1. Introduction

This Technical Report provides a comparison of the technical differences between SONET (Synchronous Optical NETwork) and SDH (Synchronous Digital Hierarchy) as described in the applicable standards pertaining to the two hierarchies. It covers only those issues raised by members of the T1X1.2 working group (Digital Transmission Network Architecture), therefore, no assurance can be given that it covers all differences between the two. Furthermore, it should be noted that the differences described are as understood at the time of this Technical Report was drafted and approved. Since the standards for both digital hierarchies continue to evolve, some differences described in this Technical Report may no longer exist, while others may have arisen.

1.1 Purpose

SONET and SDH are compatible, but not identical, digital hierarchies. Both define similar sets of overheads and functions, however, there are differences in the usage of the two overhead structures. The purpose of this technical report is to identify the areas where SONET and SDH differ

— in overhead/format definition

— in usage/interpretation of overheads

Once the differences have been clearly identified, it will be possible to assess the appropriate actions to be taken to insure smooth interworking between networks based on the two hierarchies. The Table 8 of this document is divided into two parts 8a and 8b. The first part, 8a, contains the detailed descriptions/definitions of the bytes as found in the standards documents as well as differences between SONET and SDH. The second part, 8b, documents the performance information as found in standards documents and highlights differences between SONET/SDH. In addition, the interworking information is grouped by SONET/SDH layers: Section, Line, and Path.

1.2 Scope

This report covers the comparison of transport rates; multiplexing structure; payload mappings; Operations, Administration, Management and Provisioning (OAM&P); and interworking issues.

2. Terminology

ABBREVIATIONS

ADM	Add drop multiplex
AIS	Alarm indication signal
ALS	Automatic laser shutdown
APS	Automatic protection switching
ATM	Asynchronous Transfer Mode
AU	Administrative unit
AUG	Administrative unit group
BBE	Background Block Error
BER	Bit error ratio

BIP	Bit interleaved parity
BIP-N	Bit interleaved parity N
B-ISDN	Broadband integrated services digital network
CMISE	Common Management Information Service Element
DCC	Data communications channel
DQDB	Distributed queue dual bus
ES	Errored second
FAL	Frame alignment loss
FDDI	Fiber distributed data interface
FEBE	Far end block error
FERF	Far end receive failure
HPA	Higher order path adaptation
HPC	Higher order path connection
HPT	Higher order path termination
LB	Letter Ballot
LTE	Line terminating equipment
LO	Lower order
LOF	Loss of frame
LOM	Loss of multiframe
LOP	Loss of pointer
LOS	Loss of signal
MCF	Message communications function
MS	Multiplex section
MSOH	Multiplex section overhead
MSP	Multiplex section protection
MST	Multiplex section termination
NDF	New data flag
NE	Network element
NEF	Network element function
NNI	Network node interface
OAM&P	Operations, Administration, Maintenance & Provisioning
OC-1	Optical carrier level 1
OC-N	Optical carrier level N
OS	Operations systems
OSI	Open systems interconnection
OFS	Out-of-frame second
OOF	Out-of-frame
PDH	Plesiochronous digital hierarchy
PDU	Protocol data unit
PI	Physical interface
PJE	Pointer justification event

POH	Path overhead
PTE	Path terminating equipment
RDI	Remote Defect Indication
RFI	Remote Failure Indication
RS	Regenerator section
RSOH	Regenerator section overhead
SD	Signal degrade
SDH	Synchronous digital hierarchy
SEFS	Severely errored frame second
SEMF	Synchronous equipment management function
SES	Severely errored second
SF	Signal fail
SPE	Synchronous payload envelope
STE	Section terminating equipment
STM	Synchronous transport module
STS-1	Synchronous transport module level 1
STS-N	Synchronous transport module level N
STS	Synchronous transport signal
STS-1	Synchronous transport signal level 1
STS-N	Synchronous transport signal level N
STS-Nc	Concatenated synchronous transport signal level N
TMN	Telecommunications management network
TU	Tributary unit
UAS	Unavailable Seconds
VC	Virtual container
VT	Virtual tributary
VTx	VT of size x (currently x=1.5, 2, 3, or 6)
VTx-Nc	Concatenated virtual tributary in which N Vts of size x are combined and treated as an entity.

3. SONET - SDH Overview

3.1 Scope of Standards

Complete details of the SONET standard can be found in references[1], [2], [3], [4], [5], [6] Complete details of the SDH standard can be found in references[7], [8], [9], [10], [11], [12].

3.2 Rates

The 51.84 Mbit/s Synchronous Transport Signal-Level 1 (STS-1) is the basic building block of SONET. All lower rate payloads are mapped into the STS-1, and all higher rate signals are created by synchronously multiplexing N STS-1s to form an STS-N. The multiplexing process simply byte interleaves the N incoming signals[1]. No additional overhead is added; thus, the transmission rate of an STS-N signal is exactly Nx51.84 Mbit/s. The currently defined SONET transmission rates are given in Table 1. Figure 1 shows the STS-1 frame structure.

TABLE 1: SONET TRANSPORT RATES

Level	Rate	
STS-1	51.840	Mbit/s
STS-3	155.520	Mbit/s
STS-12	622.080	Mbit/s
STS-24	1244.160	Mbit/s
STS-48	2488.320	Mbit/s

The 155.520 Mbit/s Synchronous Transport Module-Level 1 (STM-1) is the basic building block of SDH. All lower rate payloads are mapped into the STM-1, and all higher rate signals are created by byte synchronously multiplexing N payloads (called AU groups, see Reference 8) from N STM-1s and adding transport overhead to form an STM-N. The transport overhead added to the STM-N is equivalent to N times that of an STM-1: thus, the transmission rate of an STM-N signal is exactly Nx155.520 Mbit/s. The currently defined SDH transmission rates are given in the Table 2. Figure 2 shows the STM-1 frame structure. Table 3 shows the SONET/SDH transmission rates side by side for easier comparison.

TABLE 2: SDH TRANSPORT RATES

Level	Rate	
STM-1	155.520	Mbit/s
STM-4	622.080	Mbit/s
STM-16	2488.320	Mbit/s

TABLE 3: SONET/SDH Transmission Rates

SONET Signal		SDH Signal	Transmission Rate	
STS-1	*		51.840	Mbit/s
STS-3	*	STM-1	155.520	Mbit/s
STS-12	*	STM-4	622.080	Mbit/s
STS-24			1244.160	Mbit/s
STS-48	*	STM-16	2488.320	Mbit/s

* Rates expected to be frequently used.

3.3 Multiplexing Structure

SONET and SDH both support a variety of different payloads. Unlike SONET, however, SDH allows different mappings for the same payload. All of the SDH payloads which can be mapped into an AU-3 can also be mapped into an AU-4. Therefore, these payloads may be mapped into an STM-1 by first mapping them into an AU-3 and then mapping three AU-3s into an STM-1 or by mapping them into an AU-4 and then mapping a single AU-4 into an STM-1. Since SONET only provides one choice for the defined payload mappings, this is a source of incompatibility between SONET and SDH.

Figures 3 & 4 illustrate the different mapping paths for SONET and SDH. In Figure 4, following only bold lines from the payload on the right to the STM-N on the left, the SDH mapping is SONET compatible. Going through any thin lines, the mapping is not SONET compatible.

Table 4 provides some comparison between SONET and SDH terminology. It is important to understand that the comparisons are not exact, and the rest of this technical report discusses the differences.

1. This is how multiplexing is described in the current SONET standard, but the description offered in the next paragraph for SDH multiplexing more accurately reflects actual implementations.

TABLE 4: TERMINOLOGY COMPARISON

SONET	SDH
STS-3c	AU-4
STS-1	AU-3
VT	TU
SPE	VC

3.4 Payload Mappings

The STS-1 SPE supports various payloads up to 49.536 Mbit/s. Payloads such as DS1s are first mapped into Virtual Tributaries (VTs), and then the VTs are mapped into the STS-1 SPE via the seven VT Groups. Payloads such as DS3s are mapped directly into the STS-1 SPE. In addition, larger payloads can be accommodated by concatenating N SPEs to form an STS-Nc signal. In this case, the signal looks essentially the same as an STS-N except there is only one set of the path overhead (since there is only one payload). In a standard STS-N, there would be N sets of path overhead (one from each of the constituent STS-1s).

The currently defined payloads and the "containers" (VT/STS SPE) that would carry them are listed in Table-5[2]. This table lists the usable bandwidth (actual payload capacity) of each container and the rate required to cross-connect the usable bandwidth and associated overheads (VT/STS SPE bandwidth).

