

**Technical Report
TR-003**

**Framing and Encapsulation
Standards for ADSL:
Packet Mode**

June 1997

ABSTRACT:

This technical report describes the framing and encapsulation standards for variable length frames transported over ADSL technology.

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| | |
|--|-----------|
| 1. INTRODUCTION | 2 |
| 1.1 ADSL FORUM REFERENCE MODEL..... | 2 |
| 1.2 PACKET MODE REFERENCE DIAGRAM..... | 3 |
| 1.3 TERMINOLOGY OF REQUIREMENTS | 3 |
| 1.4 TERMS AND ACRONYMS..... | 4 |
| 2. RFC 1662 MODE | 5 |
| 2.1 PPP IN HDLC-LIKE FRAMING..... | 5 |
| 2.2 PPP ENCAPSULATION..... | 6 |
| 3. FRAME USER NETWORK INTERFACE (FUNI) MODE | 7 |
| 3.1 FUNI FRAMING..... | 7 |
| 3.1.1 <i>Frame Structure</i> | 8 |
| 3.1.2 <i>Address Assignment</i> | 8 |
| 3.2 PROTOCOL ENCAPSULATION..... | 8 |
| 3.2.1 <i>LLC Encapsulation</i> | 8 |
| 3.2.2 <i>Virtual circuit based multiplexing</i> | 8 |
| 4. IMPLEMENTATION REQUIREMENTS | 9 |
| 4.1 ATU-C ATTRIBUTES..... | 9 |
| 4.2 ATU-R ATTRIBUTES..... | 9 |
| 4.3 GENERAL ATTRIBUTES | 9 |
| 4.4 VENDOR SPECIFIC CHANNEL | 9 |
| 5. PACKET FORMATS | 9 |
| 5.1 RFC 1662 MODE PACKETS..... | 10 |
| 5.2 FUNI MODE PACKETS..... | 11 |
| 6. REFERENCES | 14 |

1. INTRODUCTION

This technical report defines a method for transferring variable length Layer 2 frames and/or Layer 3 packets over an ADSL link. This document describes:

- the framing mechanisms and
- protocol encapsulation capabilities

required to provide a transmission facility over ADSL links regardless of transmission layer line code. This is one document in a series of ADSL Forum technical reports that address transferring variable length frames over an ADSL link. Future documents in this specification series will describe:

- implementation specifics for different physical layers
- signaling
- management requirements
- other features

required to insure multivendor interoperability for these ADSL links. This specification makes no recommendations or requirements for the wide area network interface between the ATU-C and the Network Service Provider.

This specification relies heavily on existing standards, defined by the ISO, ITU-T, ATM Forum, and IETF standards bodies, applying them with only minimal modification to the transport of data link layer frames over ADSL links. In particular, it defines two allowable operating modes:

- PPP in HDLC-like frames (RFC 1662 mode)
- ATM Frame UNI (FUNI) frames (FUNI mode)

For this specification, the ADSL physical layer is viewed as simply a point-to-point bit stream provider. The ADSL Forum Reference Model, a Reference Diagram for this specification and some critical terminology is presented below.

1.1 ADSL Forum Reference Model

Several sections below describe features of this specification by referring to the ADSL Forum's Reference Model. It is shown below for reference.

