform the necessary segmentation/reassembly of PDUs for transport of variable length PDUs in fixed length cells, and also provides for a CRC data integrity check.

Note 2.—The CPCS-Unitdata message mode service as described in I.363 is the service assumed to be available to the ATM SNDCF.

The Common Part Indicator (CPI) field of the AAL5 CP trailer shall always be set to zero.

5.5 Virtual Circuit Management

Note 1.—Either PVC or SVC services may be used, the choice is a local matter and depends upon availability and cost considerations.

Note 2.—A network manager will need to specify the contractually provided throughput and QoS for PVCs and will similarly need to specify the throughput and QoS to be requested on SVC establishment. The source of the throughput and QoS requirements in both cases is assumed to be a network model used for capacity planning and availability prediction. Although SVCs may be established for dynamic reasons, no dynamic calculation of throughput or QoS requirements is assumed.

Virtual circuits used to support ATN data shall provide ~~either~~ a Variable Bit Rate (VBR), an Available Bit Rate (ABR) service and/or an Unspecified Bit Rate (UDR) service. UBR services shall only be used for data that is not safety related i.e. the CLNP priority is less than six.

Note 3.—VBR use is intended only when ABR services are not available and its use is deprecated whenever ABR services are available.

Note 4~~3~~.—It is the responsibility of the network manager to ensure that the Available Bit Rate is sufficient to meet the throughput requirements of safety related applications.

Note 5~~4~~.—The Quality of Service class requested is out of scope of this specification. The ATM Quality of Service class requested for a given virtual circuit may have a direct relationship with the ATSC class of routes that pass over such a virtual circuit. However, as the service class semantics can vary between service providers, it is not possible to state such a relationship in this specification.

5.5.1 Data Compression - PVC

Note.—By bilateral agreement, a PVC may support any of the data compression algorithms specified in section 5.7.6 of the ATN SARPs. When this is agreed by the Network Managers responsible for the systems communicating over the SVC then all user data sent over that PVC will be compressed using the agreed algorithms.

If any of data compression algorithms specified in section 5.7.6 of the ATN SARPs are agreed for use by the Network Managers responsible for the ATN Systems communicating over an ATM PVC, then all NPDUs sent over the PVC shall be compressed according to the agreed algorithm(s).

5.5.2 SVC Connection Establishment

An SVC shall be established either by (a) a Systems Management procedures, or (b) dynamically on demand.

5.5.2.1 Connection Initiation Procedures

Once an SVC has been established, the connection initiator shall format and send a Call Negotiation PDU as illustrated in Figure 5-2.

1100 0001							
Length Indicator							
Version Number							
SNCR (Low Octet)							
SNCR (High Octet)							
S	ACA	S	M/I	S	D	LREF	CAN
Max. Number of Directory Entries (Low Octet)							
Max. Number of Directory Entries (High Octet)							

Figure 5-2 Format of Call Negotiation PDU

The format and semantics of each field shall be as specified in section 5.7.6.2.1.5 of Subvolume 5 of the ATN SARPs.

Note 1.—The Call Negotiation PDU is sent in order to resolve call collisions and to negotiate the use of data compression algorithms on this SVC

Note 2.—Only the negotiation of data compression is mandatory, the implementation of data compression procedures is optional..

The Call Negotiation PDU shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0001.

Following the transmission of the Call Negotiation PDU, the connection initiator shall start a timer t_1. If this timer expires before the Call Negotiation Response PDU is received (see 5.5.2.2), the Call Negotiation PDU shall be retransmitted. If the Call Negotiation PDU is retransmitted n_1 times without a response then the SVC shall be terminated.

Note 2—The actual values of t_1 and n_1 depend upon the actual round trip delay, are determined locally and are outside of the scope of this specification.

When the Call Negotiation PDU is received, the connect initiator shall format and send a Call Negotiation Complete PDU. This is a zero length message and The Call Negotiation PDU shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0003.

All user data shall be sent according to the agreed data compression procedure(s), if any, as indicated on the Call Negotiation Response PDU. The connection initiator shall not send any user data until the Call Negotiation Response PDU has been received.

If a duplicate Call Negotiation Response PDU is later received, this shall be discarded, and a further Call Negotiation Complete PDU returned to the connection responder.

5.5.2.2 Connection Responder Procedures

When the connection responder receives the connection initiator’s Call Negotiation PDU, the connection responder shall determine which, if any of the proposed data compression algorithms are supported, and of these, which to accept. The connection responder shall then format and send a Call Negotiation Response PDU.

S	ACA	S	M/I	S	D	LREF	CAN

Figure 5-3 Call Negotiation Response PDU

The format and semantics of each field shall be as specified in section 5.7.6.2.2.3 of Subvolume 5 of the ATN SARPs.

Note.—The Call Negotiation Response PDU is sent in order to complete the negotiation of the use of data compression algorithms on this SVC.

The Call Negotiation PDU shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0002.

