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ATM Signaling Support for IP over ATM

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Abstract

This memo describes the ATM call control signaling exchanges needed to support Classical IP over ATM implementations as described in RFC 1577 [LAUB94]. ATM endpoints will incorporate ATM signaling services as specified in the ATM Forum User-Network Interface (UNI) Specification Version 3.1 [ATMF94]. IP over ATM implementations utilize the services of local ATM signaling entities to establish and release ATM connections. This memo should be used to define the support required by IP over ATM implementations from their local ATM signaling entities.

This document is an implementors guide intended to foster interoperability among RFC 1577, RFC 1483, and UNI ATM signaling. It applies to IP hosts and routers which are also ATM endsystems and assumes ATM networks that completely implement the ATM Forum UNI Specification Version 3.1. Unless explicitly stated, no distinction is made between the Private and Public UNI.

UNI 3.1 is considered an erratum to the UNI 3.0 specification. It has been produced by the ATM Forum, largely for reasons of alignment with Recommendation Q.2931. Although UNI 3.1 is based on UNI 3.0 there are several changes that make the two versions incompatible. A description of how to support IP over ATM using UNI 3.0 is found in Appendix B.

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1. Conventions

The following language conventions are used in the items of specification in this document:

- o MUST, SHALL, or MANDATORY -- the item is an absolute requirement of the specification.

- o SHOULD or RECOMMEND -- this item SHOULD generally be followed for all but exceptional circumstances.

- o MAY or OPTIONAL -- the item is truly optional and MAY be followed or ignored according to the needs of the implementor.

2. Overview

In a Switched Virtual Connection (SVC) environment, ATM virtual channel connections (VCCs) are dynamically established and released as needed. This is accomplished using the ATM call/connection control signaling protocol, which operates between ATM endsystems and the ATM network. The signaling entities use the signaling protocol to establish and release calls (association between ATM endpoints) and connections (VCCs). Signaling procedures include the use of addressing to locate ATM endpoints and allocation of resource in the network for the connection. It also provides indication and negotiation between ATM endpoints for selection of end-to-end protocols and their parameters. This memo describes how the signaling protocol is used in support of IP over ATM, and, in particular, the information exchanged in the signaling protocol to effect this support.

IP address to ATM address resolution and routing issues are not in the scope of this memo, and are treated as part of IP in figure 1.

```
+--------------+     +------+     +----------+
|              |     |      |<--->| IP / ARP |
|              |<--->| This |     | RFC 1577 |
|    ATM       |     | Memo |     +----------+
|  signaling   |     |      |<--->| RFC 1483 |
|              |     +------+     +----------+
|              |   ------------->  |  AAL 5   |
|              |                   +----------+
|              |   ------------->  |   ATM    |
+--------------+                   +----------+
```

Figure 1.
Relationship of this memo to IP, RFC 1483,
ATM signaling, ATM and AAL5

3. Use of Protocol Procedures

The following requirements are motivated to provide implementation guidelines on how multiple ATM connections between peer systems SHOULD be managed, to prevent connection thrashing and related problems.

3.1. VC Establishment

The owner of an existing VCC is defined to be the entity within the ATM endsystem that establishes the connection. An ATM endsystem MAY establish an ATM call when it has a datagram to send and either there is no existing VCC that it can use for this purpose, it chooses not to use an existing VCC, (e.g., for reasons of route optimization or quality of service), or the VCC owner does not allow sharing.

To reduce the latency of the address resolution procedure at the called station, the following procedure MAY be used:

If a VCC is established using the LLC/SNAP encapsulation, the calling endstation of the VCC MAY send an InARP_REQUEST to the called endstation after the connection is established (i.e. received a CONNECT message) and before the calling endstation sends the first data packet. In addition, the calling endstation MAY send its data packets without waiting for the InARP_REPLY. An endstation MAY respond, generate, and manage its ATMARP table according to the procedures specified in RFC1293 [BRAD92], Section 7, "Protocol Operation", during the life time of the VCC.

To avoid establishing multiple VCCs to the same endstation, a called endstation MAY associate the calling party number in the SETUP message with the established VCC. This VCC MAY be used to transmit data packets destined to a endstation whose ATMARP resolution results in an ATM address that is the same as the associated calling party number. Sharing of VCCs is subject to the policies configured at the endstation as described in section 4.3 of this recommendation.

3.2. Multiprotocol Support on VCs

When two ATM endsystems run multiple protocols, an ATM connection MAY be shared among two or more datagram protocol entities, as long as the VCC owner allows sharing and if the encapsulation allows proper multiplexing and demultiplexing (i.e. the LLC/SNAP encapsulation). This indication of sharing a VCC MAY be by configuration or via an API. Similarly, the Internet layer supports multiplexing of multiple end-to-end transport sessions. To properly detect idle connections while sharing a VCC among more than one higher layer protocol entities, the ATM endsystem MUST monitor the traffic at the lowest multiplexing layer.

3.3. Support for Multiple VCs

An ATMARP server or client MAY establish an ATM call when it has a datagram to send and either there is no existing VCC that it can use for this purpose, it chooses not to use an existing VCC, or the owner of the VCC does not allow sharing. Note that there might be VCCs to the destination which are used for IP, but an ARP server might prefer to use a separate VCC for ARP only. The ATMARP server or client MAY maintain or release the call as specified in RFC 1577. However, if the VCC is shared among several protocol entities, the ATMARP client or server SHALL NOT disconnect the call as suggested in RFC 1577.

Systems MUST be able to support multiple connections between peer systems (without regard to which peer system initiated each connection). They MAY be configured to only allow one such connection at a time.