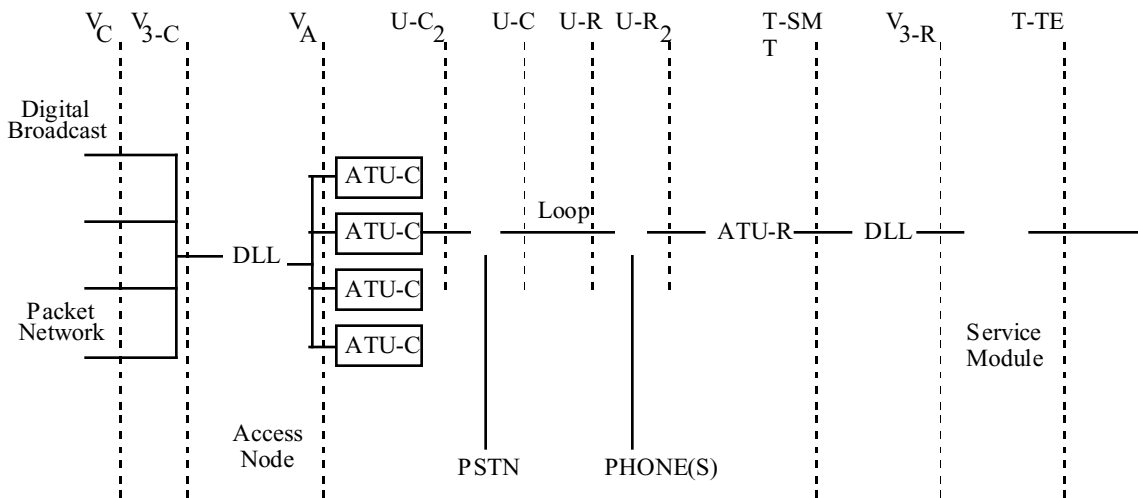


Figure 1-1: ADSL Reference Model

1.2 Packet Mode Reference Diagram

This document uses some additional terms to describe the service points and administrative domains that play a role in this specification. In particular, the document separates the concept of network access from network service. A Network Access Provider (NAP) is the administrative entity that terminates the central office end of an ADSL line. The Network Service Provider (NSP) is the administrative entity that provides access to higher-level network services. Examples of Network Service Providers are Internet Service Providers or corporate offices providing network services to a remote office or telecommuter. Note that the NAP and NSP might be in the same administrative domain, but need not be. For example, an operator could provide both ADSL service and Internet Access. The NAP and NSP are defined separately in this document to clarify the roles that each play in an end-to-end service scenario. Figure 1-2 shows these entities.

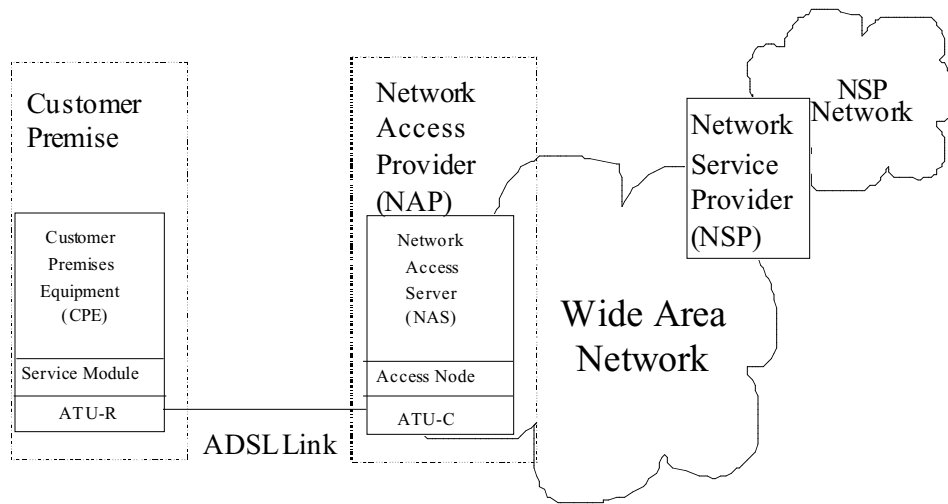


Figure 1-2: ADSL Packet Mode Reference Diagram

1.3 Terminology of Requirements

In this document, several words are used to signify the requirements of the specification. These words are often capitalized.

- MUST** This word, or the adjective “required”, means that the definition is an absolute requirement of the specification
- MUST NOT** This phrase means that the definition is an absolute prohibition of the specification.
- SHOULD** This word, or the adjective “recommended”, means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications must be understood and carefully weighted before choosing a different course.
- MAY** This word, or the adjective “optional”, means that this item is one of an allowed set of alternatives. An implementation that does not include this option **MUST** be prepared to inter-operate with another implementation that does include the option.

1.4 *Terms and Acronyms*

| | |
|-------------|---|
| AAL5 | - ATM Adaptation Layer 5 |
| Access Node | - Concentration point for Broadband and Narrowband data. |
| ADSL | - Asymmetric Digital Subscriber Line |
| ANSI | - American National Standards Institute |
| ATM | - Asynchronous Transfer Mode |
| ATU-C | - ADSL Terminal Unit - Central Office |
| ATU-R | - ADSL Terminal Unit - Remote |
| CLP | - Cell Loss Priority |
| CN | - Congestion Notification |
| CPE | - Customer Premise Equipment |
| CRC | - Cyclical Redundancy Check |
| FCS | - Frame Check Sequence |
| Frames | - Layer 2 (data link layer) information bundles |
| FUNI | - Frame User Network Interface (ATM Forum Specification) |
| HDLC | - High-Level Data Link Control |
| IETF | - Internet Engineering Task Force |
| ILMI | - Integrated Local Management Interface |
| IPCP | - Internet Protocol Control Protocol |
| ISO | - International Organization for Standardization |
| ITU-T | - International Telecommunications Union - Telecommunications Standardization Section (formerly CCITT) |
| LAN | - Local Area Network |
| LAPD | - Link Access Protocol D (HDLC derivative for ISDN) |
| LLC | - Logical Link Control |
| NAP | - Network Access Provider (administrative entity for ATU-C equipment) |
| NSP | - Network Services Provider (not necessarily Internet, could be other protocols or other IP-based networks) |
| OAM | - Operation, Administration and Maintenance |
| OUI/PID | - Organizationally Unique Identifier / Protocol Identifier |
| Packets | - Layer 3 (network layer) information bundles |
| PDU | - Protocol Data Unit |
| POP | - Point of Presence |
| PPP | - Point-to-Point Protocol |
| PSTN | - Public Switched Telephone Network |
| PTT | - Postal Telephone and Telegraph |
| PVC | - Permanent Virtual Circuit |
| PUC | - Public Utilities Commission |
| RBOC | - Regional Bell Operating Company (Baby Bell) |
| RFC | - Request For Comments |
| SDU | - Service Data Unit |
| SNAP | - Subnetwork Access Point |
| SVC | - Switched Virtual Circuit |
| UNI | - User to Network Interface |
| VPI/VCI | - Virtual Path Identifier/Virtual Connection Identifier |

