

RECOMMENDATION ITU-R S.1149-2

**Network architecture and equipment functional aspects
of digital satellite systems in the fixed-satellite
service forming part of synchronous digital
hierarchy transport networks**

(Question ITU-R 201/4)

(1995-1997-2005)

Scope

This Recommendation addresses network architecture and equipment functions relevant for the design of synchronous digital satellite systems in the FSS forming parts of, or providing synchronous interconnections between, transport networks based on the SDH.

A general architectural diagram of FSS systems with SDH network transport capability is introduced. The basic requirement is transparent transport of SDH signal elements (referred to as virtual containers) through the satellite system.

This Recommendation focuses on SDH functionalities in the satellite system synchronous baseband equipment (SBE) necessary to realize three different scenarios for satellite system integration in SDH transport networks.

The ITU Radiocommunication Assembly,

considering

- a) that digital satellite systems of the FSS are constituent elements of public/private networks in which synchronous digital hierarchy (SDH)-based transmission technologies are deployed;
- b) that ITU-T Recommendations G.707 and G.708 specify the network node interfaces (NNIs) for the SDH transport systems and reference all the other SDH Recommendations in ITU-T;
- c) that ITU-T Recommendations G.803 and G.805 define the architecture of SDH transport systems in way that is independent of the transmission technology;
- d) that ITU-T Recommendation G.780 defines the terminology of SDH and that ITU-T Recommendation G.783 specifies the characteristics of SDH functional blocks;
- e) that ITU-T Recommendations G.702, G.703, G.704 and G.957 define the bit rates, the synchronous frame structures and the physical parameters of the electrical and optical interfaces of SDH systems;
- f) that SDH timing requirements are covered in ITU-T Recommendations G.781, G.813, G.822 and G.825;
- g) that ITU-T Recommendations G.831, G.784, G.773 and G.774 define the management capabilities of SDH, the management functions, the protocols, interfaces and the management information model from the network element viewpoint;
- h) that integration with the telecommunications management network (TMN), defined in ITU-T Recommendation M.3000 – Overview of TMN Recommendations, is supported by these management recommendations and that the TMN Recommendations for SDH satellite systems are Recommendations ITU-R S.1250, ITU-R S.1251 and ITU-R S.1252;

- j) that the performance of hypothetical reference digital paths (HRDPs) through SDH systems is defined in ITU-T Recommendations G.826 and G.828. With the corresponding ITU-R Recommendations being ITU-R S.1062 and ITU-R S.1521;
- k) that the availability requirements for all transport systems are given in ITU-T Recommendation G.827 and the corresponding ITU-R Recommendations are ITU-R S.579 and ITU-R S.1522;
- l) protection switching architectures are described in ITU-T Recommendations G.841 and G.842;
- m) that ITU-T Recommendation G.861 – Radio and satellite SDH integration guidelines, describes the principles and guidelines for the integration of satellite and radio systems in SDH transport networks, including the concept of point-to-multipoint topologies;
- n) that the inherent multdestination and multipoint capabilities of satellite systems provide significant operational advantages;
- o) that Recommendations ITU-R F.750 and ITU-R F.751 define architectures, functional aspects, and transmission characteristics and performance of radio-relay systems in SDH-based networks;
- p) that ITU-T Recommendation G.832 defines the method of transporting PDH elements over SDH systems but that interconnection and interworking between PDH and SDH networks may be handled differently within a satellite system providing that the external interfaces and functionalities are compatible with terrestrial systems;
- q) that there are ongoing studies in ITU-R on transmission systems, their performance, multiple access methods and operation and maintenance (OAM) aspects,

recommends

1 that digital satellite systems in the FSS comply with the network architecture and equipment functional requirements described in this Recommendation to support their integration into SDH transport systems.

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1 Introduction

1.1 Scope

This Recommendation addresses network architecture and equipment functions relevant for the design of synchronous digital satellite systems in the FSS forming parts of, or providing synchronous interconnections between, transport networks based on the SDH.