If a receiver accepts more than one call from a single source, that receiver MUST then accept incoming PDUs on the additional connection(s), and MAY transmit on the additional connections. Receivers SHOULD NOT accept the incoming call, only to close the connection or ignore PDUs from the connection.

Because opening multiple connections is specifically allowed, algorithms to prevent connection call collision, such as the one found in section 8.4.3.5 of ISO/IEC 8473 [ISO8473], MUST NOT be implemented.

While allowing multiple connections is specifically desired and allowed, implementations MAY choose (by configuration) to permit only a single connection to some destinations. Only in such a case, if a colliding incoming call is received while a call request is pending, the incoming call MUST be rejected. Note that this MAY result in a failure to establish a connection. In such a case, each system MUST wait at least a configurable collision retry time in the range 1 to 10 seconds before retrying. Systems MUST add a random increment, with exponential backoff.

3.4. VC Teardown

Either endsystem MAY close a connection. If the connection is closed or reset while a datagram is being transmitted, the datagram is lost. Systems SHOULD be able to configure a minimum holding time for connections to remain open as long as the endpoints are up. (Note that holding time, the time the connection has been open, differs from idle time.) A suggested default value for the minimum holding time is 60 seconds.

Because some public networks MAY charge for connection holding time, and connections MAY be a scarce resource in some networks or endsystems, each system implementing a Public ATM UNI interface MUST support the use of a configurable inactivity timer to clear connections that are idle for some period of time. The timer’s range SHOULD include a range from a small number of minutes to "infinite". A default value of 20 minutes is RECOMMENDED. Systems which only implement a Private ATM UNI interface SHOULD support the inactivity timer. If implemented, the inactivity timer MUST monitor traffic in both directions of the connection.

4. Brief Overview of UNI Call Setup Signaling Procedures and Messages

This section provides a summary of point-to-point signaling procedures. Readers are referred to [ATMF93].

UNI signaling messages used for point-to-point call/connection control are the following:

Call Setup	Call Release
SETUP	RELEASE
CALL PROCEEDING	RELEASE COMPLETE
CONNECT	
CONNECT ACKNOWLEDGE	

An ATM endpoint initiates a call request by sending a SETUP message to the network. The network processes the call request to determine if the call can be progressed. If so, the network indicates the value of the newly allocated VPCI/VCI in its first response to the the SETUP message, which is either a CALL PROCEEDING or CONNECT message. If a call cannot be accepted, by the network or destination ATM end-point, a RELEASE COMPLETE is sent. At the destination ATM endpoint, the network offers the call using the SETUP message. If the destination endpoint is able to accept the call, it responds with a CONNECT message (which MAY be preceded by a CALL PROCEEDING); otherwise, it sends a RELEASE COMPLETE message. See Appendix A, Section 2 for guidance on the use of the CALL PROCEEDING message.

Call release can be initiated by either endpoint or (rarely) by the network. When an endpoint wishes to release a call, it sends a RELEASE message to the network. The network responds with a RELEASE COMPLETE message, frees up resources associated with the call, and initiates clearing toward the other endpoint. The network initiates clearing by sending a RELEASE message to the ATM endpoint, which reponds by sending a RELEASE COMPLETE message. Upon receipt of the RELEASE COMPLETE message, the network frees any resources associated with the call.

5. Overview of Call Establishment Message Content

Signaling messages are structured to contain mandatory and optional variable length information elements (IEs). IEs are further subdivided into octet groups, which in turn are divided into fields. IEs contain information related to the call, which is relevant to the network, the peer endpoint or both. Selection of optional IEs and the content of mandatory and optional IEs in a call establishment message determines the parties to and nature of the communication over the ATM connection. For example, the call establishment message for a call which will be used for constant bitrate video over AAL 1 will have different contents than a call which will be used for IP over AAL 5.

A SETUP message which establishes an ATM connection to be used for IP and multiprotocol interconnection calls MUST contain the following IEs:

AAL Parameters
ATM Traffic Descriptor
Broadband Bearer Capability
Broadband Low Layer Information
QoS Parameter
Called Party Number
Calling Party Number

and MAY, under certain circumstance contain the following IEs:

Calling Party Subaddress
Called Party Subaddress
Transit Network Selection

In UNI 3.1, the AAL Parameters and the Broadband Low Layer Information IEs are optional in a SETUP message. However, in support of IP over ATM these two IEs MUST be included. Appendix A shows an example SETUP message coded in the manner indicated in this memo.

6. Information Elements with Endpoint to Endpoint Significance

This section describes the coding of, and procedures surrounding, information elements in a SETUP message with significance only to the endpoints of an ATM call supporting IP.

6.1. ATM Adaptation Layer Parameters

The AAL Parameters IE (see section 5.4.5.5 and Annex F of [ATMF93]) carries information about the ATM Adaptation Layer (AAL) to be used on the connection. RFC 1483 specifies encapsulation of IP over AAL 5. Thus, AAL 5 MUST be indicated in the "AAL type" field.

Coding and procedure related to the ’Forward and Backward Maximum CPCS-SDU Size’ fields are discussed in [ATKI94]. Values may range from zero to 65,535. Although the default IP over AAL 5/ATM is 9188 bytes, endstations are encouraged to support MTU sizes up to and including 64k.

Ordinarily, no Service Specific Convergence Sublayer (SSCS) will be used for multiprotocol interconnect over AAL5. Therefore, the SSCS ’type’ field SHOULD be absent or, if present, coded to Null SSCS.