2. RFC 1662 MODE

This section describes one of two operating modes allowed under this standard for transporting variable length frames between an ATU-R and ATU-C over the ADSL link (across the U interface in the ADSL Forum reference diagram above Figure 1-1). This operating mode leverages existing implementations¹ of the Point-to-Point Protocol (PPP) by following, exactly, the Internet Engineering Task Force Request for Comments (IETF RFC) document RFC 1662 "PPP in HDLC-like Framing," Simpson, W., Ed.

2.1 PPP in HDLC-like Framing

Implementations operating in this mode MUST conform to RFC 1662, specifically following the recommendations for bit-synchronous links and ignoring specifications for asynchronous and octet-synchronous links. There are several references in RFC 1662 to ISO 3309, the standard for HDLC frame structure; implementers may refer to that ISO document for clarification, but where there are differences, implementations over the ADSL facility MUST follow RFC1662. Figure 2-1 below shows the format of packets transported using this operating mode.



Figure 2-1: RFC 1662 framed PPP Format

¹ For example, this mode would allow an existing PPP device to be connected to a Packet Mode ATU-C using a bit-synchronous ATU-R "modem".

2.2 PPP Encapsulation

Data encapsulation within RFC1662 framing is described in many other RFCs that provide a rich system for transporting multi-protocol data over Point-to-Point links. In particular, implementers are referred to the following RFCs as examples of the supporting IETF standards documents:

- RFC 1661 - The Point-to-Point Protocol
- RFC 1332 - The PPP Internet Protocol Control Protocol (IPCP)

Additional RFCs extend PPP for other protocols, bridging, encryption, compression, and authentication. All such implementations² that are valid over RFC 1662 are valid over an ADSL facility implementing this PPP operating mode with the following exception. Section 4.3 below allows a compliant implementation to switch between operation in this RFC 1662 mode and FUNI mode operation.

² Implementers should check the latest index of RFCs (<ftp://ds.internic.net/rfc/rfc-index.txt>) for the most current RFC revisions.

³ The autodetection algorithm is outside the scope of this document.

3. FRAME USER NETWORK INTERFACE (FUNI) MODE

The second allowed operating mode for standard-compliant implementations is based on the FUNI specifications from the ATM Forum. In particular, ADSL end points transmitting variable length frames or packets across the U interface MUST implement the FUNI variant described in this specification when operating in this FUNI mode. Currently, the only FUNI features specified by this document are basic frame structure and encapsulation methods. Other features such as ILMI and OAM support are under study for future technical reports in this series.

3.1 FUNI Framing

ATM Frame UNI (currently under revision to version 2, defined in ATM Forum document *str-saa-funi_01.01*) is a derivative of ATM Data Exchange Interface (ATM DXI, ATM Forum *af-dxi-0014_000.doc*). Like the PPP operating mode, the framing is a member of the HDLC family of data link control protocols and, in this implementation, uses the same number of header bytes. It uses standard HDLC start and stop flag bytes to guarantee flag recognition and bit-stuffing to achieve data transparency. The ATM FUNI frame header contains address and control fields. The address field encodes the Service Data Unit's (SDU) virtual connection Virtual Path Identifier (VPI) and Virtual Connection Identifier (VCI).

The multiplexing of multiple network layer protocols on a single FUNI virtual connection using RFC1483 LLC or PPP is discussed below in section 3.2, entitled *Protocol Encapsulation*.