A general architectural diagram of FSS systems with SDH network transport capability is shown in Fig. 1. The basic requirement is transparent transport of SDH signal elements (referred to as virtual containers) through the satellite system.

This Recommendation focuses on SDH functionalities in the satellite system synchronous baseband equipment (SBE) necessary to realize three different scenarios for satellite system integration in SDH transport networks:

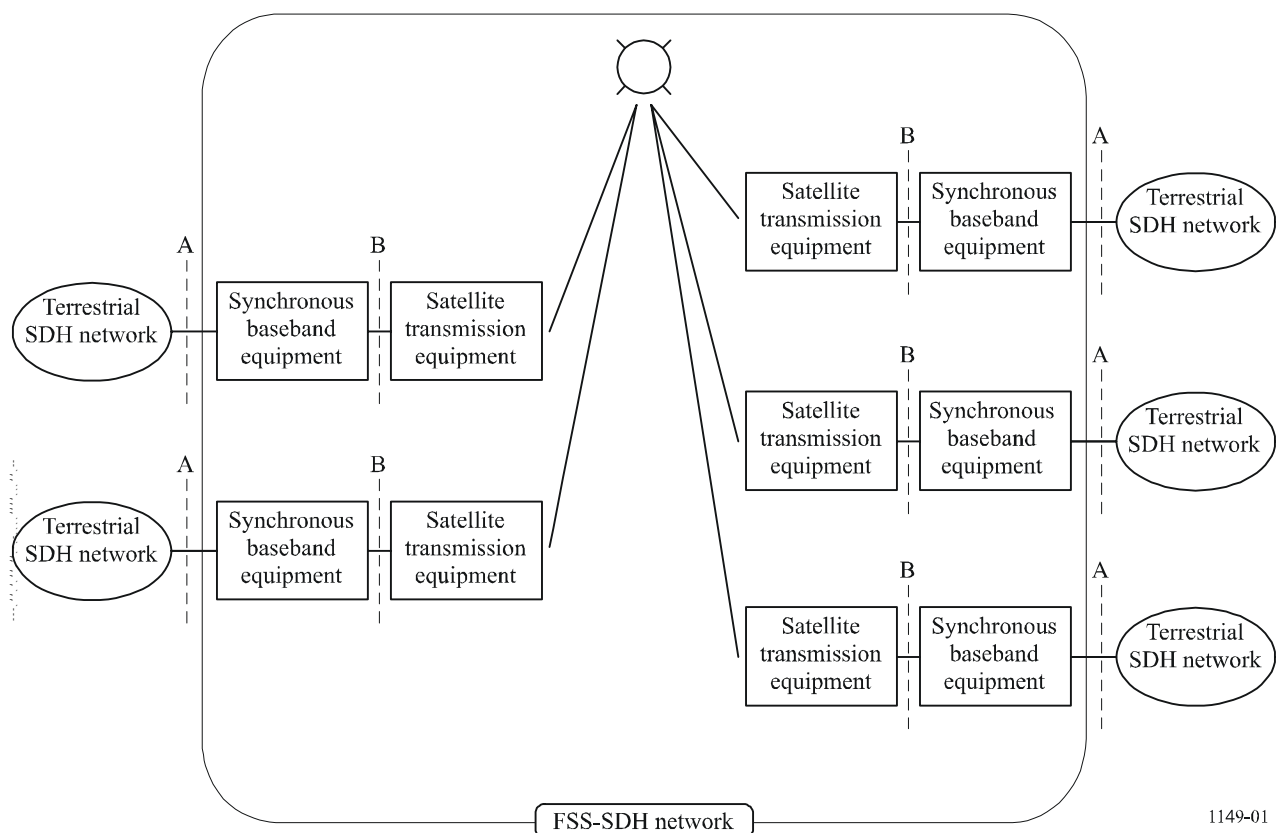
Scenario 1: SDH multiplex section

Scenario 2: wide-area single-rate cross-connect (common internal section bit rate of 51.84 Mbit/s)

Scenario 3: wide-area multi-rate cross-connect (a range of internal section bit rates <51.84 Mbit/s)

This Recommendation follows the “ITU-T Recommendation G.861 radio and satellite SDH integration guidelines”.