Format and field values of AAL Parameters IE

```
-----------------------------------------------------------
| aal_parameters                                          |
-----------------------------------------------------------
|  aal_type                     5        (AAL 5)          |
|  fwd_max_sdu_size_identifier 140                        |
|  fwd_max_sdu_size             65,535   (desired IP MTU) |
|  bkw_max_sdu_size_identifier 129                        |
|  bkw_max_sdu_size             65,535   (desired IP MTU) |
|  sscs_type identifier         132                       |
|  sscs_type                    0        (null SSCS)      |
-----------------------------------------------------------
```

6.2. Broadband Low Layer Information

Selection of an encapsulation to support IP over an ATM VCC is done using the Broadband Low Layer Information (B-LLI) IE, along with the AAL Parameters IE, and the B-LLI negotiation procedure.

RFC 1577 specifies LLC/SNAP as the default encapsulation. This encapsulation MUST be implemented by all endstations. LLC encapsulation MUST be signaled in the B-LLI as shown below. Signaling indication of other encapsulations is discussed in Appendix D, Section 4. Note that only LLC is indicated in the B-LLI. It is up to the LLC layer to look into the encapsulation header of the packets following call setup. A B-LLI specifying both LLC and a layer_3_id SNAP layer is not recommended. If in those packets, the SNAP header indicates IP, it is the LLC layer's job to hand the packets up to IP.

Format of B-LLI IE indicating LLC/SNAP encapsulation

bb_low_layer_information		
layer_2_id	2	
user_information_layer	12	(lan_llc - ISO 8802/2)

6.2.1. Framework for Protocol Layering

The support of connectionless services from a connection oriented link layer exposes general problems of connection management, specifically the problems of connection acceptance, assignment of quality of service, and connection shutdown. For a connection to be associated with the correct protocol on the called host, it is necessary for information about one or more layers of protocol identification to be associated with a connection "management entity" or "endpoint". This association is what we call a binding in this memo. In this section we attempt to describe a framework for a usable binding or service architecture given the available IEs in the ATM call control messages.

It is important to distinguish between two basic uses of protocol identification elements present in the UNI setup message. The first is the description of the protocol encapsulation that will be used on the data packet over the virtual connection, the second is the entity that will be responsible for managing the call. All protocols present in various IEs MUST be used to encapsulate the call, but the most specific, or highest, layer specified SHOULD manage the call. This defines a hierarchy of services and provides a framework for applications, including LLC and IP, to terminate calls. This hierarchy provides a clear mechanism for support of higher level protocol and application bindings, when their use and specification is defined in the appropriate standards bodies.

In general, it would be desirable to allow data packets to be stored directly into an application's address space after connection is established. This is possible only if we have both encapsulation and managing entity indications in the signaling message.

The B-LLI is the only information element currently available in UNI 3.1 for designating protocol endpoints. It contains codepoints that describe layer 2 and layer 3 protocol entities associated with the call. There are other information elements under consideration in the ATM Forum and ITU, which could come to play a significant role in the description of application to connection binding, but their use is not yet defined, and they are not part of the framework described by RFC 1577. They include B-HLI, for containing information for a higher layer protocol, Network Layer Information (NLI) to contain information for the network layer, and UUI, which is meant to carry information for use by the top level application.

The following figure shows a B-LLI that MAY be used for specifying in call setup that IP will manage the call and that this VC will be used only for IP traffic. Called parties MUST accept this B-LLI. The caller using VC MUST use LLC-SNAP encapsulation on all IP datagrams, despite the fact that the caller views the VC as dedicated to IP. The reason for this requirement is that while we require receivers to accept this form of call setup, they may choose whether or not to multiplex the call through LLC, in other words to ignore the Layer 3 information. This choice is dependent on the receiver’s implementation’s protocol architecture and is local to the receiver.

Format of B-LLI IE indicating VC ownership by IP
(NOTE: LLC/SNAP encapsulation is still used)

bb_low_layer_information	
layer_2_id	2
user_information_layer	12 (lan_llc - ISO 8802/2)
layer_3_id	3
ISO/IEC TR 9577 IPI	204 (0xCC)

Null-encapsulated VCs are described in RFC 1483. Such a VC would result in the most direct form of binding a VC to IP. However, the method of signaling for this type of VC has not yet been integrated into the IP over ATM context. For completeness, we mention that the signaling would use a B-LLI containing the layer 3 identifier with the ISO/IEC TR-9577 protocol codepoint and omitting the layer 2 identifier [ATMF93]. Since no layer 2 is specified, frames produced by AAL processing would be given directly to IP. Processing of this B-LLI is not required at this time.

7. Information Elements with Significance to the ATM Network

This section describes the coding of, and procedures surrounding, information elements with significance to the ATM network, as well as the endpoints of an ATM call supporting multiprotocol operation.

The standards, implementation agreements, research and experience surrounding such issues as traffic management, quality of service and bearer service description are still evolving. Much of this material is cast to give the greatest possible latitude to ATM network implementation and service offerings. ATM endsystems need to match the traffic contract and bearer service they request from the network to the capabilities offered by the network. Therefore, this memo can only offer what, at the present time, are the most appropriate and efficient coding rules to follow for setting up IP and ATMARP VCCs. Future revisions of this memo may take advantage of ATM services and capabilities that are not yet available.

7.1. ATM Traffic Descriptor

The ATM traffic descriptor characterizes the ATM virtual connection in terms of peak cell rate (PCR), sustainable cell rate (SCR), and maximum burst size. This information is used to allocate resources (e.g., bandwidth, buffering) in the network. In general, the ATM traffic descriptor for supporting multiprotocol interconnection over ATM will be driven by factors such as the capacity of the network, conformance definition supported by the network, performance of the ATM endsystem and (for public networks) cost of services.

