Network Working Group
Request for Comments: 2615
Obsoletes: 1619
Category: Standards Track
A. Malis
Ascend Communications, Inc.
W. Simpson
DayDreamer
June 1999

PPP over SONET/SDH

Status of this Memo

Copyright Notice

Abstract

The Point-to-Point Protocol (PPP) [1] provides a standard method for transporting multi-protocol datagrams over point-to-point links. This document describes the use of PPP over Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) circuits.

This document replaces and obsoletes RFC 1619. See section 7 for a summary of the changes from RFC 1619.

Table of Contents

1. Introduction

PPP was designed as a standard method of communicating over point-to-point links. Initial deployment has been over short local lines, leased lines, and plain-old-telephone-service (POTS) using modems. As new packet services and higher speed lines are introduced, PPP is easily deployed in these environments as well.

This specification is primarily concerned with the use of the PPP encapsulation over SONET/SDH links. Since SONET/SDH is by definition a point-to-point circuit, PPP is well suited to use over these links.

Real differences between SONET and SDH (other than terminology) are minor; for the purposes of encapsulation of PPP over SONET/SDH, they are inconsequential or irrelevant.

For the convenience of the reader, we list the equivalent terms below:

SONET	SDH
SPE	VC
STS-SPE	Higher Order VC (VC-3/4/4-Nc)
STS-1 frame	STM-0 frame (rarely used)
STS-1-SPE	VC-3
STS-1 payload	C-3
STS-3c frame	STM-1 frame, AU-4
STS-3c-SPE	VC-4
STS-3c payload	C-4
STS-12c/48c/192c frame	STM-4/16/64 frame, AU-4-4c/16c/64c
STS-12c/48c/192c-SPE	VC-4-4c/16c/64c
STS-12c/48c/192c payload	C-4-4c/16c/64c

The only currently supported SONET/SDH SPE/VCs are the following:

SONET	SDH
STS-3c-SPE	VC-4
STS-12c-SPE	VC-4-4c
STS-48c-SPE	VC-4-16c
STS-192c-SPE	VC-4-64c

The keywords MUST, MUST NOT, MAY, OPTIONAL, REQUIRED, RECOMMENDED, SHALL, SHALL NOT, SHOULD, and SHOULD NOT are to be interpreted as defined in [6].

2. Physical Layer Requirements

PPP treats SONET/SDH transport as octet oriented synchronous links. SONET/SDH links are full-duplex by definition.

Interface Format

PPP in HDLC-like framing presents an octet interface to the physical layer. There is no provision for sub-octets to be supplied or accepted [3][5].

The octet stream is mapped into the SONET STS-SPE/SDH Higher Order VC, with the octet boundaries aligned with the SONET STS-SPE/SDH Higher Order VC octet boundaries.

Scrambling is performed during insertion into the SONET STS-SPE/SDH Higher Order VC to provide adequate transparency and protect against potential security threats (see Section 6). For backwards compatibility with RFC 1619 (STS-3c-SPE/VC-4 only), the scrambler MAY have an on/off capability where the scrambler is bypassed entirely when it is in the off mode. If this capability is provided, the default MUST be set to scrambling enabled.

For PPP over SONET/SDH, the entire SONET/SDH payload (SONET STS-SPE/SDH Higher Order VC minus the path overhead and any fixed stuff) is scrambled using a self-synchronous scrambler of polynomial X**43 + 1. See Section 4 for the description of the scrambler.

The proper order of operation is:

When transmitting:

IP -> PPP -> FCS generation -> Byte stuffing -> Scrambling -> SONET/SDH framing

When receiving:

SONET/SDH framing -> Descrambling -> Byte destuffing -> FCS detection -> PPP -> IP

The Path Signal Label (C2) indicates the contents of the SONET STS-SPE/SDH Higher Order VC. The value of 22 (16 hex) is used to indicate PPP with X^43 + 1 scrambling [4].