FIGURE 1
General FSS-SDH network architecture



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NOTE 1 – Synchronous baseband equipment and satellite transmission equipment are illustrated as separate units for the purpose of explanation; they may be implemented physically as one unit.

NOTE 2 – Reference point A: open EI for scenario 1; NNI and NNRP for scenarios 2 and 3.

NOTE 3 – Reference point B: SRP and open SEI for scenarios 1 and 2, SRP and closed SEI for scenario 3 (see the “ITU-T Recommendation G.861 radio and satellite SDH integration guidelines”).

The basic functions of the SBE are one or more of the following, depending on the scenario:

- perform SDH multiplex set of functions, adapted to satellite applications and dependent on scenario;
- conversion and adaptation of section and path layers to satellite system internal interfaces or reference points;
- establishment of section and possibly path layer asymmetrical multdestination connections, and support point-to-point symmetrical path layer cross-connected connections;
- perform specific section functions for signal transmission over the satellite medium;
- integration of SDH pointer and satellite system timing;
- SBE SDH multiplex based management functions.

The basic functions of the satellite transmission equipment are:

- modem functions;
- multiple access system protocols, procedures and their management functions;
- timing preservation.

1.2 Abbreviations

AIS:	alarm indication signal
APS:	automatic protection switching
AU:	administrative unit
AUG:	administrative unit group
BIP:	bit interleaved parity
DCC:	data communication channel
DXC:	digital cross connect
EI:	equipment interface
FDMA:	frequency division multiple access
HOVC:	higher order virtual container
HPA:	higher order path adaptation
HPC:	higher order path connection
HPOM:	higher order path overhead monitor
HPT:	higher order path termination
HSPA:	higher order satellite path adaptation
HSPT:	higher order satellite path termination
HSSA:	higher order satellite section adaptation
HSUG:	higher order supervisory unequipped generator

HSUM:	higher order supervisory unequipped monitor
IOS:	intra-office section
ISI:	internal satellite interface
LOVC:	lower order virtual container
LPA:	lower order path adaptation
LPC:	lower order path connection
LPOM:	lower order path overhead monitor
LPT:	lower order path termination
LSSA:	lower order satellite section adaptation
LSUG:	lower order supervisory unequipped generator
LSUM:	lower order supervisory unequipped monitor
LT:	line termination
MCF:	message communications function
MDSS:	multi-destination satellite server
MSA:	multiplex section adaptation
MSOH:	multiplex section overhead
MSP:	multiplex section protection
MST:	multiplex section termination
NNI:	network node interface
NNRP:	network node reference point
OAM:	operation, administration and maintenance
OHA:	overhead access
PDH:	plesiochronous digital hierarchy
POH:	path overhead
RDI:	remote defect indication
REI:	remote error indication
RSOH:	regenerator section overhead
RST:	regenerator section termination
SBE:	synchronous baseband equipment
SDH:	synchronous digital hierarchy
SEI:	satellite equipment interface
SETPI:	synchronous equipment timing physical interface
SETS:	synchronous equipment timing source
S-IOS:	satellite intra-office section
SOH:	section overhead

SPI:	synchronous physical interface
SRP:	satellite reference point
SRT:	satellite regenerator termination
SSOH:	satellite section overhead
SSPI:	synchronous satellite physical interface
SST:	satellite section termination
SSTM- <i>n</i> :	satellite synchronous transport module- <i>n</i>
STM- <i>N</i> :	synchronous transport module- <i>N</i>
STUG- <i>ij</i> :	satellite tributary unit group <i>ij</i>
TDMA:	time division multiple access
TMN:	telecommunication management network
TU:	tributary unit
TUG:	tributary unit group
VC:	virtual container
VOW:	voice order wire