The most convenient model of IP behavior corresponds to the Best Effort Capability (see section 3.6.2.4 of [ATMF93]). If this capability is offered by the ATM network(s), it MAY be requested by including the Best Effort Indicator, the peak cell rate forward (CLP=0+1) and peak cell rate backward (CLP=0+1) fields in the ATM Traffic Descriptor IE. When the Best Effort Capability is used, no guarantees are provided by the network, and in fact, throughput may be zero at any time. This type of behavior is also described by RFC 1633 [BRAD94].

Format and field values of ATM Traffic Descriptor IE

traffic_descriptor	
fwd_peak_cell_rate_0+1_identifier	132
fwd_peak_cell_rate_0+1	(link rate)
bkw_peak_cell_rate_0+1_identifier	133
bkw_peak_cell_rate_0+1	(link rate)
best_effort_indication	190

When the network does not support Best Effort Capability or more predictable ATM service is desired for IP, more specific traffic parameters MAY be specified and the Best Effort capability not used. Doing so includes use of two other traffic-related IEs and is discussed in the following paragraphs and sections.

The Traffic Descriptor IE is accompanied by the Broadband Bearer Capability IE and the QoS Parameter IE. Together these define the signaling view of ATM traffic management. In this memo, we present an agreed-on, required subset of traffic management capabilities, as specified by using the three IEs. The figure immediately below shows the set of the allowable combinations of traffic parameters which all IP over ATM endsystems MUST support in their ATM signaling. The subset includes Best Effort in the form of a non-guaranteed bitrate combination (the rightmost column of the table below); a type of traffic description that is intended for ATM "pipes", for example between two routers (the middle column); and a type of traffic description that will allow initial use of token-bucket style characterizations of the source, as presented in RFC 1363 [PART92] and RFC 1633, for example (the leftmost column).

Combinations of Traffic Related Paramenters
that MUST be supported in the SETUP message

Broadband Bearer Capability			
Broadband Bearer	C	X	X
Traffic Type (CBR,VBR)		CBR	&
Timing Required		YES	&&
Traffic Descriptor Parameter			
PCR (CLP=0)			
PCR (CLP=0+1)	S	S	S
SCR (CLP=0)			
SCR (CLP=0+1)	S		
MBS (CLP=0)			
MBS (CLP=0+1)	S		
Best Effort			S
Tagging	NO	NO	NO
QOS Classes	0	0	0

S = Specified
& = Parameter is coded to either "no indication" or VBR or octet 5a (Traffic Type/Timing Required) is absent; these three codings are treated as equivalent
&& = Parameter is coded to either "no indication" or "No" or octet 5a is absent; these three codings are treated as equivalent

Use of other allowable combinations of traffic parameters listed in the large table in Appendix C may work, since they are allowed by [ATMF94], but this will depend on the the calling endsystem, the network, and the called endsystem.

If Best Effort service is not use, link rate SHOULD not be requested as the peak cell rate. Without any knowledge of the application, it is RECOMMENDED that a fraction, such as 1/10th, of the the link bandwidth be requested.

[ATMF93] does not provide any capability for negotiation of the ATM traffic descriptor paramenters. This means that:

a) the calling endsystem SHOULD have some prior knowledge as to the traffic contract that will be acceptable to both the called endsystem and the network.

b) if, in response to a SETUP message, a calling endsystem receive a RELEASE COMPLETE message, or a CALL PROCEEDING message followed by a RELEASE COMPLETE message, with cause #37, User Cell Rate Unavailable, it MAY examine the diagnostic field of the Cause IE and reattempt the call after selecting smaller values for the parameter(s) indicated. If the RELEASE COMPLETE or RELEASE message is received with cause #73, Unsupported combination of traffic parameter, it MAY try other combinations from table 5-7 and 5-8 of [ATMF93].

c) the called endsystem SHOULD examine the ATM traffic descriptor IE in the SETUP message. If it is unable to process cells at the Forward PCR indicated, it SHOULD clear the call with cause #37, User Cell Rate Unavailable.

7.2. Broadband Bearer Capability

Broadband Bearer Connection Oriented Service Type X (BCOB-X) or Type C (BCOB-C) are both applicable for multiprotocol interconnection, depending on the service(s) provided by the ATM network and the capabilities (e.g., for traffic shaping) of the ATM endsystem. The table in the previous section showed the use of BCOB-X and BCOB-C with other parameters. The figure below shows format and field values for a BCOB-X when the Traffic Descriptor IE indicates Best Effort.

Format and field values of Broadband Bearer Capability IE

bb_bearer_capability		
spare	0	
bearer_class	16	(BCOC-X)
spare	0	
traffic_type	0	(no indication)
timing_reqs	0	(no indication)
susceptibility_to_clipping	0	(not suscept)
spare	0	
user_plane_configuration	0	(point_to_point)

IP over ATM signaling MUST permit BCOB-C and BCOB-X, in the combinations shown in the previous section. It MAY also permit one of the allowable combinations shown in Appendix C.

Currently, there is no capability for negotiation of the broadband bearer capability. This means that:

a) the calling endsystem SHOULD have some prior knowledge as to the broadband bearer capability that will be acceptable to both the called endsystem and the network.

b) if, in response to a SETUP message, a calling endsystem receives a RELEASE COMPLETE message, or a CALL PROCEEDING message followed by a RELEASE COMPLETE message, with cause #57, bearer capability not authorized or #58 bearer capability not presently available, it MAY reattempt the call after selecting another bearer capability.