For compatibility with RFC 1619 (STS-3c-SPE/VC-4 only), if scrambling has been configured to be off, then the value 207 (CF hex) is used for the Path Signal Label to indicate PPP without scrambling.

The Multiframe Indicator (H4) is unused, and MUST be zero.

Control Signals

PPP does not require the use of control signals. When available, using such signals can allow greater functionality and performance. Implications are discussed in [2].

3. Framing

The framing for octet-synchronous links is described in "PPP in HDLC-like Framing" [2].

The PPP frames are located by row within the SONET STS-SPE/SDH Higher Order VC payload. Because frames are variable in length, the frames are allowed to cross SONET STS-SPE/SDH Higher Order VC boundaries.

4. X**43 + 1 Scrambler Description

The X**43 + 1 scrambler transmitter and receiver operation are as follows:

Transmitter schematic:

```
                                           Unscrambled Data
                                                  |
                                                  v
      +-------------------------------------+    +---+
   +->|     --> 43 bit shift register -->   |--->|xor|
   |  +-------------------------------------+    +---+
   |                                               |
   +-----------------------------------------------+
                                                  |
                                                  v
                                            Scrambled Data
```

Receiver schematic:

```
                                            Scrambled Data
                                                  |
  +-----------------------------------------------+
  |                                               |
  |                                               v
  |  +--------------------------------------+    +---+
  +->|     --> 43 bit shift register -->    |--->|xor|
     +--------------------------------------+    +---+
                                                  |
                                                  v
                                          Unscrambled Data
```

Note: While the HDLC FCS is calculated least significant bit first as shown:

```
           <-  <-  <-  <-
           A   B   C   D
```

(that is, the FCS calculator is fed as follows: A[0], A[1], ... A[7], B[0], B[1], etc...), scrambling is done in the opposite manner, most significant bit first, as shown:

```
            ->  ->  ->  ->
            A   B   C   D.
```

That is, the scrambler is fed as follows: A[7], A[6], ... A[0], B[7], B[6], etc...

The scrambler operates continuously through the bytes of the SONET STS-SPE/SDH Higher Order VC, bypassing bytes of SONET Path Overhead and any fixed stuff (see Figure 20 of ANSI T1.105 [3] or Figure 10-17 of ITU G.707 [5]). The scrambling state at the beginning of a SONET STS-SPE/SDH Higher Order VC is the state at the end of the previous SONET STS-SPE/SDH Higher Order VC. Thus, the scrambler runs continuously and is not reset per frame. The initial seed is randomly chosen by transmitter to improve operational security (see Section 6). Consequently, the first 43 transmitted bits following startup or reframe operation will not be descrambled correctly.

5. Configuration Details

Other than the FCS length (see below), the standard LCP sync configuration defaults apply to SONET/SDH links.

The following Configuration Options are RECOMMENDED for STS-3c-SPE/VC-4:

Magic Number
No Address and Control Field Compression
No Protocol Field Compression

For operation at STS-12c-SPE/VC-4-4c and above, Address and Control Field Compression and Protocol Field Compression are NOT RECOMMENDED. The Magic Number option remains RECOMMENDED.

Regarding the FCS length, with one exception, the 32-bit FCS MUST be used for all SONET/SDH rates. For STS-3c-SPE/VC-4 only, the 16-bit FCS MAY be used, although the 32-bit FCS is RECOMMENDED. The FCS length is set by provisioning and is not negotiated.

6. Security Considerations

The major change from RFC 1619 is the addition of payload scrambling when inserting the HDLC-like framed PPP packets into the SONET STS-SPE/SDH Higher Order VC. RFC 1619 was operationally found to permit malicious users to generate packets with bit patterns that could create SONET/SDH-layer low-transition-density synchronization problems, emulation of the SDH set-reset scrambler pattern, and replication of the STM-N frame alignment word.