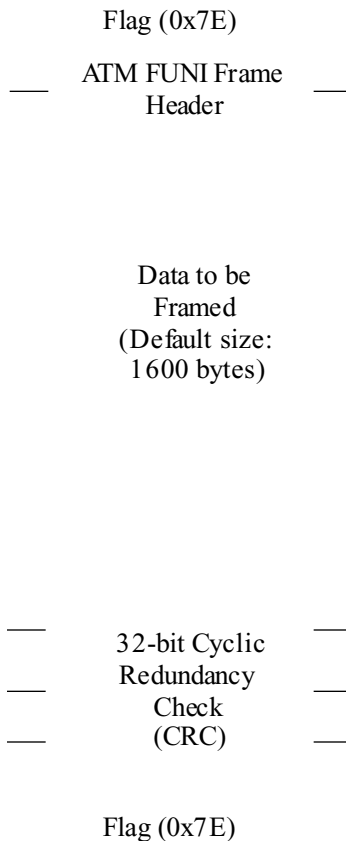


Figure 2-2: ATM Frame UNI Format

3.1.1 Frame Structure

Implementations of this specification operating in FUNI mode MUST frame data using the ATM FUNI derivative of HDLC framing as described in ATM Forum *str-saa-funi-01.01* with specific restrictions as outlined below. This framing MUST include a two-byte frame header and four-byte CRC. Implementations SHOULD support the Congestion Notification (CN) and Cell Loss Priority (CLP) bits as described in ATM Forum *str-saa-funi-01.01* section 3.2. At initialization, the default maximum size of the data framed between the FUNI header and the CRC MUST be 1600 bytes to allow interoperability with most foreseeable encapsulations of 1500 byte Ethernet frames. Implementations MAY negotiate other maximum size frames through mechanisms that are outside the scope of this document.

3.1.2 Address Assignment

Specific VPI/VCI addresses for ADSL physical layer management, vendor-specific channel and default user data channel will be defined in future technical reports in this series.

3.2 Protocol Encapsulation

A conforming FUNI mode implementation at the ADSL U interface MUST support the protocol multiplexing techniques defined in RFC 1483 "Multi-Protocol Encapsulation Over ATM AAL5". The specifics of applying RFC1483 to FUNI mode implementations are described in this section 3.2.

RFC 1483 describes two multiplexing techniques (refer to RFC 1483 section 2):

- LLC encapsulation
- Virtual circuit based multiplexing.

If an implementation supports this FUNI mode, it MUST support one of these RFC 1483 multiplexing modes over the Frame UNI and SHOULD support the PPP over FUNI virtual circuit based encapsulation described in section 3.2.2 below.

3.2.1 LLC Encapsulation

One encapsulation technique specified in RFC1483 uses a multi-protocol IEEE 802.1 LAN Logical Link Control (LLC) header to encapsulate the payload. FUNI mode implementations may use this technique for all FUNI payloads, with one important exception for PPP. PPP PDUs over ADSL FUNI circuits MUST be transported using the Virtual circuit based multiplexing described in section 3.2.2 below.

3.2.2 Virtual circuit based multiplexing

RFC 1483 also allows alternate encapsulations by using virtual circuit based multiplexing. Any payload may be transported in a FUNI frame without any additional encapsulation; there is no in-band LLC based protocol type discriminator at the beginning of the frame's information field. In this scenario, the end systems create a distinct parallel virtual circuit connection for each payload protocol type. See Figure 5-4 and Figure 5-5 of Section 5 for example frame diagrams. The lack of any protocol type discriminator means that there MUST be some other (out-of-band) method for the endpoints to agree on the interpretation of the payload that immediately follows the FUNI header. See RFC 1483 for further explanation of this multiplexing mode.

This ADSL Forum standard defines a special case for PPP payloads inside FUNI frames. A compliant implementation that chooses to carry Point-to-Point Protocol (PPP) PDUs inside a FUNI frame (PPP over FUNI) MUST carry the PPP PDUs directly over FUNI using Virtual circuit based multiplexing. PPP MUST NOT be encapsulated within an LLC header when framed by a FUNI header across the ADSL U interface.

4. IMPLEMENTATION REQUIREMENTS

Section 2 (RFC 1662 mode) and section 3 (FUNI mode) define two methods for framing and encapsulating packet data over the U interface specified in Figure 1-1: The ADSL Reference Model. This section defines procedural aspects as they pertain to the ATU-R and the ATU-C.

4.1 *ATU-C Attributes*

The ATU-C MUST support the following:

- RFC 1662 mode, as described in Section 2
- FUNI mode, as described in Section 3.

4.2 *ATU-R Attributes*

The ATU-R MUST support AT LEAST ONE of the following:

- RFC 1662 mode, as described in Section 2
- FUNI mode, as described in Section 3.