The data compression algorithms used, if any, shall be those identified in the Call Negotiation Response PDU.

Following the transmission of the Call Negotiation Response PDU, the connection initiator shall start a time t_2. If this timer expires before the Call Negotiation Complete PDU is received, the Call Negotiation Response PDU shall be retransmitted. If the Call Negotiation Response PDU is retransmitted n_2 times without a response then the SVC shall be terminated.

Note 2—The actual values of t_2 and n_2 depend upon the actual round trip delay, are determined locally and are outside of the scope of this specification.

All user data shall be sent according to the agreed data compression procedure(s), if any. The connection responder shall not send any user data until it has received the Call Negotiation Complete PDU. Duplicate Call Negotiation Complete PDUs shall be ignored.

5.5.3 SVC Network Reset Simulation

Note.—Under certain error conditions, the data compression algorithms require that a Network Reset is generated in order to re-synchronise the compression algorithm. Such a function is not explicitly provided under AAL5. The following procedure is used to simulate a network reset.

5.5.3.1 Procedure for Network Reset Request

When a Network Reset is required to be performed by the data compression algorithm, all outgoing user data queued for transmission shall be discarded and a Network Reset PDU formatted and sent over the virtual circuit. The Network Reset PDU shall comprise a single octet containing the diagnostic code. The Network Reset PDU shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0004.

Note 1.—The resetting cause is implicitly DTE originated.

Following the transmission of the Network Reset PDU, the reset requestor shall start a timer t_1. If this timer expires before the Network Reset Confirm PDU is received, the Network Reset PDU shall be retransmitted. If the Network Reset PDU is retransmitted n_1 times without a response then the SVC shall be terminated.

Note 2—The actual values of t_1 and n_1 depend upon the actual round trip delay, are determined locally and are outside of the scope of this specification.

When the Network Reset Confirm PDU is received, the reset requestor shall format and send a Network Reset Complete PDU. This is a zero length message and the Call Negotiation PDU shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0005.

All user data received over the SVC shall be ignored until the Network Reset Confirm PDU is received.

5.5.3.2 Procedures for Network Reset Confirm

When a Network Reset Request PDU is received, this event shall be notified to the service user, and all outgoing user data queued for transmission shall be discarded.

Note 1.—The service user is required to confirm the reset or terminate the virtual circuit. Any user data sent before the reset is confirmed may be discarded to transmitted. However, the result will be the same as it will be ignored by the receiver.

When the service user confirms the network reset, a Network Reset Confirm PDU shall be formatted and sent over the ATM Virtual Circuit. The Network Reset Confirm PDU shall comprise a zero length user data component,. and shall be sent over an ATM virtual circuit using the CPCS-UNITDATA invoke service with:

a) The Cell Loss Priority set to “High Priority”.

b) The User-to-user indication set to 0000 0006.

Following the transmission of the Network Reset Confirm PDU, the sender shall start a timer t_2. If this timer expires before the Network Reset Complete PDU is received, the Network Reset PDU shall be retransmitted. If the Network Reset PDU is retransmitted n_2 times without a response then the SVC shall be terminated.

Note 2—The actual values of t_2 and n_2 depend upon the actual round trip delay, are determined locally and are outside of the scope of this specification.

Between the transmission of the Network Reset Confirm PDU and the receipt of the Network Reset Complete PDU, any user data received from the service user shall be queued for transmission but shall not be sent until the Network Reset Complete PDU has been received. Any user data received over the ATM virtual circuit shall be passed to the service user.

5.5.4 SVC Connection Termination

An SVC shall be terminated either by (a) a Systems Management procedure, or (b) dynamically due to no use over a period specified by a Network Manager.

5.6 Traffic Management

Virtual circuits used to transfer higher priority (six or greater) traffic shall be given preferential access to the ATM service - i.e. provided the maximum permitted data rate for the circuit has not been exceeded, the use of a given ATM cell for user data on such a virtual circuit shall be preferred over a virtual circuit that is not used to transport safety related data.

5.6.1 Use of the Variable Bit Rate Service

When a virtual circuit providing a VBR service is used:

a) the contractually agreed *sustainable cell rate* shall be sufficient to support at least the expected average data transfer rate.

b) The *peak cell rate* shall be sufficient to support the expected maximum data transfer rate

c) The maximum burst size shall be sufficient to support a typical period when the data transfer rate exceeds the sustainable cell rate.

Note 1.—In practice, service provider limitations may be such that ideal values for these parameters may not be possible. Users of VBR services are expected to provide a relatively continuous data stream with occasional peaks and troughs rather than the more variable data stream typical of true data transfer. Therefore, the maximum difference between sustainable and peak cell rates may be smaller than that required. In such a case, the sustainable cell rate will have to be set at a higher value than is optimal.

When a virtual circuit providing a VBR service is used to transfer higher priority (six or greater) traffic, the ATM SNDCF shall limit the rate at which PDUs are transferred such that:

a) the *peak cell rate* is never exceeded

b) the number of cells sent at a rate higher than the *sustainable cell rate* does not exceed the *maximum burst size*.