TABLE 5: SONET PAYLOADS

Payload		"Container"	Actual Payload Capacity	VT/STS SPE Bandwidth
DS1	(1.544 Mbit/s)	VT1.5 SPE	1.648 Mbit/s(Note 1)	1.664 Mbit/s
DS1A	(2.048 Mbit/s)	VT2 SPE	2.224 Mbit/s(Note 1)	2.240 Mbit/s
DS1C	(3.152 Mbit/s)	VT3 SPE	3.376 Mbit/s (Note 1)	3.392 Mbit/s
DS2	(6.312 Mbit/s)	VT6 SPE	6.832 Mbit/s (Note 1)	6.848 Mbit/s
DS3	(44.736 Mbit/s)	STS-1 SPE	49.536 Mbit/s (Note 2)	50.112 Mbit/s
FDDI	(125.000 Mbit/s)	STS-3c SPE	149.760 Mbit/s	150.336 Mbit/s
DS4NA	(139.264 Mbit/s)	STS-3c SPE	149.760 Mbit/s	150.336 Mbit/s
ATM	(149.760 Mbit/s)	STS-3c SPE	149.760 Mbit/s	150.336 Mbit/s
DQDB	(149.760 Mbit/s)	STS-3c SPE	149.760Mbit/s	150.336 Mbit/s
ATM (Note 3)	(599.040 Mbit/s)	STS-12c SPE	599.040 Mbit/s	601.344 Mbit/s

Note 1: These values assume that the R bytes are available for payload. ITU has claimed these bytes for extended POH, thus reducing the available capacity to that shown in Table 6 (for SDH).

Note 2: Current mappings include two columns of fixed stuff, reducing the available capacity to 48.384 Mbit/s (equivalent to the capacity of a VC-3)

Note 3: This mapping is not shown in the current standard, but it has been agreed by T1X1.5 and will appear in the update of Reference 1.

Note 4: For VT payloads, the "Actual Payload Capacity" is equivalent to the capacity of the VT SPE without the VT POH (V5 byte).

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2. Other same rate payloads may also be supported by these mappings (e.g. The 139.264 Mbit/s DS4NA mapping will accommodate any asynchronous 139.264 Mbit/s signal).

Note 5: For STS payloads, the "Actual Payload Capacity" is equivalent to the capacity of the STS SPE without the STS POH.

Note 6: For VT payloads, the "Payload & POH" is equivalent to the VT SPE.

Note 7: For STS payloads, the "Payload & POH" is equivalent to the STS SPE.

SDH has four hierarchical levels in the payload of an STM-1. A PDH digital signal to be transported over a synchronous digital network is first mapped into a container (C) that is appropriate to the tributary signal bit rate. In the next step, Path Overhead (POH) which provides OAM&P capabilities for the payload end-to-end, is added to this container C. The use of the bytes in POH is the same regardless of the tributary signal rate. The unit thus formed (Container plus POH) is called Virtual Container, VC. Higher Order (HO) VCs (VC-3, VC-4) are mapped into either an Administrative Unit Level 3 (AU-3) or an AU-4. Lower Order (LO) VCs (VC-11, VC-12, VC-2, VC-3) are mapped into HO VCs, using Tributary Unit (TU) pointers to locate them within the HO VC (Note that a VC-3 may be either a LO VC or a HO VC, depending on the multiplexing path used). Then, either three AU-3s or one AU-4 is mapped into the SPE of the STM-1. The AU-3 pointer will be included in each AU-3, or an AU-4 pointer will be included in the AU-4 to identify the position of the first byte of the payload frame within the SPE. Further, concatenated STM-Ns can be used to transport larger payloads in the form of a VC-4-Nc signal which will contain only one set of the path overhead since it contains only one payload.

The currently defined payloads and the "containers" (Cs) that would carry them are listed in Table 6 (see footnote 2). This table lists the usable bandwidth (Actual Payload Capacity) of each container and the rate required cross-connect the usable bandwidth and associated overheads (VC bandwidth).

TABLE 6: SDH PAYLOADS

Payload		"Container"	Actual Payload Capacity	VC Bandwidth
DS1 DS1	(1.544 Mbit/s) (1.544 Mbit/s)	C-11 C-12	1.600 Mbit/s 2.176 Mbit/s	1.664 Mbit/s 1.664 Mbit/s
DS1A	(2.048 Mbit/s)	C-12	2.176 Mbit/s	2.240 Mbit/s
DS2	(6.312 Mbit/s)	C-2	6.784 Mbit/s	6.848 Mbit/s
E3	(34.368 Mbit/s)	C-3	48.384 Mbit/s	48.960 Mbit/s
DS3	(44.736 Mbit/s)	C-3	48.384 Mbit/s	48.960 Mbit/s
DS4NA	(139.264 Mbit/s)	C-4	149.760 Mbit/s	150.336 Mbit/s
ATM	(149.760 Mbit/s)	C-4	149.760 Mbit/s	150.336 Mbit/s
ATM	(599.040 Mbit/s)	C-4-4c	599.040 Mbit/s	601.344 Mbit/s
ATM	(2396.16 Mbit/s)	C-4-16c	2396.16 Mbit/s	2405.376 Mbit/s

Notes:

A. For C-3, the "Actual Payload Capacity" is equivalent to the capacity of the STS-1 SPE without the STS POH and the two fixed stuff columns.

B. For C-3, the "Payload & POH" is equivalent to the STS-1 SPE without the two fixed stuff columns.

C. For C-4, the "Actual Payload Capacity" is equivalent to the capacity of the STS-3c SPE without the STS POH.

D. For C-4, the "Payload & POH" is equivalent to the STS-3c SPE.

E. For C-4-4c, the "Actual Payload Capacity" is four times the capacity of the VC-4 (columns 2 to 4 of the VC-4-4c are specified in G.709 as fixed stuff).

Table 7 shows the SONET and SDH payload mappings. The left column lists the currently planned payloads. Most of these payloads correspond to levels in the existing asynchronous hierarchies. The remaining columns list the "container" which would be used to map the payload into an STS-1, STS-Nc, AU-3-based STM-1, or AU-4-based STM-1. If no mapping exists for a particular payload into a particular signal, "None" appears in the table for that entry. The compatible SONET/SDH mappings are enclosed in brackets.

TABLE 7: SONET/SDH Payload Mappings

Payload		STS-1	STS-Nc	AU-3 Based STM-1	AU-4 Based STM-1
DS1	1.544 Mbit/s	(VT1.5)	None	(VC-11) or VC-12 (Note 1)	VC-11 or VC-12 (Note 1)
DS1A	2.048 Mbit/s	(VT2)	None	(VC-12)	VC-12
DS1C	3.152 Mbit/s	VT 3	None	None	None
DS2	6.312 Mbit/s	(VT 6)	None	(VC-2)	VC-2
E3	34.368 Mbit/s	None	None	VC-3	VC-3
DS3	44.736 Mbit/s	(STS-1 SPE)	None	(VC-3)	VC-3
FDDI	125.000 Mbit/s	None	(STS-3c SPE)	None	None
DS4NA	139.264 Mbit/s	None	(STS-3c SPE)	None	(VC-4)
DQDB	149.760 Mbit/s	None	(STS-3c SPE)	None	None
ATM	149.760 Mbit/s	None	(STS-3c SPE)	None	(VC-4)
ATM (Note 2)	599.040 Mbit/s	None	None	None	(VC-4-4c)
ATM	2405.376 Mbit/s	None	None	None	(VC-4-16c)

( ) Compatible SONET/SDH mappings.

Note 1: In SDH, a DS1 may be carried in a VC-12 (2 Mbit/s)

Note 2: This mapping is not shown in the current standard, but it has been agreed by T1X1.5 and will appear in the update of Reference 1.

3.5 Operations, Administration, Maintenance, and Provisioning

Network Management (NM) features required to support operations of digital transmission networks are embedded in the SONET/SDH standard signal format. The basic ability to locate faults in the network is contained in the layered format structure of section, line and path with each layer having bytes of information dedicated to monitoring network performance. For example, bit interleaved parity information is one of those bytes (B1, B2, & B3) contained in each layer that calculates coding violations (CVs) to help determine the location and cause of faults. Other bytes in the overheads (OHs) are used for framing (A1, A2) and end-to-end path status and other operational functions.

Table 8a describes the functions of the OH bytes defined in the SONET/SDH standards and identifies differences between the SONET/SDH standards. Table 8b contains the performance information. Although descriptions in columns 2 and 3 of Table 8a and 8b may differ, they are functionally compatible unless stated in difference column.