1.3 Definition of satellite specific terms

HSPA:	higher order satellite path adaptation – a higher order adaptation function within the satellite system synchronous baseband equipment.
HSPT:	higher order satellite path termination – a higher order path termination function within the satellite system synchronous baseband equipment.
HSSA:	higher order satellite section adaptation – a higher order section adaptation function within the satellite system synchronous baseband equipment.
ISI:	internal system interface – a system specific internal interface which is not subject to standardization.
LSP:	lower order satellite path – a lower order path through the satellite system.
LSSA:	lower order satellite section adaptation – a lower order section adaptation function within the satellite system synchronous baseband equipment.
MDSS:	multidestination satellite server layer – the layer in the model which represents the multidestination capability of the satellite transmission system.
SFCOH:	satellite frame complementary overhead – an overhead to the baseband composite signal to accommodate satellite transmission system's OAM functions (e.g. modem alarms and VOW).
S-IOS:	satellite intra office section – an SDH section which is internal to the satellite system and which may have multipoint topology. It may cover a wide geographical area.
SLT:	satellite line terminal – performs normal RST, MST and MS APS functions on the satellite side of the NNI.
SRP:	satellite reference point – the point between the synchronous baseband equipment and the satellite transmission equipment.

- SSOH: satellite section overhead – the overhead used within the satellite section between the synchronous baseband equipment.
- SSPI: satellite synchronous physical interface – the physical interface between the synchronous baseband equipment and the satellite transmission equipment.
- SST: satellite section termination – the function where the section overhead may be manipulated.
- SS-TDMA: satellite switched time-division multiple access – a fixed TDMA system with on-board burst-to-burst cyclic inter-beam connection reconfigurations.
- SSTM- n : satellite synchronous transport module order n – similar to STM- n of terrestrial transport systems but consisting of STUG payload multiplex and satellite section specific overhead.
- STUG- ij : satellite tributary unit group ij – similar to a terrestrial tributary unit group TUG but represents a new multiplexing stage in between the G.708 TUG-2 level and TUG-3/VC-3 level.

2 SDH transport network description

2.1 SDH multiplexing techniques

2.1.1 Basic structure

The basic SDH multiplexing techniques (bit rates, frame formats and structures) are described in ITU-T Recommendation G.707. The SDH multiplex hierarchy has a level 1 bit rate of 155.52 Mbit/s (STM-1) with several higher and some lower bit rates.

The bit rates listed in Table 1 constitute the current SDH but higher speeds may be added in the future:

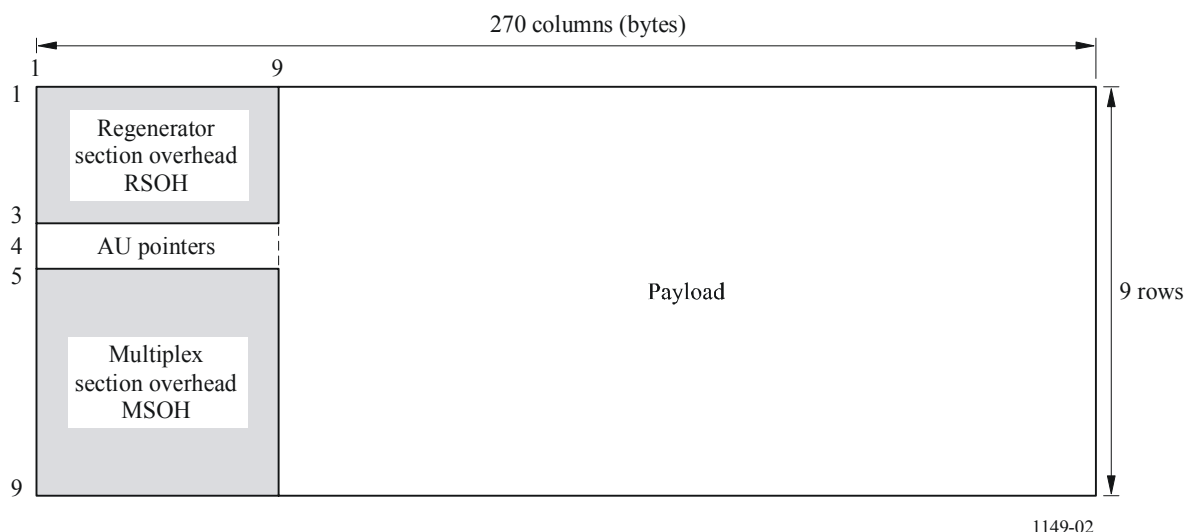
TABLE 1
SDH hierarchical bit rates

Identity	SDH level	Hierarchical bit rate (kbit/s)
STM-0	0	51 840
STM-1	1	155 520
STM-4	4	622 080
STM-16	16	2 488 320
STM-64	64	9 953 280
STM-256	256	39 813 120

NOTE – The specification of levels higher than 256 requires further study.

Figure 2 shows the basic 125 μ s frame structure of the STM-1 signal in a 270×9 bytes matrix format. This SDH element is referred to as a virtual container (VC).

FIGURE 2
STM-1 (155.52 Mbit/s) frame structure



The smallest SDH synchronous tributary signal element defined in the STM-*n* multiplex is the primary rate bit-streams with the VC-11 running at 1.664 Mbit/s and the VC-12 (virtual container-12) running at 2.240 Mbit/s. End-to-end transparency at the VC level is available to the SDH system clients. Lower order paths (LOVC) and higher order path (HOVC) are defined, which can be flexibly configured and set up, through remote management operation, on a network-edge-to-network-edge, or node-to-node basis. HOVCs are either VC-4s or VC-3s. LOVCs are VC-2s, VC-11s and VC-12s.

Network nodes in SDH are interconnected by multiplex sections, which in turn may consist of a number of regenerator sections. Internode management is facilitated by functions communicated within multiplex section overhead (MSOH). The allocation of section overhead (SOH) capacity and byte allocation are described in ITU-T Recommendations G.707 and G.784.

2.1.2 Sub-STM-1 multiplex signals for radio systems

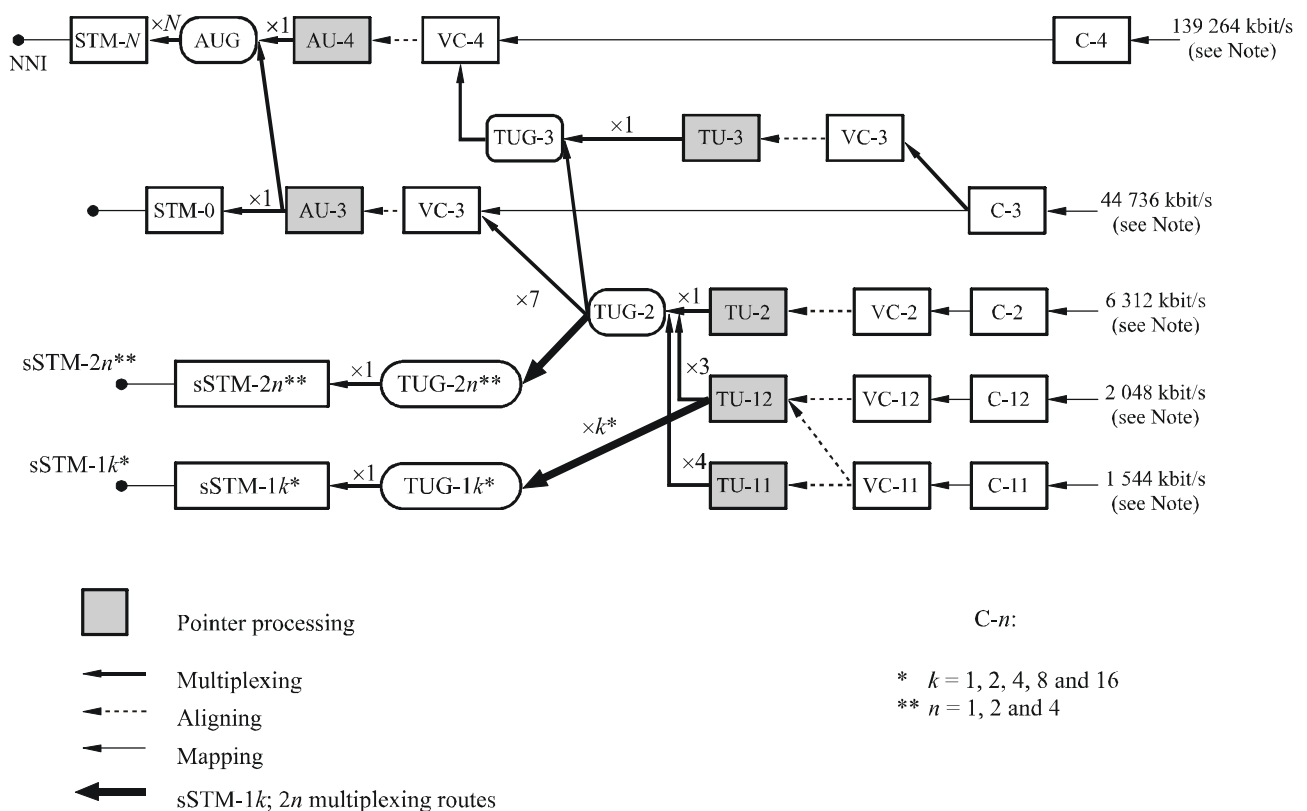
SDH multiplex signal bit rates for systems operating at lower speeds than STM-1 have been added to SDH, see Table 2. Originally for satellite system transmission but later adopted by ITU-T for all transmission technologies. The interworking multiplexing tree is shown in Fig. 3, (which is derived from ITU-T Recommendation G.708 – Sub-STM-0 network node interface for the synchronous digital hierarchy (SDH)).