The use of the x^43 + 1 self-synchronous scrambler was introduced to alleviate these potential security problems. Predicting the output of the scrambler requires knowledge of the 43-bit state of the transmitter as the scrambling of a known input is begun. This requires knowledge of both the initial 43-bit state of the scrambler when it started and every byte of data scrambled by the device since it was started. The odds of guessing correctly are 1/2**43, with the additional probability of 1/127 that a correct guess will leave the frame properly aligned in the SONET/SDH payload, which results in a probability of 9e-16 against being able to deliberately cause SONET/SDH-layer problems. This seems reasonably secure for this application.

This scrambler is also used when transmitting ATM over SONET/SDH, and public network carriers have considerable experience with its use.

A known security issue is bandwidth reduction by intentional transmission of characters or sequences requiring transparency processing by including flag and/or escape characters in user data. A user may cause up to a 100% increase in the bandwidth required for transmitting his or her packets by filling the packet with flag and/or escape characters.

7. Changes from RFC 1619

As mentioned in the previous section, the major change from RFC 1619 was the addition of payload scrambling when inserting the HDLC-like framed PPP packets into the SONET STS-SPE/SDH Higher Order VC. Other changes were:

The terminology was updated to better match that used by ANSI and ITU-T.

The specification's applicability is now specifically restricted to:

SONET	SDH
STS-3c-SPE	VC-4
STS-12c-SPE	VC-4-4c
STS-48c-SPE	VC-4-16c
STS-192c-SPE	VC-4-64c

The Path Signal Label (C2) is set to 22 (16 hex) when using X^43 + 1 scrambling.

The 32-bit FCS is required except for operation with STS-3c-SPE/VC-4, in which case the 16-bit FCS is allowed (but the 32-bit FCS is still recommended).

The Security Considerations section was added.

8. Intellectual Property

The IETF takes no position regarding the validity or scope of any intellectual property or other rights that might be claimed to pertain to the implementation or use of the technology described in this document or the extent to which any license under such rights might or might not be available; neither does it represent that it has made any effort to identify any such rights. Information on the IETF's procedures with respect to rights in standards-track and standards-related documentation can be found in BCP-11. Copies of claims of rights made available for publication and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or permission for the use of such proprietary rights by implementors or users of this specification can be obtained from the IETF Secretariat.

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights which may cover technology that may be required to practice this standard. Please address the information to the IETF Executive Director.

9. Acknowledgments

The scrambler description was provided by J. Manchester, S. Davida, B. Doshi, and J. Anderson of Lucent Technologies, R. Broberg of Cisco Systems, and Peter Lothberg of Sprint Corporation. The security analysis was provided by Iain Verigin of PMC-Sierra and Larry McAdams of Cisco Systems. The authors would also like to thank the members of the IETF's Point-to-Point Protocol Extensions Working Group for their many suggestions and improvements to the text.

10. References

[1] Simpson, W., Editor, "The Point-to-Point Protocol (PPP)", STD 51, RFC 1661, Daydreamer, July 1994.

[2] Simpson, W., Editor, "PPP in HDLC-like Framing", STD 51, RFC 1662, Daydreamer, July 1994.

[3] American National Standards Institute, "Synchronous Optical Network (SONET) - Basic Description including Multiplex Structure, Rates and Formats," ANSI T1.105-1995.

[4] American National Standards Institute, "Synchronous Optical Network (SONET)--Payload Mappings," T1.105.02-1998.

[5] ITU Recommendation G.707, "Network Node Interface For The Synchronous Digital Hierarchy", 1996.

[6] Bradner, S., "Key words for use in RFCs to indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

11. Authors' Addresses

Andrew G. Malis
Ascend Communications, Inc.
1 Robbins Road
Westford, MA 01810 USA

Phone: +1 978 952 7414
EMail: malis@ascend.com

William Allen Simpson
DayDreamer
Computer Systems Consulting Services
1384 Fontaine
Madison Heights, Michigan 48071

EMail: wsimpson@GreenDragon.com

12. Full Copyright Statement

Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.