Table 8a: Comparison of Overhead Bytes
Section Layer

Byte(s)	SONET	SDH	Difference
A1, A2 (Framing)	These "framing" bytes are dedicated to each STS-1. The framing pattern shall be A1A2 (A1=11110110 and A2=00101000). A1 and A2 shall be provided in all STS-1 signals within an STS-N (T1.105-1991, p12). These bytes are unscrambled.	These framing bytes are dedicated to each STM-1 signal. The framing pattern shall be A1A1A1A2A2A2 (A1=11110110 and A2=00101000). These bytes shall be provided in all STM-1 signals within an STM-N (G.708). These bytes are unscrambled.	
C1	STS-1 Identification byte. This is an unique number assigned just prior to byte interleaving that stays with that STS-1 until the signal is decomposed. The C1 byte in each STS-1 shall be set to a binary number corresponding to its order of appearance in the byte interleaved STS-N frame. At the May 1993 T1X1.5 meeting it was provisionally agreed to make the C1 byte no longer used for STS-1 ID and to consider its use for a Section Trace Function. These bytes are unscrambled.	STM Identifier. It is a unique identifier indicating the binary number value of the multi-column, interleave depth coordinate, c. It may be used to assist in the frame alignment (G.708). The STM identifier C1 bytes are present in the RSOH (regenerator section overhead) within the STM-N signal; However, processing of the C1 bytes is not required (G.783, Nov 1992, p10). Also, it was provisionally agreed at January 1993 CCITT Study Group XVIII meeting to "deactivate" the C1 byte with the intention of redefining it as "section trace". Also, it was agreed that "in the case of interworking of equipment with the C1 byte definition according to the 1991 version of G.708 and new equipment employing the section trace function, the pattern carried by the C1 byte shall be in accordance with the 1991 version of G.708". The new equipment shall interpret this pattern as "section trace, unspecific". This unspecific section trace can also be used if no use of the section trace is made. When the section trace is required in a STM-N signal (where N>1) it shall be provided in the C1 byte contained in STM-1 #1, the contents of the remaining C1 bytes are not defined. These bytes are unscrambled.	In SDH, at the international boundary, both the E.164 [14], and a 256 bit oriented format is being considered. SONET uses STS-1 (51.84 Mbit/s) interleaving while SDH uses STM-1 (155 Mbit/s). In the case of SDH, the remaining bytes are used as national bytes.
B1 - (BIP-8)	One byte is allocated in each STS-1 for a section error monitoring function. This function shall be a bit interleaved parity 8 code using even parity. The section BIP-8 is calculated over all the bits of the previous STS-N frame after scrambling. The computed BIP-8 is placed in the B1 byte of STS-1 #1 before scrambling. This byte is defined only for STS-1 number 1 of an STS-N signal (T1.105-1991, p12).	One byte is allocated for regenerator section error monitoring. This function shall be a bit interleaved Parity 8 (BIP-8) code using even parity. The BIP-8 is computed over all bits of the previous STM-N frame after scrambling and is placed in byte B1 before scrambling (G.708).	

Byte(s)	SONET	SDH	Difference
E1	Orderwire. One byte is allocated to be used as a local orderwire channel that shall be used as a voice communication channel. It is reserved for communication between section terminating equipments, hubs, and remote terminal locations and it is only defined for STS #1 of an STS-N (T1.105-1991, p12).	Orderwire This byte may be used to provide an orderwire channel for voice communication. E1 is part of the regenerator section overhead and may be accessed at regenerators (G.708).	SDH defines the encoding law conversion between A-law and μ law according to ITU-T (CCITT) Recommendation G.802. In SONET, Signaling on the E1 byte is for further study.
F1	One byte is set aside for the user's purposes. This byte shall be passed from section to section within a line and shall be readable, writable, or both at each section terminating equipment in that line (T1.105-1991, p12). It is defined only for STS-1 number 1 of an STS-N.	This byte is reserved for user purposes (G.708).	The use of this function is optional in SONET.
D1, D2 & D3	Section DCC These bytes are allocated for Section Data Communication and should be considered one 192 kbit/s message based channel for alarms, maintenance, control, monitor, administration, and other communication needs between Section terminating equipment. These bytes are defined only for STS-1 # 1 of an STS-N (T1.105-1991, p13). A seven layer OSI- conformant protocol stack has been specified for use on this channel. It utilizes CMISE/ASN.1 to form the actual messages (ANSI T1.119-199x)	Regenerator Section DCC. A 192 kbit/s channel is defined using these bytes (G.708). These bytes are allocated for regenerator section data communication and should be considered one 192 kbit/s message based channel for alarms, maintenance, control, monitor, administration, and other communication needs between Section terminating equipment. A seven layer OSI- conformant protocol stack has been specified for use on this channel. It utilizes CMISE/ASN.1 to form the actual messages (M.3010) [13].	

Table 8a: Comparison of Overhead Bytes (continued)
Line Layer

Byte(s)	SONET	SDH	Difference
H1, H2, H3	Payload pointer H1, H2 are allocated to a pointer that indicates the offset in bytes between the pointer and the first byte of the STS SPE. It shall be used to align the STS-1 Transport Overheads in an STS-N signal as well as perform frequency justification. These bytes shall be provided in all STS-1 signals within an STS-N (T1.105-1991). Four bits (1-4) of H1 & H2, are used as a "New data Flag", two bits indicate the size of the SPE (default="00"). The last 10 bits (bits 7 thru 16) of the pointer word carry the pointer value. the pointer value is a binary number with a range of 0 to 782 that indicates the offset between the pointer and the start of the STS SPE. The value of all "1"s in the offset bits indicates that the payload is concatenated with the previous STS-1 SPE (T1.105-1991). H3 is called Pointer action byte. It is allocated for frequency justification purposes. Depending on the pointer value, this byte is used to adjust the fill of input buffers (T1.105-1991).	AU-4 Pointer. The AU-4 pointer is contained in bytes H1, H2 and H3. The three individual AU-3 pointers are contain in three separate H1, H2 and H3 bytes. VC-3 payloads can also be carried as TU-3s (Tributory Unit) in a VC-4. The TU-3 consists of VC-3 with VC-3 POH and the TU-3 pointer. TU-3 pointer also consists of H1, H2, H3 bytes. The pointer contained in H1 and H2 designates the location of the byte where the VC-4 begins. Bits 1-4 of the pointer word carry an new data flag. Two bits indicate the size of the AU (default="10"). The last 10 (7-16) bits of the pointer word carry the pointer value. The AU-4 pointer value is a binary number with a range of 0 to 782 which indicates the offset, in three byte increments, between the pointer and the first byte of the VC-4 The value of all "1"s in the bits 7-16 indicates concatenation (G.709). H3 byte = Negative justification opportunity (G.709).	The bits 5-6 (ss bits) are set differently in SONET and SDH. For a SONET STS-3c, the ss bits are undefined for H1 #1, and set to 00 for H1 #2 and H1 #3. For an SDH STM-1 with an AU-4, the ss bits are 10 for H1 #1, and undefined for the equivalent H1 #2 and H1 #3. At the September 1992 SG XV meeting it was agreed to keep the ss bits in SDH & SONET the way they are and to add the following note to Annex B of G.783: "In some applications, interworking with North American countries may require that the ss bits in the AU-n pointer be ignored."
H4	Multiframe indicator: This byte provides a generalized multiframe indicator for payloads. Currently, this indicator is only used for VT-structured payloads (T1.105-1991, p15).	Multiframe Indicator. This byte provides a generalized multiframe indicator for payloads and can be payload specific (for example, H4 can be used as a multiframe position indicator for the VC-1/VC-2). (G.709).	
B2	Line BIP-8. One byte is allocated in each STS-1 for a line error monitoring function and provide data for fault sectionalization. This function shall be a bit-interleaved parity 8 code using even parity. The Line BIP-8 is calculated over all bits of the Line overhead and STS-1	Multiplex Section BIP-24xN The B2 bytes are allocated for a Multiplex Section error monitoring function. This function shall be a Bit Interleaved Parity Nx24 code (BIP-Nx24) using an even parity.	

Byte(s)	SONET	SDH	Difference
	Envelope Capacity of the previous STS-1 frame before scrambling. The computed BIP-8 is placed into the B2 byte of the STS-1 before scrambling. This byte shall be provided in all STS-1 signals within an STS-N signal (T1.105-1991, p13).	The BIP-Nx24 is computed over all the bits of the previous STM-1 frame except for the first three rows of SOH and is placed in the bytes of B2 before scrambling (G.708).	
K1, K2	Line automatic protection switching. These two bytes are allocated for Automatic Protection Switching (APS) signaling between Line level entities. These bytes shall be defined only for STS-1 number 1 of an STS-N signal (T1.105-1991, p13).	Multiplex Section Automatic Protection Switching The two bytes K1 and K2 are allocated for APS signaling (G.708).	
K1 byte functions	The first four bits of K1 are used for Switch Preemption Priority and the bits 5-8 are used for channel requesting switch action/destination node id (T1.105-1991, p29/T1X1.5/92-004R8). A total of 16 functions have been defined for the K1 byte bits 1-4. For example, the value of 1111 indicates lockout of protection (span) or signal fail (protection) and 0000 indicates no request. [More information can be found in T1X1.5/92-004R8 (Draft ANSI T1-105.01-199x)].	The first four bits of K1 indicate the protection switching request. The last four bits indicate the line requesting the switch. A total of 16 functions have been defined for the K1 byte bits 1-4. For example, the value of 1111 indicates lockout of protection and 0000 indicates no request. (More information can be found in G.783, Annex A). The bits 5-8 of K1 byte are used for destination node identification.	
K2 byte functions	The first four bits of K2 are used for Source Node Identification purposes. Bit 5 indicates the type of protection switching configuration. Zero (0) indicates a short path code and 1 indicates a long path code. Bits 6-8 of byte K2 are used on all OC-N signals to signal FERF and Line AIS [(T1X1.5/92-004R8, (Draft ANSI T1.105.01-199x), p15)].	Bits 1-4 of K2 indicate channel number. Bit 5 indicates the type of the MSP architecture (G.783, Nov 1992, p67). Bits 6-8 of K2 (codes 110 & 111) are used for MS-AIS detection and MS-FERF indication (G.783, Nov 1992, p13).	Line switching work has not been done in SDH.
D4-D12	Line Data Communication Channel. It is a 576 kb/s message-based channel for OAM&P needs between Line terminating entities. This is defined only for STS-1 number 1 of an STS-N signal (T1.105-1991, p13). A seven layer OSI- conformant protocol stack has been specified for use on this channel. It utilizes CMISE/ASN.1 to form the actual messages (ANSI T1.119-199x)	Multiplex section DCC. It is a 576 kb/s message-based channel for OAM&P communication among the NEs and between NEs and the OS/MD (G.708). A seven layer OSI- conformant protocol stack has been specified for use on this channel. It utilizes CMISE/ASN.1 to form the actual messages (M.3010).	