TABLE 2
Sub-STM-1 bit rates

STM type	STM bit rate (kbit/s)
sSTM-11	2 880
sSTM-12	5 184
sSTM-14	9 792
sSTM-18	19 792
sSTM-116	3 444
sSTM-21	7 488
sSTM-22	14 400
sSTM-24	28 224
STM-0	51 840
STM-1	155 052
STM-4	622 080
STM-16	2 488 320
STM-64	9 953 280

FIGURE 3

Demultiplexing/remultiplexing routes for constructing Sub-STM-1 signals



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2.2 Layered network modelling

ITU-T Recommendation G.805 defines the concept of layered modelling for all transport networks independent of technology.

The following examples illustrate the layering concept as applied to the transport of ATM client traffic over SDH transport systems.

2.2.1 ATM supported on SDH layer networks

2.2.1.1 Figure 4 shows ATM supported on SDH.

The example shows two ATM virtual channel terminations interconnected with an ATM virtual channel switch/cross-connect and two ATM virtual path terminations interconnected with an ATM virtual path switch/cross-connect and a SDH higher-order path cross-connect at intermediate locations. All interfacing uses the SDH STM-N section layer network.

A five-layer network structure is shown:

- ATM I.361 virtual channel layer network;
- ATM I.361 virtual path layer network;
- SDH G.707 higher-order path (e.g. VC-4) layer network;
- SDH G.707 multiplex section layer network;
- SDH G.707 regenerator section layer network.

2.2.1.2 Figure 5 shows high-speed ATM being supported on multiple SDH tributaries.

This example might be particularly appropriate to the satellite environment.

The example shows an aggregate ATM cell stream that is supported through an ATM inverse multiplexer over a number of parallel G.702 primary rate paths, which in turn are supported over PDH and SDH. One ATM VP terminating equipment interfaces at the PDH rate to an SDH multiplexer. The other has an integrated SDH interface. In the ATM inverse multiplex the trail termination has been decomposed to portray the individual ATM inverse multiplex trails that support the VP network connection.

A nine-layer networks is shown:

- ATM I.361 virtual path layer network;
- Composite ATM inverse multiplex layer network;
- Individual ATM inverse multiplex layer network;
- PDH G.702 primary rate layer network;
- PDH G.703 intra-office section layer network;
- SDH G.707 lower order path layer network;
- SDH G.707 higher order path layer network;
- SDH G.707 multiplex section layer network;
- SDH G.707 regenerator section layer network.