7.3. QoS Parameter

The Unspecified QoS class (Class 0) is the only QoS class that must be supported by all networks and the only QoS class allowed when using the Best Effort service. The Specified QoS Class for Connection Oriented Data Transfer (Class 3) or the Specified QoS Class for Connectionless Data Transfer (Class 4) may be applicable to multiprotocol over ATM, but their use has to be negotiated with the network provider. The combinations of QoS parameters with the ATM Traffic Descriptor and the Broadband Bearer Capability are detailed in the Traffic Descriptor section and in Appendix C.

Format and field values of QoS Parameters IE

qos_parameter		
qos_class_fwd	0	(class 0)
qos_class_bkw	0	(class 0)

[ATMF93] does not provide any capability for negotiation of Quality of Service parameters. This means that:

a) the calling endsystem SHOULD have some prior knowledge as to the QoS classes offered by the ATM network in conjunction with the requested Broadband Bearer Service and Traffic Descriptor.

b) if, in response to a SETUP message, a calling endsystem receives a RELEASE COMPLETE message, or a CALL PROCEEDING message followed by a RELEASE COMPLETE message, with cause #49, Quality of Service Unavailable, it MAY reattempt the call after selecting another QoS class.

Note: The two-bit ’coding standard’ field of the General Information octet in the IE header, SHOULD be set to ’00’ now that the ITU-T has standardized QoS class 0. Endsystems SHOULD treat either value (’11’ or ’00’) as requesting the ITU-T QoS class.

7.4. ATM Addressing Information

ATM addressing information is carried in the Called Party Number, Calling Party Number, and, under certain circumstance, Called Party Subaddress, and Calling Party Subaddress IE. Section 5.8 of [ATMF93] provides the procedure for an ATM endsystem to learn its own ATM address from the ATM network, for use in populating the Calling Party Number IE. Section 5.4.5.14 [ATMF94] describes the syntax and semantics of the calling party subaddress IE.

RFC 1577 RECOMMENDS that a router be able to provide multiple LIS support with a single physical ATM interface that may have one or more individual ATM endsystem addresses. Use of the Selector field in the NSAPAs and E.164 addresses (in the NSAP format) is identified as a way to differentiate up to 256 different LISs for the same ESI. Therefore, an IP router MAY associate the IP addresses of the various LISs it supports with distinct ATM addresses differentiated only by the SEL field. If an IP router does this association, then its signaling entity MUST carry in the SETUP message the ATM addresses corresponding to the particular IP entity requesting the call, and the IP entity it is requesting a call to. These ATM addresses are carried in the Calling and Called Party Number IEs respectively. Native E.164 addresses do not support a SEL field. For IP routers residing in a Public UNI where native E.164 addresses are used it is RECOMMENDED that multiple E.164 addresses be used to support multiple LISs. Note: multiple LIS support is the only recommended use of the SEL field. Use of this field is not recommended for selection of higher level applications.

Resolution of IP addresses to ATM addresses is required of hosts and routers which are ATM endsystems that use ATM SVCs. RFC 1577 provides a mechanism for doing IP to ATM address resolution in the classical IP model.

Format and field values of Called and Calling Party Number IE

```
---------------------------------------------------------
| called_party_number                                   |
---------------------------------------------------------
|  type_of_number      (international number / unknown) |
|  addr_plan_ident     (ISDN / ATM Endsystem Address)   |
|  addr_number         (E.164 / ATM Endsystem Address)  |
---------------------------------------------------------


---------------------------------------------------------
| calling_party_number                                  |
---------------------------------------------------------
|  type_of_number      (international number / unknown) |
|  addr_plan_ident     (ISDN / ATM Endsystem Address)   |
|  presentation_indic  (presentation allowed)           |
|  spare               0                                |
|  screening_indic     (user provided verified & passed) |
|  addr_number         (E.164 / ATM Endsystem Address   |
---------------------------------------------------------
```

8. Dealing with Failure of Call Establishment

If an ATM call attempt fails with any of the following causes, the situation SHOULD be treated as Network Unreachable (if the called ATM endsystem is a router) or Host Unreachable (if the called ATM endsystem is a host). See the treatment of Network and Host Unreachable conditions in RFC 1122 [BRAD89].

```
# 1  unallocated (unassigned) number
# 3  no route to destination
# 17 user busy
# 18 no user reponding
# 27 destination out of order
# 38 network out of order
# 41 temporary failure
# 47 resource unavailable, unspecified
```

If an ATM call attempt fails with any of the following causes, the ATM endsystem MAY retry the call, changing (or adding) the IE(s) indicated by the cause code and diagnostic.

```
# 2  no route to specified transit network
# 21 call rejected
# 22 number changed
# 23 user rejects call with CLIR
# 37 user cell rate unavailable
# 49 quality of service unavailable
# 57 bearer capability not authorized
# 58 bearer capability not presently available
# 65 bearer capability not implemented
# 73 unsupported combination of traffic parameter
# 88 incompatible destination
# 91 invalid transmit network selection
# 78 AAL parameter cannot be supported
```

9. Security Considerations

Not all of the security issues relating to IP over ATM are clearly understood at this time, due to the fluid state of ATM specifications, newness of the technology, and other factors. Future revisions of this specification will address the security capabilities that future signaling standards may offer to IP over ATM signaling.

10. Open Issues

- o This document version is specifically an RFC 1577/RFC 1483 implementation document. Although RFC 1577 and RFC 1483 specify an LLC/SNAP encapsulation, which is inherently a multiprotocol encapsulation, it is beyond to scope of this document to go into any multiprotocol specifications other than to point out some examples (see Appendix D for an example of NLPID encapsulation).