Table 8a: Comparison of Overhead Bytes (continued)
Line Layer

Byte(s)	SONET	SDH	Difference
Z1 Byte	Sync. status messages Bits 5 to 8 of byte Z1 are allocated for synchronization status messages.	Sync. status messages Bits 5-8 of Z1 byte are allocated for Synchronization status messages.	Six messages were defined for SDH (June 92) and the other codes are reserved for quality levels defined by individual administrations. In SDH, Z1 is renamed to S1.
Z2	General FEBE for BISDN (UNI) for both STS-3c and STS-12c (T1.624-1993)	Section FEBE Section FEBE for STM-1 & STM-4 levels. This byte conveys the count interleaved bit blocks that have been detected in error by the BIP-Nx24 (B2).	The need for section FEBE in SONET has not been established yet. In SDH, Z2 is renamed to M1.
E2	Express orderwire. One byte is allocated in the Line layer for an express orderwire between line entities. This byte is defined only for STS-1 number 1 of an STS-N and its use is optional (T1.105-199,1 p13).	Orderwire. This byte is part of the MSOH and may be accessed at multiplex section terminations (G.708) for voice communication.	SDH defines the encoding law conversion between A-law and μ law according to ITU-T (CCITT) Recommendation G.802. In SONET, signaling on the E2 byte is for further study.

Table 8a: Comparison of Overhead Bytes (continued)
Path Layer

Byte(s)	SONET	SDH	Difference
J1	Path Trace. This byte is used to repetitively transmit a 64 byte, fixed length, string so that a receiving terminal in a path can verify its continued connection to the intended transmitter (T1.105-1991, p14).	Path Access Point Identifier (VC-3/VC-4 path trace). This is the first byte in the VC. Its location is indicated by the associated AU or TU pointer. The J1 byte may be either a 64 byte free format or 16 byte E.164 format within a national network. At the international boundary, only the E.164 format shall be used. Where the 16 byte format is transferred in the 64 byte field, it shall be repeated four times.	ITU-T prefers E.164 whereas U.S. prefers CLLI/CLEI.
B3	Path error monitoring One byte is allocated for path error monitoring function. This function shall be a bit interleaved parity 8 code using even parity. The path BIP-8 is calculated over all bits of the previous STS SPE before scrambling (T1.105-1991, p14).	Path error monitoring One byte is allocated in each VC-3 or VC-4 for a path error monitoring function. This function shall be a BIP-8 code using even parity. The path BIP-8 is calculated over all bits of the previous VC-3 or VC-4 before scrambling. The computed BIP-8 is placed in the B3 byte of the current VC-3 or VC-4 before scrambling (G.709).	In SONET, B3 calculation covers the entire SPE including the fixed stuff bytes. SDH excludes the fixed stuff bytes in the calculation. For purposes of consistency between SONET and SDH, in SDH, the byte in each row of the two columns (30 & 59) of fixed stuff of each AU-3 shall be the same; This guaranteeing the even parity required by SONET. It should be noted, however, that SONET equipment looks for parity errors over a larger field, and will therefore count more errors over time than SDH equipment.
C2	Signal Label One byte is allocated to indicate the construction of the STS SPE. Note than any value received, other than value 0 constitutes an equipped condition (T1.105-1991, p14).	Signal Label This byte is allocated to indicate the composition of the VC-3/VC-4. Note that any value received, other than 0 constitutes an equipped condition (G.709).	
G1, bits 1-4	Path Status, Class A One byte is allocated to convey back to an originating STS PTE the path terminating status and performance.	Path status One byte is allocated to convey back to an originating VC terminating equipment the path terminating status and performance.	

Table 8a: Comparison of Overhead Bytes (continued)
Path Layer

Byte(s)	SONET	SDH	Difference
	This permits the status and performance of the complete duplex path to be monitored at either end, or at any point along that path (T1.105-1991). Bits 1 thru 4 convey the count interleaved bit blocks that have been detected in error by the Path BIP-8 code , B3 (T1.105-1991, p14).	This permits the status and performance of the complete duplex path to be monitored at either end, or at any point along that path (G.709). Bits 1-4 convey the count of interleaved-bit blocks that have been detected in error by the path BIP-8 code (B3) (G.709).	
G1, bit 5	It was agreed in March 1993 to allocate bit 5 of G1 as STS path RDI. In the current T1.105-1991 document, (p14), bit 5 is an STS Path Yellow indicator (RFI: Remote Failure Indicator).	Path FERF (RDI) used to convey path status back to the far end.	STS path RFI is for further study.
G1 - bits (6,7,8)	Unassigned at this time.	Unassigned at this time.	
V1, V2, V3	Payload Pointers. The VT Payload Pointer provides a method of allowing flexible and dynamic alignment of the VT SPE within the Virtual Tributary superframe, independent of the actual contents of the envelope (T1.105-1991, p20). Bits (1-4) of the pointer Word carry a "New data Flag". Bits 5-6 indicates the VT size. The last 10 bits (7-16) of the pointer word carry the pointer value. the pointer value is a binary number indicates the offset between the pointer and the start of the VT SPE within the VT superframe. The value of all "1"s in the offset bits indicates that the payload is concatenated with the previous VT SPE. The V3 byte indicates the location for the stuff byte.	TU-1/TU-2 pointers are contained in the V1 and V2 bytes. The two s bits, 5-6 indicate the TU type. The pointer value (bits 7-16) is a binary number which indicates the offset from V2 to the first byte of the VC-1/VC-2 (G.709). Four bits (1-4) are used as a "New data Flag", two bits indicate the type of the VC. The last 10 bits of the pointer word carry the pointer value. the pointer value is a binary number. The value of all "1"s in the 10 offset bits indicates concatenation. The V3 byte provides a location of the stuff byte.	

Table 8a: Comparison of Overhead Bytes (continued)
Path Layer

Byte(s)	SONET	SDH	Difference
V5, bits 1, 2	VT Path Overhead. This byte provides the same functions that B3, C2, and G1 provide for STS Paths, namely, error checking, Signal Label, and Path Status (T1.105-1991, p21). Bits 1-2 are used for error performance monitoring. Bit 1 even parity calculated over all odd numbered bits (1,3,5 and 7) in all bytes in the previous VT SPE. Similarly, bit 2 is even parity calculated over the even numbered bits. Note that the calculation of the BIP-2 includes the VT POH bytes but excludes the VT pointers (T1.105-1991, p15).	VC-1/VC-2 Path Overhead. This byte provides the function of error checking, signal label, and path status of the VC-1/VC-2 paths. V5 is used only in floating mode VC-1/VC-2s and is designated as an R byte in locked mode VC-1/VC-2 (G.709). Bits 1 and 2 are used for error performance monitoring. A BIP scheme is specified. Bit 1 is set such that parity of all odd number bits (1,3,5 and 7) in all bytes in the previous VC-1/VC-2 is even and bit 2 is set similarly for the even number bits (2,4,6 and 8). Note that the calculation of the BIP-2 includes the VC POH bytes but excludes bytes V1, V2, and V3 (except when used for negative justification) and V4 (G.709).	
V5, bit 3	Bit 3 is a VT Path far-End-Block-Error (FEBE) indication that is sent back towards an originating VT PTE if one or more errors was detected by the BIP-2 (T1.105-1991, p15).	Bit 3 is a VC-1/VC-2 path FEBE indication that is set to one and sent back towards a VC-1/VC-2 path originator if one or more errors are detected by the BIP-2, and is otherwise set to zero (G.709).	
V5, bit 4	Bit 4 provides a RFI information (March 1993 agreement).	Bit 4 is allocated for an optional path RFI function.	
V5, bits 5,6 & 7	VT signal label. Eight binary values are possible in these three bits. Code 0 indicates VT path unequipped and code 1 indicates VT path equipped- non specific payload (T1.105-1991, p15).	Bit 5-7 provide a VC-1/VC-2 signal label. Eight binary values are possible in three bits. Three values are defined to indicate the specific mappings. The use of these three values are optional although they are not to be used for other purpose (G.709).	
V5, bit 8	VT path yellow indication. Yellow signals are associated with the lowest maintainable facility level associated with a particular service. Upon detection of a service affecting failure at a terminal a local red alarm is declared, and a Yellow signal is returned to the far end network element that terminates the service (T1.105-1991, p16,17). It was agreed (March 1993) to allocate bit 8 of V5 to VT path RDI.	VC-1/VC-2 Path FERF (RDI). Bit 8 is a VC-1/VC-2 path FERF. This is set to one if either a TU-1/TU-2 path AIS or a signal failure condition is being received, otherwise it is set to zero. The VC-1/VC-2 path FERF is sent back by the VC-1/VC-2 assembler (G.709).	