FIGURE 4
Application of the layered functional architecture to a case of ATM supported on SHD

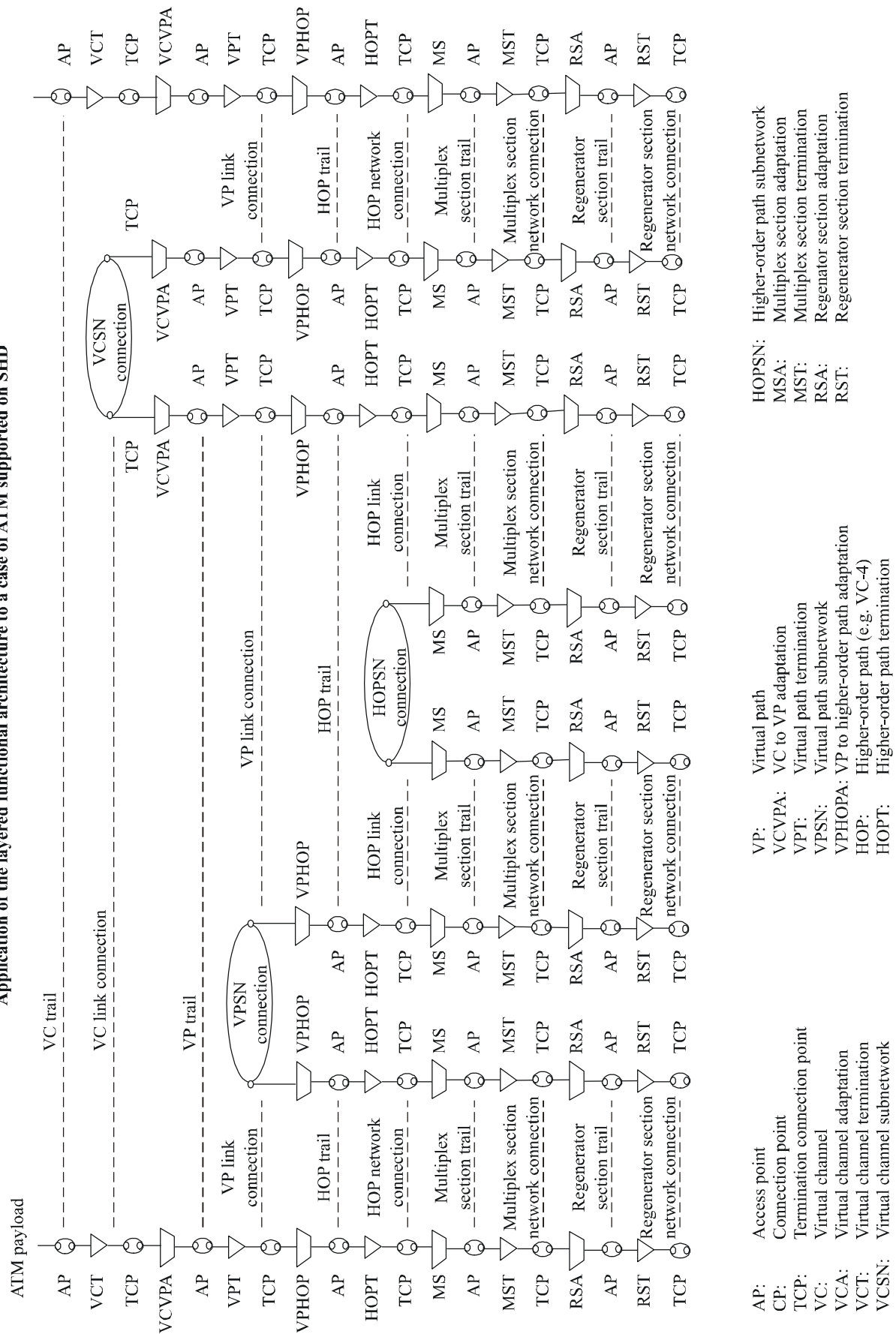