11. Acknowledgments

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Appendix A. Sample Signaling Messages

1. SETUP and CONNECT messages

This appendix shows sample codings of the SETUP and CONNECT signaling messages. The fields in the IE header are not shown.

```
  +----------------------------------------------------------------------+
                                SETUP

    Information Elements/
      Fields                          Value/(Meaning)
    --------------------              ---------------

    aal_parameters
      aal_type                        5        (AAL 5)
      fwd_max_sdu_size_ident          140
      fwd_max_sdu_size                (send IP MTU value)
      bkw_max_sdu_size_ident          129
      bkw_max_sdu_size                (recv IP MTU value)
      sscs_type identifier            132
      sscs_type                       0        (null SSCS)

    user_cell_rate
      fwd_peak_cell_rate_0_1_ident    132
      fwd_peak_cell_rate_0_1          (link rate)
      bkw_peak_cell_rate_0_1_ident    133
      bkw_peak_cell_rate_0_1          (link rate)
      best_effort_indication          190

    bb_bearer_capability
      spare                           0
      bearer_class                    16       (BCOC-X)
      spare                           0
      traffic_type                    0        (no indication)
      timing_reqs                     0        (no indication)
      susceptibility_to_clipping      0        (not susceptible to
                                                clipping)
      spare                           0
      user_plane_configuration        0        (point_to_point)

    bb_low_layer_information
      layer_2_id                      2
      user_information_layer          12       (lan_llc (ISO 8802/2)

    qos_parameter
      qos_class_fwd                   0        (class 0)
      qos_class_bkw                   0        (class 0)
```

```
    called_party_number
      type_of_number                (international number / unknown)
      addr_plan_ident               (ISDN / ATM Endsystem Address)
      number                        (E.164 / ATM Endsystem Address)

    calling_party_number
      type_of_number                (international number / unknown)
      addr_plan_ident               (ISDN / ATM Endsystem Address)
      presentation_indic            (presentation allowed)
      spare                         0
      screening_indic               (user_provided verified and passed)
      number                        (E.164 / ATM Endsystem Address)

  +---------------------------------------------------------------------+
                               Figure 1.
                     Sample contents of SETUP message
```

[* : optional, ignored if present]

In IP over ATM environments the inclusion of the "AAL parameters" IE is *mandatory* to allow for MTU size negotiation between the source and destination. The "Broadband Low Layer Information" IE is also mandatory for specifying the IP encapsulation scheme.

```
+----------------------------------------------------------------------+
                               CONNECT

   Information Elements/
     Fields                         Value
   --------------------             -----
   aal_parameters
     aal_type                       5        (AAL 5)
     fwd_max_sdu_size_ident         140
     fwd_max_sdu_size               (send IP MTU value)
     bkw_max_sdu_size_ident         129
     bkw_max_sdu_size               (recv IP MTU value)
     sscs_type identifier           132
     sscs_type                      0        (null SSCS)

   bb_low_layer_information
     layer_2_id                     2
     user_information_layer         12       (lan_llc (ISO 8802/2)

   connection identifier
     spare                          0
     vp_assoc_signaling             1        (explicit indication of VPCI)
     preferred_exclusive            0        (exclusive vpci/vci)
     vpci                           (assigned by network)
     vci                            (assigned by network)
+----------------------------------------------------------------------+
```

Figure 2.
Sample contents of CONNECT message

As in the SETUP message, IP over ATM environments demand the inclusion of the "AAL parameters" IE so that the destination may specify the MTU size that it is willing to receive.

2. Hints on Use of CALL PROCEEDING Message

Use of the CALL PROCEEDING message is beneficial in implementations where the called party’s ATM signaling entity and AAL Users are decoupled. An arriving SETUP may result in an immediate CALL PROCEEDING response from the called party’s ATM signaling entity, while it locally queries the called IP-ATM entity to see if the SETUP’s conditions are acceptable. The acceptance of the SETUP’s conditions would then cause the ATM signaling entity to issue a CONNECT back to the switch. The two possible refusal modes at the called party then become:

a) Called party has no IP-ATM entity resident. Issue RELEASE COMPLETE in response to SETUP.

b) Called party has a resident IP-ATM entity, so CALL PROCEEDING was issued. The IP-ATM entity rejects the call request, so a RELEASE is issued instead (to be acknowledged by the network with RELEASE COMPLETE).

Appendix B. IP over ATM using UNI 3.0 Signaling

This appendix describes how to support IP over ATM using UNI 3.0 signalling. Differences in the coding or semantics of each relevant IE is given.

1. AAL parameter

Values for maximum SDU size may range from one (not zero) to 64K.

A 'mode' field is an allowable field in UNI 3.0. Nevertheless, this 'mode' field SHOULD be omitted from the AAL Parameters IE and MUST be ignored by the destination endsystem.

2. Traffic Management Related IEs

In UNI 3.0 issues of traffic management were less understood than in UNI 3.1. UNI 3.0 does not contain a guide to coordinating the use of the User Cell Rate IE (Traffic Descriptor IE in UNI 3.1), Broadband Bearer Capability IE, and QoS parameters IE. Therefore, the recommendation for specifying parameters in these IEs is the same as that given above when using UNI 3.1. The following section merely describes relevant differences in names and code values.

2.1 ATM User Cell Rate (instead of ATM Traffic Descriptor)

The ATM Traffic Descriptor IE is refered to as 'ATM User Cell Rate' IE in UNI 3.0. Also, the value for the cause 'user cell rate unavailable' is #51.

2.3 QoS parameters

The two-bit 'coding standard' field of the General Information octet in the IE header, should be set to '11' inidicating that the IE is a standard defined for the network (as opposed to an ITU-TS standard) present on the network side of the interface.