Table 8a: Comparison of Overhead Bytes (continued)
Path Layer

Byte(s)	SONET	SDH	Difference
F2	Path user channel-class c. One byte is allocated for user communication purposes between path elements (T1.105-1991, p15).	Path user channel. One byte is allocated for user communication purposes between path elements (G.709).	
J2	Not defined.	Path Trace Identifier for LO VCs. It was agreed to use the J2 byte as a path trace identifier (as J1 for HO VCs); And the format will be E.164 (G.709). (See Figure 7)	The need for J2 byte has not been established in SONET.
Z3, Z4	In SONET, Z3 is a growth byte and is reserved for future needs. Z3 is being used for a function in IEEE 802.6 DQDB mapping into SONET.	In SDH, Z3 is a growth byte and is reserved for future needs.	
Z5	This byte is used for Tandem Monitoring. For Tandem connection maintenance, byte Z5 is used in the following manner: bits 1 to 4 are used as an incoming error count (IEC) (with the MSB of the IEC in bit 1) and bits 5 to 8 are used as a communication channel. This byte can be overwritten in an operator domain without affecting the end to end performance monitoring facility of the byte B3.	This byte is allocated for specific management purposes. For Tandem connection maintenance, byte Z5 is used in the following manner: bits 1 to 4 are used as an incoming error count (IEC) (with the MSB of the IEC in bit 1) and bits 5 to 8 are used as a communication channel.	
Z6	Not defined in SONET	Z6 is allocated for LO Tandem Connection features. (See Figure 7).	The need for the use of Z6 byte has not been established in SONET.
Z7	Not defined in SONET	Reserved for future use. (See Figure 7).	Not defined in SONET.

Table 8b: Comparison of Performance Monitoring Information

Byte(s)	SONET	SDH	Difference
Framing bytes: A1, A2			
Defect Processing OOF	OOF (Out Of Frame) events are collectively referred to as LOF (Loss of Frame) defects. An LOF defect occurs when an SEF (Section Severely Errored Frame) defect persists for a period of 3 milliseconds. An SEF defect is the occurrence of four contiguous errored frame alignment words. An SEF defect is terminated when two contiguous error-free frame words are detected. Any implementation of the frame recovery circuitry which achieves realignment following an out of frame within the 250 µs (two frame) interval implied by this definition is acceptable (T1M1.3/93-005R1, p19).	If in the in-frame state, the maximum OOF detection shall be 625µsec for a random unframed signal (G.783, Nov 1992, p10). The algorithm to used to check the alignment shall be such that, under normal operation, a 10^{-3} (Poisson type) error ratio will not cause a false OOF more than once per six minutes. If the OOF state persists for (TBD) milliseconds, a Loss of Frame shall be declared (G.783, Nov 1992, p10).	
LOF	A Loss of Frame (LOF) defect occurs when a SEF defect persists for a period of 3 milliseconds. As an option to provide intermittent SEFs, a 3 ms integration timer may be provided (T1M1.3/93-005R1, April 1993, p19).	If in the OOF state, the maximum frame alignment time shall be 250µs for an error free signal with no emulated framing patterns. The algorithm used to recover from OOF shall be such that the probability for false frame recovery with a random unframed signal is no more than 10^{-5} per 250µs time interval (G.783, Nov 1992, p10). To provide for the case of intermittent OOFs, the integrating timer shall not be set to zero until an in-frame condition persists continuously for (TBD) milliseconds (G.783, Nov 1992, p10).	Use of an integrating timer is an option in SONET but it is a requirement in SDH.
Perf. Failures LOF	A LOF failure is declared when LOF defect persists for 2.5± 0.5 seconds, except when an LOS defect or failure is present. The LOF failure is cleared when LOS failure is declared, or when the LOF defect is absent for 10 ± 0.5 seconds (T1M1.3/93-005R1, April 1993, p21).		SONET specifies the times for declaring LOF where as in SDH it is TBD (times for LOF or exit of LOF are not defined in SDH).
Perf. Parameters SEFS	SEFS is a count of one-second intervals containing one or more SEF defects (T1M1.3/93-005R1, April 1993, p23)	Out of Frame second (OFS) is defined as a second in which one or more out of frame events have occurred (G.783, Nov 1992, p44); and its implementation is optional (COM XV-R116, Nov 1992, p12).	

Byte(s)	SONET	SDH	Difference
B1 Section/Regenerator monitoring			
Perf. Parameters CV-S	This parameter is a count of BIP-8 errors that are detected at the section layer of the incoming signal. A section CV counter shall be incremented for each BIP-8 error detected. That is, each BIP-8 can be detect up to eight errors per STS-N frame, with each error incrementing the CV counter. CVs for the section layer shall be collected using the BIP-8 in the B1 byte located in the section overhead of STS-1 #1 (T1M1.3/93-005R1, April 93, p23).	Error monitoring byte B1 is recovered from RSOH after descrambling and compared with the computed BIP-8 over all bits of the previous STM-N frame at B before descrambling. Any errors are responded at reference point S2 as the number of errors within the B1 byte per frame. The B1 byte shall be monitored and recomputed at every RST function (G.783, Nov 1992, p10).	
ES-S	This parameter is a count of one second intervals containing one or more BIP-8 errors (B1 byte), one or more SEF defects, or one or more LOS defects. (T1M1.3/93-005R1, April 1993, p23).	ES information for regenerator section is derived from one second filters (G.783, Nov 1992, p44);and it is application specific (G.784 COM XV-R116, Nov 1992, p12).	
ESA-S	ESA-S is a count of one second intervals containing one BIP-8 error (B1 byte), and no SEF or LOS defects; its implementation is optional (T1M1.3/93-005R1, April 1993, p23).		ESA-S are not defined in SDH.
ESB-S	ESB-S is a count of one second intervals containing more than one but less than x BIP-8 errors (B1 byte), and no SEF or LOS defects. The value of x is rate dependent. Its implementation is optional. (T1M1.3/93-005R1, April 1993, p23).		ESB-S are not defined in SDH.
SES-S	SES-S is a count of one second intervals containing x or more BIP-8 errors (B1 byte), one or more, SEF defect, or one or more LOS defects. Its implementation is optional (T1M1.3/93-005R1, April 1993, p23).	SES information for regenerator section is derived from one second filters (G.783, Nov 1992, p44) and its implementation is optional (G.784 COM XV-R116, Nov 1992, p12).	
SEFS-S	SEFS-S is a count of one second intervals containing one or more SEF defects; and, it is a requirement (T1M1.3/93-005R1, April 1993, p23).	Out of Frame second (OFS) is defined as a second in which one or more out of frame events have occurred (G.783, Nov 1992, p44);and its implementation is optional (COM XV-R116, Nov 1992, p12).	
B2 Line Monitoring			
Defect processing CV-L	CV-L parameter is a count of the BIP-8 errors detected at the line layer of the incoming signal. The line CV counter	The error monitoring byte B2 is allocated in the STM-N for multiplex section bit error monitoring function.	

Byte(s)	SONET	SDH	Difference
	shall be incremented for each BIP-8 error detected. The CVs for the line layer are collected using the BIP-8s in the B2 byte located in the line overhead of of each STS-1 (T1M1.3/93-005R1, April 1993, p23-24).	This function shall be a bit interleaved parity (BIP-24N) code using even parity. The BIP-24N is computed over all bits (except those in the RSOH bytes) of the previous STM-N frame and placed in the 3xN respective B2 byte positions of the current STM-N frame (G.783, Nov 1992, p11)	
ES-L	ES-L parameter is a count of one second intervals containing one or more BIP-8 errors (B2 byte), or one or more AIS defects (T1M1.3/93-005R1, April 93, p24).	ES information is derived for multiplex section is available from the one second filter (G.783, Nov 1992, p44) and it is a requirement (G.784 COM XV-R116, Nov 1992, p12).	
ESA-L	ESA-L parameter is a count of one second intervals containing one one BIP-8 errors (B2 byte) and no AIS defects and its implementation is optional (T1M1.3/93-005R1, April 1993, p24).		ESA-L are not defined in CCITT.
ESB-L	ESB-L parameter is a count of one second intervals containing more than one but less than x BIP-8 errors (B2 byte), and no AIS defects and its implementation is optional (T1M1.3/93-005R1, April 1993, p24).		ESB-L are not defined in CCITT.
SES-L	SES-L parameter is a count of one second intervals containing x or more BIP-8 errors (B2 byte) or one or more AIS defects. (T1M1.3/93-005R1, April 1993, p24).	SES information for multiplex section is derived from one second filter (G.783, Nov 1992, p44) and it is a requirement (G.784 COM XV-R116, p12).	
UAS-L	This parameter is a count of one second intervals for which the SONET line is unavailable. The line becomes unavailable at the onset of 10 contiguous SES-Ls. The 10 SES-Ls are included in unavailable time. Once unavailable, the line becomes available at the onset of 10 contiguous seconds with no SES_Ls. The 10 seconds with no SES_Ls are excluded from unavailable time. (T1M1.3/93-005R1, April 1993, P24)	A period of unavailable time begins at the onset of 10 consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of ten consecutive non-SES events. These 10 seconds are considered to be part of available time (G.826, Annex 1). Its implementation is optional (G.784, COM XV-R116, Nov 1992, p12).	