Note 2.—this is to avoid loss through discard of safety related data.

5.6.2 Use of the Available Bit Rate Service

When a virtual circuit providing an ABR service is used to transfer higher priority (six or greater) traffic, the ATM SNDCF shall limit the rate at which PDUs are transferred such that the ABR is never exceeded.

Note.—this is to avoid loss through discard of safety related data.

~~Virtual circuits used to transfer higher priority (six or greater) traffic shall be given preferential access to the ATM service - i.e. provided the ABR for the circuit has not been exceeded, the use of a given ATM cell for user data on such a virtual circuit shall be preferred over a virtual circuit that is not used to transport safety related data.~~

Recommendation.—When the same ATM Virtual Circuit is used for safety and non-safety data (i.e. all ATN priorities) and lower priority traffic becomes subject to delay (due to the ABR being taken up by safety related data), then the lower priority traffic should be transferred to an alternative virtual circuit to the same destination and which is not used for safety related data.

Note.—The purpose of this recommendation is to allow lower priority data to be sent in such circumstances, albeit at the risk of discard if the other circuit's ABR is exceeded, or if it provides only a UBR service. This procedure will ensure that safety related data can be given delivery guarantees, whilst non-safety data can be used for the remaining ABR, or, if none is available, can still be sent over a lower tariff UBR circuit or perhaps an ABR circuit dynamically established during periods of peak load but which is not subject to the traffic management requirements of a circuit that supports safety related data.

5.6.3 Use of the Unspecified Bit Rate Service (UBR)

A virtual circuit providing the UBR Service shall only be used for non-safety related data.

Note. No service guarantees are offered by UBR and traffic management, if any, is at the discretion on the Network Manager.

5.7 SN Service Provision

5.7.1 The SN-UNITDATA.Request

Note 1.—The parameters of the SN-UNITDATA.request include the user data, its priority, ATSC Class and destination (either an ATM NSAP Address of an existing multicast circuit identifier).

Note 2.—The SN-UNITDATA item can be any network layer PDU including CLNP, ES-IS and IS-IS PDUs.

If the destination of an SN-UNITDATA item is an ATM NSAP Address, then the ATM SNDCF shall locate, if possible an existing virtual circuit to that destination that meets the service requirements implied by its priority and ATSC Class. If no such virtual circuit is available and the SVC service is provided and its use is permitted by a Network Manager, then a suitable virtual circuit shall be established. The SN-UNITDATA items shall be queued for transfer over the virtual circuit.

If the destination of an SN-UNITDATA item is a multicast circuit identifier then the SN-UNITDATA item shall be queued for transfer over this virtual circuit.

In both cases, the outgoing queues shall be maintained in priority order.

When an SN-UNITDATA item is sent over an ATM virtual circuit, the CPCS-UNITDATA invoke service shall be used as follows:

a) The Cell Loss Priority shall be set to “High Priority”.

b) The User-to-user indication shall be set to zero.

5.7.2 The SN-UNITDATA.Indication

Note.—The CPCS-UNITDATA signal service indicates delivery, without error, of an incoming NPDU from the AAL5.

In response to a CPCS-UNITDATA signal service event reporting NPDU delivery, the ATM SNDCF shall inspect the first octet (i.e. the Network Layer Protocol Identifier) of the user data and determine the network layer protocol. If an SN Service User exists that accepts the indicated protocol then the NPDU shall be delivered to that user as an SN-UNITDATA.Indication, and otherwise discarded.

If the CP-CS-UNITDATA signal service reports a CPCS Congestion Indication then this shall be reported to the SN Service User. If the SN Service User is CLNP then the Congestion Experience “bit” in the CLNP header shall be set to one if the CPCS Congestion Indication reports congestion.

5.7.3 Point to Multipoint Virtual Circuit Management

Note.—When a multicast distribution tree for a Group NSAP Address is maintained by a Router and copies of NPDUs sent to that Group are to be distributed to more than one ATN System on the same ATM Network, then a point-to-multipoint ATM virtual circuit may be established to support this distribution. Such a virtual circuit is established and maintained by the Routing Decision process through a separate interface to the ATM SNDCF. NPDUs to be distributed over such a virtual circuit will include a local circuit identifier rather than an ATM NSAP Address as the destination field of the SN-UNITDATA request.

For the purposes of point to multipoint virtual circuit management, the ATM SNDCF shall provide a local interface supporting the following functions:

a) Creation of a point to multipoint virtual circuit and the assignment of a local identifier to this virtual circuit.

b) Adding a new destination (expressed as an ATM NSAP Address) to an existing point to multipoint virtual circuit.

c) Removing a destination (expressed as an ATM NSAP Address) from an existing point to multipoint virtual circuit.

d) Termination of a point to multipoint virtual circuit.

It shall be possible to send an NPDU over a point to multipoint virtual circuit by using the local identifier as the destination of an SN-UNITDATA request.