4.3 *General Attributes*

Both the ATU-C and the ATU-R MAY support the following:

- The Vendor-specific channel for FUNI framing, as described in Section 4-4.

4.4 *Vendor Specific Channel*

An OPTIONAL vendor-specific channel is defined only for FUNI mode. This standard assigns a dedicated PVC channel for this connection. A well-known (TBD) VPI/VCI pair identifies the vendor-specific channel. For payloads that are outside the scope described in section 3.2 above, the vendor-specific virtual connection MUST be implemented and used. Examples of such uses might include

- Negotiation of or indication of private extension,
- Flash ROM updates
- Proprietary debugging
- And other vendor-specific actions.

All packets exchanged over the vendor specific channel MUST use RFC 1483 LLC encapsulation. Those packets containing vendor specific information MUST use a SNAP header having the IEEE assigned Organizationally Unique Identifier (OUI) value of the implementing vendor. Packets containing unrecognized OUI values MUST be silently discarded. Compliant devices MUST be able to interoperate without using this vendor-specific channel.

The Vendor Specific Channel may be used to negotiate extensions outside the standard. If both peers indicate agreement to such extensions (in some vendor-specific manner), then those extensions are not restricted in any way by this standard, including use of non-vendor-specific VPI/VCI pairs.

5. PACKET FORMATS

5.1 RFC 1662 Mode Packets

The packet format for PPP-based framing is:



Figure 5-1: HDLC-like-framed PPP PDU

5.2 FUNI mode Packets

For FUNI implementations, packets (and frames) in the data plane are multiplexed and encapsulated per RFC 1483, using either LLC encapsulation or VC based multiplexing.

PPP frames, if transmitted, MUST be virtual circuit-multiplexed. Since, with VC-multiplexing, the carried network interconnect protocol is identified implicitly by the corresponding virtual connection, there is no need to include explicit multiplexing information. Therefore, the LLC multiplexing field is not included, and the PPP frame starts at the first byte of the FUNI Service Data Unit field.

The Vendor-specific channel, if implemented, MUST be LLC-encapsulated.

Packet formats for FUNI-based framing are:

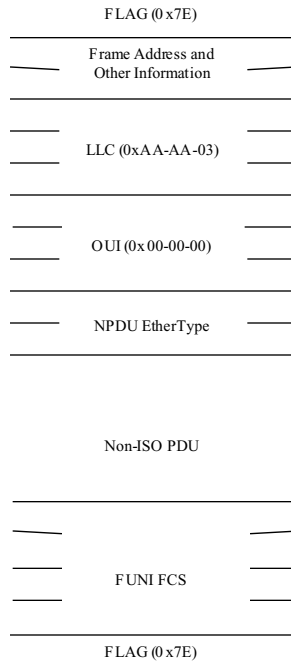


Figure 5-2: FUNI-based LLC-encapsulated non-ISO PDU

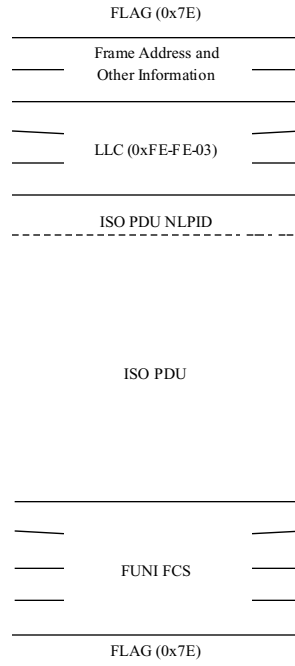


Figure 5-3: FUNI-based LLC-encapsulated ISO PDU

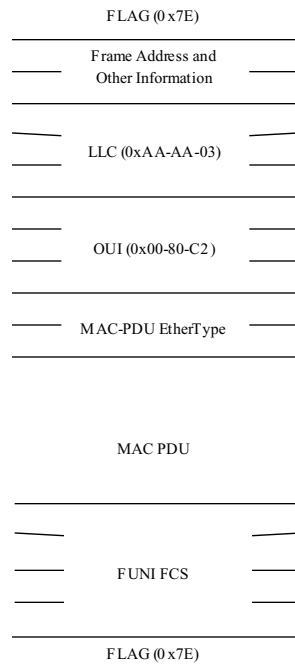


Figure 5-4: FUNI-based LLC-encapsulated MAC PDU



Figure 5-5: FUNI-based, VC-multiplexed PPP PDU



Figure 5-6: FUNI-based VC-multiplexed PDU (requires pair-wise agreement of ADSL endpoints)

6. REFERENCES

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