Table 8b: Comparison of Performance Monitoring Information (continued)

Byte(s)	SONET	SDH	Difference
Pointer word H1, H2, H3			
Defect processing LOP-P	LOP-P (Loss of Pointer) defect occurs when an either a valid pointer is not detected in eight consecutive frames, or when eight consecutive frames are detected with the New data Flag (NDF) set to "1001" without a valid concatenation indicator. A LOP-P defect is terminated when either a valid pointer with a normal NDF set to "0110", or a valid concatenation indicator is detected for three contiguous frames. Incoming STS-path AIS shall not result in the declaration of an LOP-P defect (T1M1.3/93-005R1, April 1993, p20).	A LOP failure is defined as a transition of the pointer interpreter from the NORM_state to the LOP_state or the AIS_state, or a transition from the CONC_state to the LOPC_state or AISC_state in any concatenated AU/TU. The LOP-state is entered in the case of either of the following: N consecutive invalid pointers (8≤N≤10) or N consecutive NDF enable flags (8≤N<=10) (G.783, Annex B, p75). The LOP-P defect is cleared if the pointer interpreter is in the 3 consecutive equal norm_point indications or 3 consecutive AIS indications (G.783, Nov 1992, Annex B, p75-76).	SONET distinguishes LOP defects and failures on the basis of persistency whereas SDH does not.
Perf. Failures LOP-P	A LOP-P failure is declared when LOP-P defect persists for a 2.5± 0.5 seconds. The LOP-P failure is cleared when the LOP-P defect is absent for 10 seconds (T1M1.3/93-005R1, April 1993, p21).		
AIS-P	AIS-P defect is the occurrence of all ones in bytes H1 and H2 in three contiguous frames. The AIS-P defect is terminated when a valid STS pointer is detected with the NDF set to 1001 (inverted) for a single frame, or a valid STS pointer is detected with the NDF set to 0110 normal for three contiguous frames (T1M1.3/93-005R1, April 1993, p20). An AIS-P failure is declared when an AIS-P defect persists for 2.5± 0.5 seconds. The AIS-P failure is cleared when the AIS-P defect is absent for 10 ± 0.5 seconds. (T1M1.3/93-005R1, April 1993, p21).	The transition between the states will be consecutive events, e.g., three consecutive AIS indications to go from NORM-state to the AIS_state. The only transition on a single event is the one from the AIS_state to the NORMAL_state after receiving an NDF enabled with a valid pointer value (G.783, Nov 1992, Annex B, p75-76).	SONET distinguishes LOP defects and failures on the basis of persistency whereas SDH does not.

Table 8b: Comparison of Performance Monitoring Information (continued)

Byte(s)	SONET	SDH	Difference
K2 bits 6-8 : Line/Multiplex section AIS	This code is to indicate to the LTE that a loss of signal condition of some type has been detected and alarmed at a STE.	An Alarm Indication Signal (AIS) is a signal sent downstream as an indication that an upstream failure has been detected and alarmed (G.709).	
Defect processing RDI-L	Line RDI is defined in T1.105 as FERF. RDI-L signal is the occurrence of a "110" code in bits 6,7,8 of K2 byte in STS-1 #1. The RDI-L defect is the occurrence of an RDI-L signal in five contiguous frames. The RDI-L defect is terminated when no RDI-L signal is detected in five contiguous frames (T1M1.3/93-005R1, April 1993, p20).	An incoming MS-FERF defect shall be detected by the MST function when the pattern 110 is observed in bits 6,7,8 of byte K2 in at least three consecutive frames. Removal of the MS-FERF defect shall take place when any pattern other than the code 110 in bits 6,7, and 8 of the byte K2 is received in at least three consecutive frames (G.783, Nov 1992, p13). If the signal defect is detected, MS-FERF shall be applied within 250µs (G.783, Nov 1992, p12).	• The number of frames observed before declaring detection of Line/MS AIS. • Timing difference of 125µs vs 250µs between insertion/deletion.
AIS-L	An AIS-L failure is declared when an AIS-L defect persists for 2.5 ± 0.5 seconds. The AIS-L failure is cleared when the AIS-L defect is absent for 10± 0.5 seconds. (T1M1.3/93-005R1, April 1993, p21)	An MS-AIS defect shall be detected by the MST function when the pattern 111 is observed in bits 6,7,8 of byte K2 in at least three consecutive frames. Removal of the MS-AIS defect shall take place when any pattern other than the code 111 in bits 6,7, and 8 of the byte K2 is received in at least three consecutive frames (G.783, Nov 1992 p13).	
G1, bit 5 Defect Processing RDI-P	The RDI-P signal shall be generated within 100 ms by the STS PTE upon detection of an AIS-P or LOP-P defect. The RDI-P signal shall accurately report, the presence or absence of the AIS-P or LOP-P defects.	The VC-3/VC-4 path FERF (RDI) is bit 5. It is set to a "1" to indicate VC-3/VC-4 path FERF, and is otherwise set to zero (G.709).	
RDI-P defect	The RDI-P defect is the occurrence of an RDI-P Signal in five contiguous frames. The RDI-P defect is terminated when no RDI-P signal is detected in five contiguous frames (T1M1.3/93-005R1, April 1993, p20)		
Perf. Failure RFI-P	RFI-P Failure (Derived). The RFI-P failure is derived when the RDI-P defect persists for 2.5± 0.5 seconds. The RFI-P failure is cleared when RDI-P defect is absent for 10+-0.5 seconds (T1M1.3/93-005R1, April 1993, p21)		Persistency check is for further study in SDH (G.783, Nov 1992, p28). STS path RFI is for further study.

Byte(s)	SONET	SDH	Difference
V1, V2, V3 Defect Processing LOP-V	An VT path Loss of Pointer occurs when either a valid pointer is not detected in eight contiguous VT superframes, or when eight contiguous VT superframes are detected with the NDF set to "1001" without a valid concatenation indicator. An LOP-V defect terminates when either a valid pointer with a normal NDF set to "0110", or a valid concatenation indicator is detected for three contiguous VT superframes or the occurrence of the AIS-V defect. Incoming VT-path AIS shall not result in declaring an LOP-V defect (T1M1.3/93-005R1, April 1993, p20).	A persistent mismatch between provisioned and received TU type will result in a LOP defect (G.783, Nov 1992, p30).	
Perf. Failures LOP-V	LOP-V failure is declared when an LOP-V defect persists for 2.5± 0.5 seconds. The LOP-V failure is cleared when the LOP-V defect is absent for 10± 0.5 seconds (T1M1.3/93-005R1, April 1993, p21)		
AIS-V	AIS-V signal Upon detection of line AIS, or STS-path AIS indication, an STS PTE will generate downstream VT-path AIS indication if the STS SPE is carrying floating VTs. AIS-V defect: The AIS-V defect is the occurrence of all 1s in bytes V1 and V2 in three contiguous superframes. The AIS-V defect terminates when a valid VT pointer with a valid VT size is detected with the NDF set to 1001 (inverted) for 1 VT superframe, or a valid VT pointer with a valid VT size is detected with the NDF set to 0110 (normal) for three contiguous VT superframes (T1M1.3/93-005R1, April 1993, p20). An AIS-V failure is declared when an AIS-V defect persists for 2.5± 0.5 seconds. The AIS-V failure is cleared when the AIS-V defect is absent for 10± 0.5 seconds (T1M1.3/93-005R1, April 1993, p21).	TU-1/TU-2 Path AIS. The TU-n (n=1,2,3) path AIS is specified as all "1"s in the entire TU-n, including the TU-n pointer. Similarly, the AU-3/4 path AIS is specified as all "1"s in the entire AU-n, including the AU-n pointer. All path AISs are carried within STM-N signals having valid SOH.	SDH does not seem to differentiate between LOP failures and LOP defects.

Table 8b: Comparison of Performance Monitoring Information (continued)

Byte(s)	SONET	SDH	Difference
Perf. Parameters CV-V	This is a count of BIP-2 errors that are detected at the VT path later of the incoming signal. The CVs for the VT-path layer are collected using the BIP-2 in the V5 overhead byte of the floating VT (T1M1.3/93-005R1, April 1993, p25).	BBE (Background Block Error : an errored block not occurring as part of an SES) information will be made available and its implementation is application specific (G.826, G.784 COM XV-R116, p12).	
ES-V	This parameter is a count of one second intervals containing one or more BIP-2 errors (V5 byte), one or more AIS defects, or one or more LOP-V defects (T1M1.3/93-005R1, April 1993, p25).	ES information will be made available and its implementation is application specific (G.784 COM XV-R116, p12).	
ESA-V	This parameter is a count of one second intervals containing exactly one BIP-2 error (V5 byte), and no LOP-V or AIS defects. (T1M1.3/93-005R1, April 1993, p25).		ESA-V are not defined in SDH.
ESB-V	This parameter is a count of one second containing more than one but less than x BIP-2 errors (V5 byte), and no LOP-V or AIS defects occurred. The value of x are rate dependent. (T1M1.3/93-005R1, April 1993, p26).		ESB-V are not defined in SDH.
SES-V	This parameter is a count of one second intervals containing x or more BIP-2 errors (V5 byte), or one or more LOP-V defects, or one or more AIS defects. (T1M1.3/93-005R1, April 1993, p26).	SES information will be made available and its implementation is application specific (G.784 COM XV-R116, Nov 1992, p12).	
AIS/LOP-V	This parameter is a count of one second intervals containing one or more AIS-LOP defects or ore or more LOP defects (T1M1.3/93-005R1, April 1992, p26).		AIS/LOP-V are not defined in SDH.
UAS-V	This parameter is a count of one second intervals for which the SONET VT-path is unavailable. The SONET VT-path becomes unavailable at the onset of 10 contiguous SES-Vs. The 10 SES-Vs are included in unavailable time. Once unavailable, the VT-path becomes available at the onset of 10 contiguous seconds with no SES-Vs. The 10 seconds with no SES-Vs are excluded from unavailable time. Some parameters are not counted during unavailability (T1M1.3/93-005R1, April 1993, p26).	A period of unavailable time begins at the onset of 10 consecutive SES events. These ten seconds are considered to be part of unavailable time. A new period of available time begins at the onset of ten consecutive non-SES events. These 10 seconds are considered to be part of available time (G.826, Annex 1). Its implementation is optional (G.784, COM XV-R116, Nov 1992, p12).	
FEBE-V	The far-end VT Path layer performance is conveyed back to the near-end VT PTE via the VT path overhead byte, V5. Bit 3 is a VT-path FEBE error indication and conveys the count of interleaved bit blocks that have been detected in error by the VT-path BIP-2 code. (T1M1.3/93-005R1, April 1993, p26).	Bit 3 is a VC-1/VC-2 path FEBE indication that is set to one and sent back towards a VC-1/VC-2 path originator if one or more errors are detected by the BIP-2, and is otherwise set to zero.	