3. ATM Addressing Information

In UNI 3.1, the 'ATM Endsystem Address' type was introduced to differentiate ATM addresses from OSI NSAPs. In UNI 3.0, 'ATM Endsystem Address' is not a valid type. Therefore, in the called and calling party subaddress IEs the three-bit 'type of subaddress' field MUST specify 'NSAP' (value = 001) when using the subaddress IE to carry ATM addresses.

4. Dealing with Failure of Call Establishment

In UNI 3.0 the there are certain cause values which are different than UNI 3.1. Two relevant differences are the following:

'AAL Parameter Cannot Be Supported' is #93 (#78 in UNI 3.1), and

'User Cell Rate Unavailable' is #51 (#37 in UNI 3.1).

Appendix C.

Combinations of Traffic Related Parameters
tha MAY be supported in the SETUP message

Broadband Bearer Capability												
Broadband Bearer	A,C	X	X	C	X	C	X	A,C	X	X	C	X
Traffic Type (CBR,VBR)		CBR	&		&		&		CBR	&	&	&
Timing Required		Y	&&		&&		&&		Y	&&		&&
Traffic Descriptor Parameter												
PCR (CLP=0)	S	S	S									
PCR (CLP=0+1)	S	S	S	S	S	S	S	S	S	S	S	S
SCR (CLP=0)					S	S						
SCR (CLP=0+1)							S	S				
MBS (CLP=0)					S	S						
MBS (CLP=0+1)							S	S				
Best Effort											S	S
Tagging	Y/N	Y/N	Y/N	Y/N	Y/N	N	N	N	N	N	N	N
QOS Classes	*	*	*	*	*	*	*	*	*	*	0	0

(Table 2 is a reproduction of Table F-1 of Appendix F in [ATMF 94].)

PCR = Peak Cell Rate, SCR = Sustainable Cell Rate,
MBS = Maximum Burst Size

Y = Yes, N = No, S = Specified

Y/N = either "Yes" or "No" is allowed

* = allowed QoS class values are a network option. Class 0 is always supported for alignment with ITU-T

& = parameter is coded to either "no indication" or VBR or octet 5a(Traffic Type/Timing Required) is absent; these three codings are treated as equivalent

&& = parameter is coded to either "no indication" or "No" or octet 5a(Traffic Type/Timing Required) is absent; these three codings are treated as equivalent

A blank entry in the table indicates that the parameter is not present.

Appendix D. Frame Relay Interworking

1. RFC 1490 over FR-SSCS vs. RFC 1483 over null-SSCS

Procedures for Frame Relay to ATM signaling interworking have not yet been specified by ITU-T, the ATM Forum, or the Frame Relay Forum. If an ATM endsystem wishes to use FR-SSCS, FR-SSCS and RFC 1490 encapsulation must both be be specified in the SETUP message. Nevertheless, since neither LLC encapsulation nor VC-multiplexing will interoperate when used over FR-SSCS, these two encapsulations cannot be negotiated as alternatives to RFC 1490 encapsulation (see Section 4, Encapsulation Negotiation).

In ATM environments the SSCS layer is part of the AAL functionality. The SSCS serves to coordinate the needs of a protocol above with the requirements of next lower layer, the Common Part Convergence Sublayer (CPCS). For example, the UNI ATM signaling protocol runs on top of a signaling SSCS which among other things provides an assured transfer service for signaling messages. Since the SSCS is considered part of the AAL, the SSCS type is specified as one of the parameters in the AAL Parameters IE. To date there has not been an SSCS defined for data transmission in ATM and this type field is usually set to 'null'.

The exception occurs when doing FR interworking where an ATM endsystem may choose to use the FR-SSCS over AAL 5 in order to communicate with a FR endsystem. In that case the SSCS type in the AAL Parameters IE of the SETUP message is set to 'FR-SSCS'.

Also included in a SETUP message is an indication in the B-LLI IE of the protocol layers to be used above the AAL. In particular, ATM connections established to carry connectionless network interconnect traffic require a layer above the AAL for multiplexing multiple protocols over a single VC [HEIN 93]. As mentioned above, RFC 1577 defines LLC as default multiplexing layer for IP over AAL5.

Specification of the SSCS restricts the encapsulation protocol used over it, since RFC 1483 (in addition to applicable ITU standards) defines the use of RFC 1490 encapsulation over the FR-SSCS, and LLC or null encapsulation otherwise. The fact that it is not possible, in the UNI 3.0 signaling specification, to negotiate between the FR-SSCS and null-SSCS can result in interoperability restrictions between stations that implement and wish to use the FR-SSCS and those that do not, even though they both are using IP. The guidelines in the following section were developed to decrease the chance that such interoperability restrictions occur.

2. Scenarios for Interworking

The following discussion uses the terms "network interworking" and "service interworking". "Network interworking" uses FR-SSCS over AAL5 between the InterWorking Unit (IWU) and the ATM endsystem, and the ATM endsystem is aware that the other endpoint is a FR/ATM Network IWU. "Service interworking" aims to make the operation transparent to the ATM endsystem by adding encapsulation translation and other payload processing in the FR/ATM Service IWU to allow the ATM endsystem to operate as if it were talking to another ATM endsystem.