Table 8b: Comparison of Performance Monitoring Information (continued)

Byte(s)	**SONET**	**SDH**	**Difference**
RFI-V	VT-path RFI-V Signal Bit 4 of V5 is an RFI-V signal, which conveys the occurrence of far-end failures (T1M1.3/93-005R1, April 1993, p26). The RFI-V signal is only required for the case of byte synch mapped DS1s where the DS1 frame bit is not mapped. RFI-V signal is specified in ANSI T1.105, where it is currently called VT Path Yellow. When provided, the RFI-V signal is used to indicate the occurrence of far-end failures. When RFI-V is not provided, far-end failures are derived from local timing of RDI-V defect. RFI-V Failure An RFI-V failure is declared within 5ms of detecting the incoming RFI-V signal. The RFI-V failure is cleared within 50ms of detecting the removal of the incoming RFI-V signal. An RFI-V failure (derived) is declared when the RDI-V defect persists for 2.5± 0.5 seconds. An RFI-V failure (derived) is cleared when the RDI-V defect is absent of 10± 0.5 seconds (T1M1.3/93-005R1, April 1993, p22)	Bit 4 is provisionally allocated for an optional path RFI function.	
RDI-V	RDI-V Signal Bit 8 of V5 provides an RDI-V signal, which conveys the occurrence of AIS or LOP defects detected at the far end (T1M1.3/93-005R1, April 1993, p26). The RDI-V signal shall be generated within 100ms by the VT PTE upon the detection of an AIS-V or LOP-V defect. Transmission of the RDI-V ceases within 100ms when the VT PTE no longer detects an AIS-V or LOP-V defect. The RDI-V signal shall accurately report, superframe by superframe, the AIS-V or LOP-V defects. The RDI-V defect is the occurrence of an RDI-V signal in five contiguous VT superframes. The RDI-V defect is terminated when no RDI-V signal is detected in five contiguous VT superframes. (T1M1.3/93-005R1, April 1993, p21) The VT path RFI failure is cleared in the NE within 50 ms of the detection of the deactivation of the incoming VT-path RFI signal (T1M1.3/92-005R2, June 1992, p23).	VC-1/VC-2 Path FERF (RDI) This is set to one if either a TU-1/TU-2 path AIS or a signal failure condition is being received, otherwise it is set to zero. The VC-1/VC-2 path FERF is sent back by the VC-1/VC-2 assembler.	

4. Interworking Concerns

The level of interworking between SONET and SDH will depend greatly on the payloads and the payload mappings chosen. Although SDH does provide SONET compatible mappings in most cases, these mappings may not be widely used. CCITT Recommendation G.708[8] states that the AU-4 structure should be used when interconnecting between AU-3 and AU-4 based STMs.

Note that, whereas the VC-3 path is maintained through the international interworking gateway when a C3 is being carried, the VC-3 Path is terminated and a VC-4 Path created when TUG-2s are being carried.

Both SONET and SDH define similar sets of overheads and functions. Figures 5 and 6 show the overheads for an STS-3/AU-3 based STM-1, and STS-3c/AU-4 based STM-1, respectively. There are only minor differences between the overhead structures [3], but there are still functions which are not completely defined as well as overheads which are currently unassigned. Figure 7 indicate the locations of J2, Z6, Z7 bytes in SDH structure.

3. For example, bytes Z1, E1, E2, and F1 are not completely defined, and DCC messages and applications are still being worked.

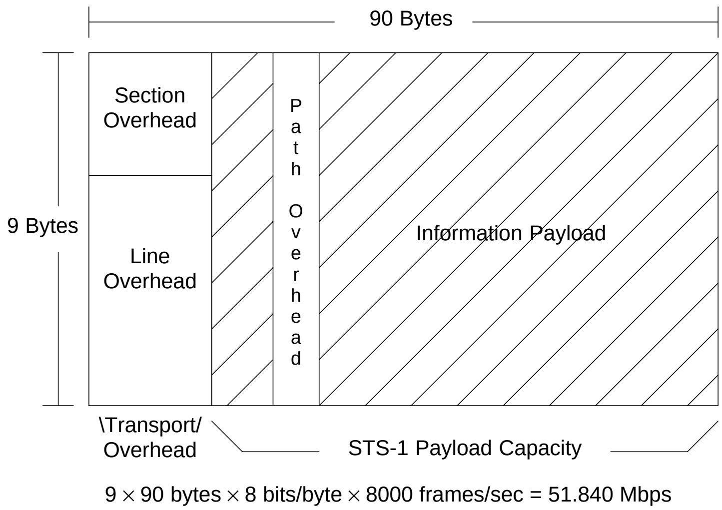

Figure 1. STS-1 Frame Structure

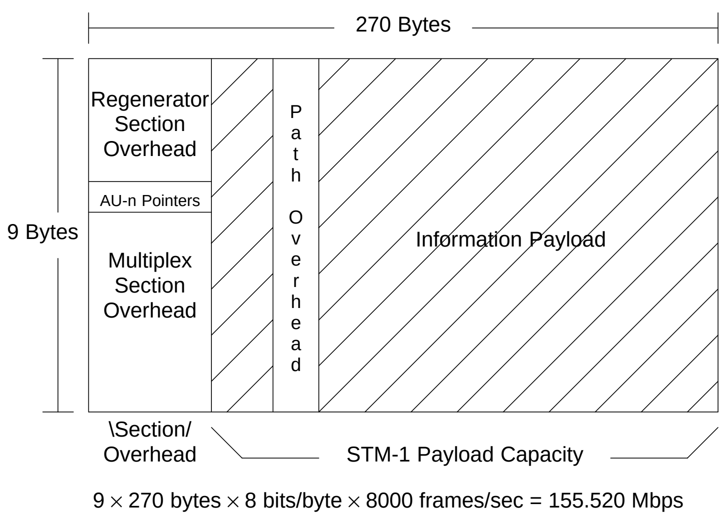

Figure 2. STM-1 Frame Structure

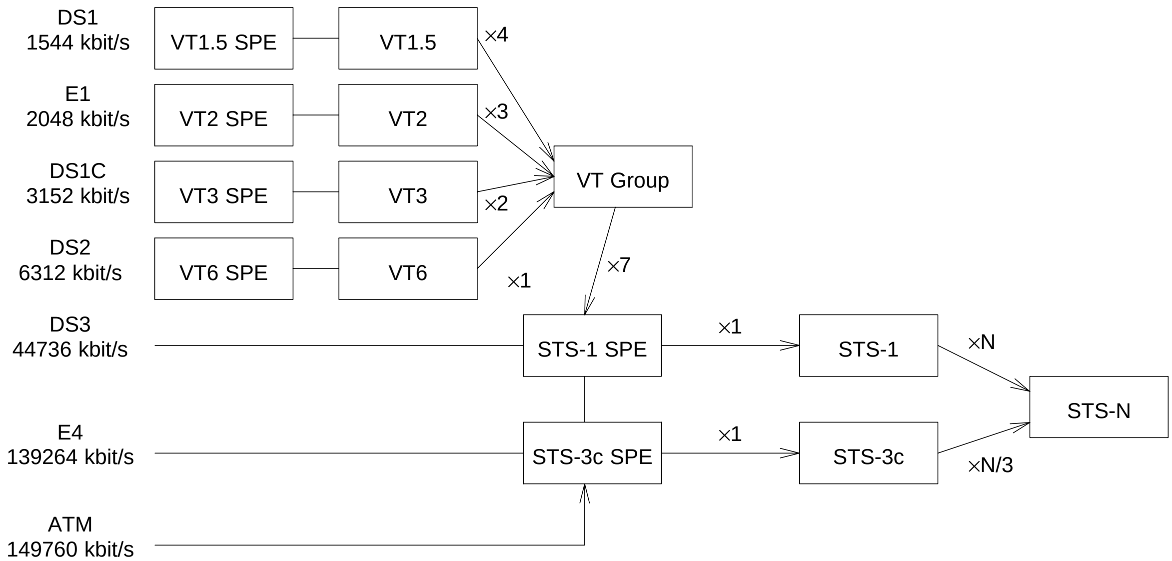

Figure 3. SONET Multiplexing

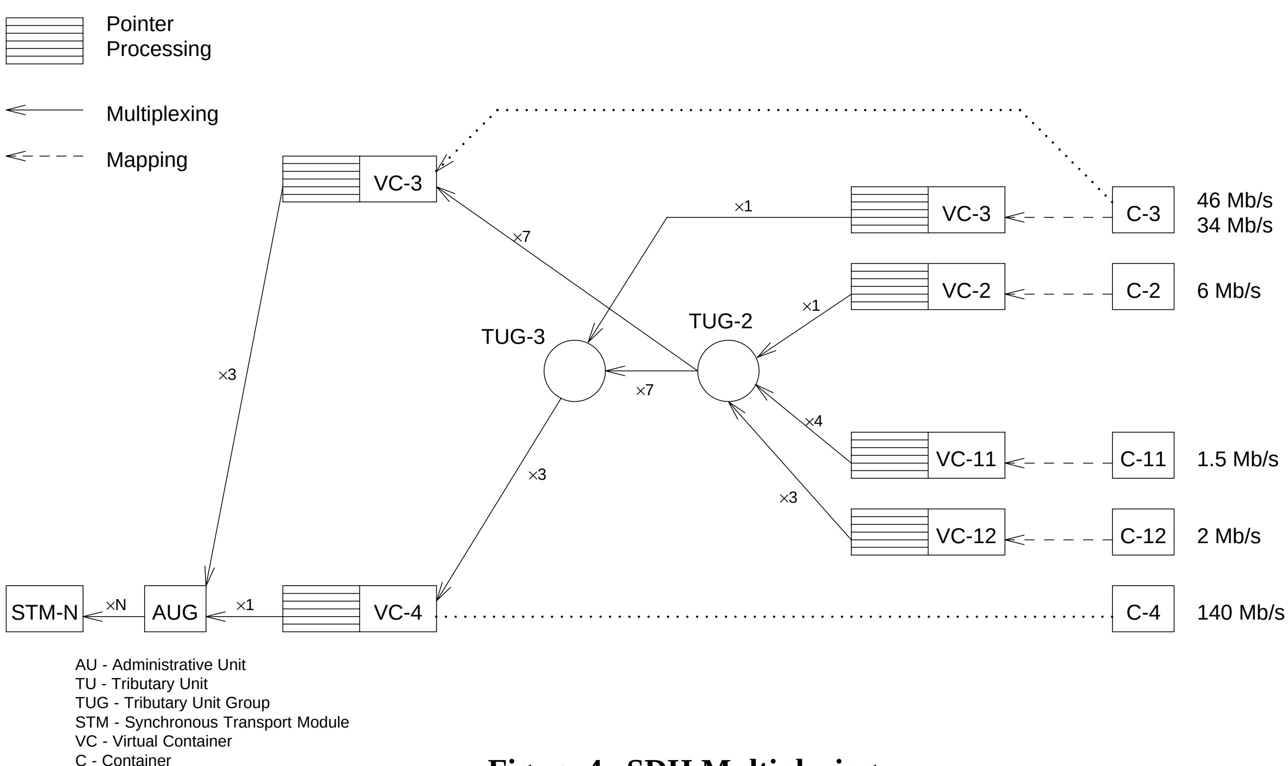

Figure 4. SDH Multiplexing

Framing A1	Framing A1	Framing A1	Framing A2	Framing A2	Framing A2	STS-1 ID C1	STS-1 ID C1	STS-1 ID C1		Trace J1	Trace J1	Trace J1
BIP-8 B1			Orderwire E1			User F1				BIP-8 B3	BIP-8 B3	BIP-8 B3
Data Com D1			Data Com D2			Data Com D3				Sig Label C2	Sig Label C2	Sig Label C2
Pointer H1	Pointer H1	Pointer H1	Pointer H2	Pointer H2	Pointer H2	Ptr Action H3	Ptr Action H3	Ptr Action H3		Path Stat G1	Path Stat G1	Path Stat G1
BIP-8 B2	BIP-8 B2	BIP-8 B2	APS K1	APS K1	APS K1	APS K2				User F2	User F2	User F2
Data Com D4			Data Com D5			Data Com D6				Multiframe H4	Multiframe H4	Multiframe H4
Data Com D7			Data Com D8			Data Com D9				Growth Z3	Growth Z3	Growth Z3
Data Com D10			Data Com D11			Data Com D12				Growth Z4	Growth Z4	Growth Z4
Growth Z1	Growth Z1	Growth Z1	Growth Z2	Growth Z2	Growth Z2	Orderwire E2				Growth Z5	Growth Z5	Growth Z5

Path Overhead

Transport Overhead — Payload Capacity

- Included In STS-3. Not Included in STM-1

Figure 5. STS-3/AU-3 Based STM-1 Overhead

Framing A1	Framing A1	Framing A1	Framing A2	Framing A2	Framing A2	STS-1 ID C1	STS-1 ID C1	STS-1 ID C1		Trace J1
BIP-8 B1			Orderwire E1			User F1				BIP-8 B3
Data Com D1			Data Com D2			Data Com D3				Sig Label C2
Pointer H1	1001ss11	1001ss11	Pointer H2	11111111	11111111	Ptr Action H3	Ptr Action H3	Ptr Action H3		Path Stat G1
BIP-8 B2	BIP-8 B2	BIP-8 B2	APS K1			APS K2				User F2
Data Com D4			Data Com D5			Data Com D6				Multiframe H4
Data Com D7			Data Com D8			Data Com D9				Growth Z3
Data Com D10			Data Com D11			Data Com D12				Growth Z4
Growth Z1	Growth Z1	Growth Z1	Growth Z2	Growth Z2	Growth Z2	Orderwire E2				Growth Z5

Path Overhead

Transport Overhead — Payload Capacity

- Included In STS-3. Not Included in STM-1

SS = 10 In STS-3c. In STM-1 SS Is Unspecified

Figure 6. STS-3c/AU-4 Based STM-1 Overhead

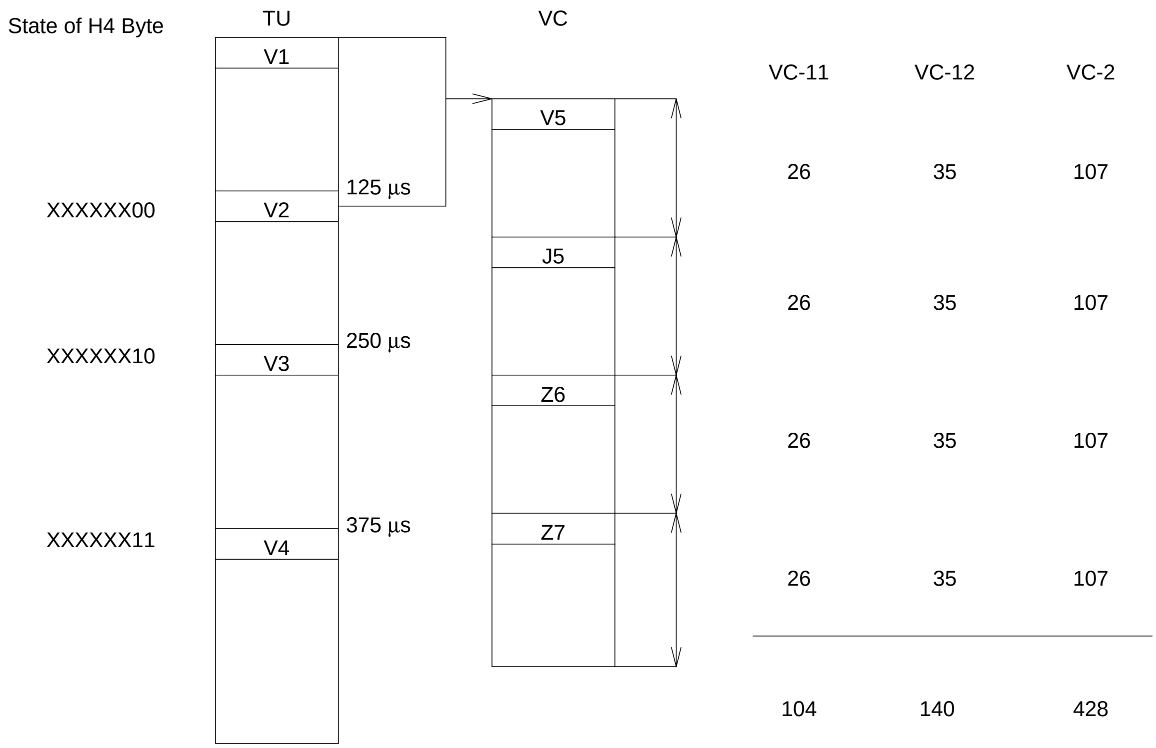

Figure 7. Location of J2, Z6, Z7 in SDH Structure
(Figure 3.10/G.709, Com XVIII-R 105.E, July 92)

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