The most common scenario where FR-SSCS could be negotiated is between an ATM endsystem and a FR/ATM network IWU to allow connectivity among an ATM endsystem and a FR endsystem residing behind a FR/ATM network IWU.

```
                     --------        --------
      -------       |        |      |        |       -------
     |   A   |      | FR/ATM |      |  ATM   |      |   B   |
     |  (FR) |----->|  IWU   |----->| switch |----->| (ATM) |
      -------       |        |      |        |       -------
                     --------        --------

             |      |        |                      |
              ----->          --------------------->
             FR call                 ATM call
```

A network IWU can place a call to an ATM host (on behalf of a FR host) by signaling for FR-SSCS and assuming that the ATM endsystem supports FR-SSCS. The B-LLI IE SHALL be encoded to indicate RFC 1490 encapsulation and the SSCS type field of the AAL Parameters IE SHALL be coded to indicate FR-SSCS. If the FR-SSCS negotiation fails because the called ATM host does not support FR-SSCS, the IWU can retry the call negotiating for LLC encapsulation or VC-multiplexing.

However, the IWU can only attempt the retry if it is able to do FR-ATM service interworking. Such service interworking adds extra processing overhead during the call.

The even more problematic case occurs when a call is requested in the opposite direction, i.e. when an ATM host places a call to a host residing behind an IWU.

```
                  --------        --------
   -------       |        |      |        |       -------
  |   B   |      | FR/ATM |      |   ATM  |      |   A   |
  |  (FR) |<-----|  IWU   |<-----| switch |<-----| (ATM) |
   -------       |        |      |        |       -------
                  --------        --------

          |      |        |                      |
           <-----          <---------------------
          FR call                 ATM call
```

Not knowing that the destination resides behind an IWU, the calling host will negotiate for the default LLC encapsulation (possibly requesting VC-multiplexing as an alternative). In this situation the IWU can accept the call and do the necessary service interworking or reject the call specifying 'AAL Parameters not supported'. If the IWU rejects the call it risks the possibility that calling host does not support FR-SSCS or simply does not retry and the call will never be established.

3. Possible Alternatives

While Frame Relay interworking is possible, it is not possible to negotiate FR-SSCS with LLC encapsulation or VC-multiplexing, which decreases the chances of completing an ATM call. However, interoperability can be increased using the following alternatives:

1. Maintaining external knowledge that a particular destination uses FR-SSCS. This knowledge can be configured, or in the future added to some network host database.

2. In the absence of such external knowledge, an ATM endsystem is required to negotiate for the default LLC encapsulation (possibly requesting VC-multiplexing as an alternative). There are three sub-cases:

2a. The IWU supports service interworking and network interworking, and prefers service interworking. The IWU simply accepts the call using LLC encapsulation.

2b. The IWU supports service interworking and network interworking, and prefers network interworking. The IWU simply accepts the call, but attempts to open a parallel connection back to the original ATM endsystem negotiating the FR-SSCS use. If the connection is accepted, the IWU closes the service interworking connection.

2c. The IWU supports network interworking only. The IWU rejects the call specifying 'AAL Parameters not supported', and then attempts to open a connection back to the original ATM endsystem negotiating the FR-SSCS use.

4. Encapsulation negotiation

The call/connection control signaling protocol includes a mechanism to support negotiation of encapsulation for endsystems that support more than one. This section describes the procedures for negotiation of an encapsulation.

The B-LLI negotiation procedures (see Annex C of [ATMF93]) are initiated by the calling ATM endsystem by including up to three instances of the B-LLI IE in the SETUP message in descending order of preference (following the rule for repeating IE in section 5.4.5.1 of [ATMF93]).

The following is the list of the three possible combinations that B-LLI IE instances MAY be included in the SETUP message. Each instance is referred to by its encapsulation name as it appears in RFC 1483, and corresponding section labels from Appendix D of the ATM Forum UNI 3.0 specification.

a) LLC/SNAP encapsulation (D.3.1)

In this case, the calling ATM endsystem can only send and receive packets preceded by an LLC/SNAP identification. This memo requires that hosts and routers which are ATM endsystems implement LLC/SNAP encapsulation.

b) VC-multiplexing (D.3.2) and LLC/SNAP (D.3.1)

The calling ATM endsystem prefers to use VC multiplexing, but is willing to agree to use LLC/SNAP encapsulation instead, if the called ATM endsytem only supports LLC/SNAP.

c) RFC 1490 encapsulation (NLPID multiplexing) over FRSSCS (D.3.3, omitting octets 7a and 7b and MUST have FR-SSCS in SSCS type of AAL Parameters IE.)

The calling ATM endsystem can only send and receive packets using RFC 1490 encapsulation (NLPID multiplexing) over FRSSCS. Use of RFC 1490 encapsulation presently cannot be negotiated as an alternative to LLC encapsulation or VC-multiplexing. If the B-LLI IE is encoded to indicate RFC 1490 encapsulation, the SSCS type field of the AAL Parameters IE SHALL coded to indicate FRSSCS. Note that the AAL Parameters IE can not be coded to indicate both NULL and FR-SSCS and neither LLC encapsulation nor VC-multiplexing will be interoperable when used over FR-SSCS.

The called ATM endsystem SHALL select the encapsulation method it is able to support from the B-LLI IE present in SETUP message. If it supports more than one of the encapsulations indicated in the SETUP message, it MUST select the one which appears first in the SETUP message. The called ATM endsystem then includes the B-LLI IE content corresponding to the selected encapsulation in the CONNECT message. If the called endsystem does not support any encapsulation indicated in the incoming SETUP message, it SHALL clear the call with cause #88, incompatible destination. If the received SETUP message does not include the B-LLI IE, the call SHALL be cleared with cause #21, "call rejected", with diagnostics indicating rejection reason = information element missing and the B-LLI IE identifier. As described in Annex C of [ATMF93], if the calling ATM endpoint receives a CONNECT message that does not contain a B-LLI IE, it SHALL assume the encapsulation indicated in the first BLLI IE that it included in the SETUP message.