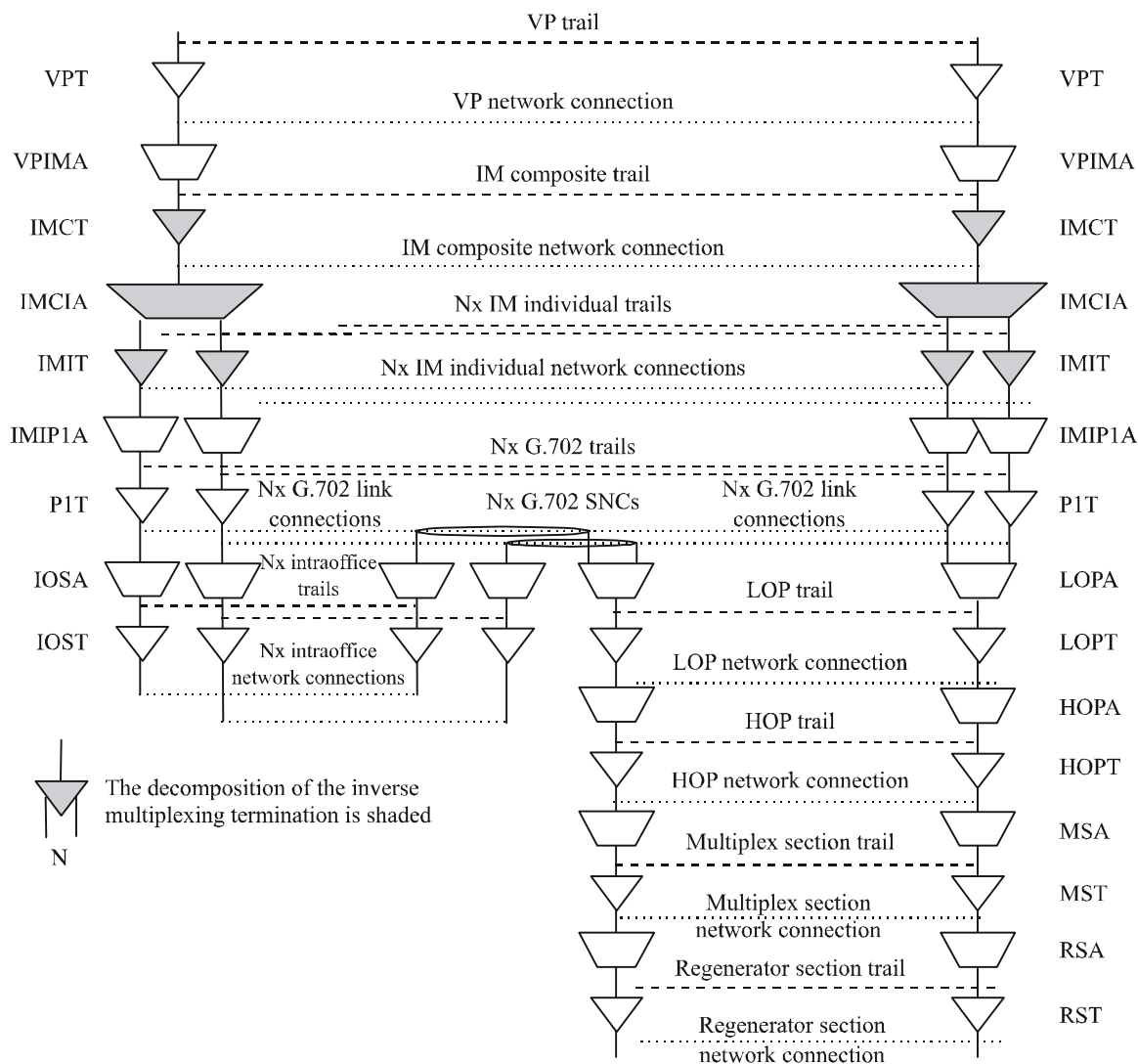


FIGURE 5

Application of the layered functional architecture to a case of an ATM inverse multiplexing

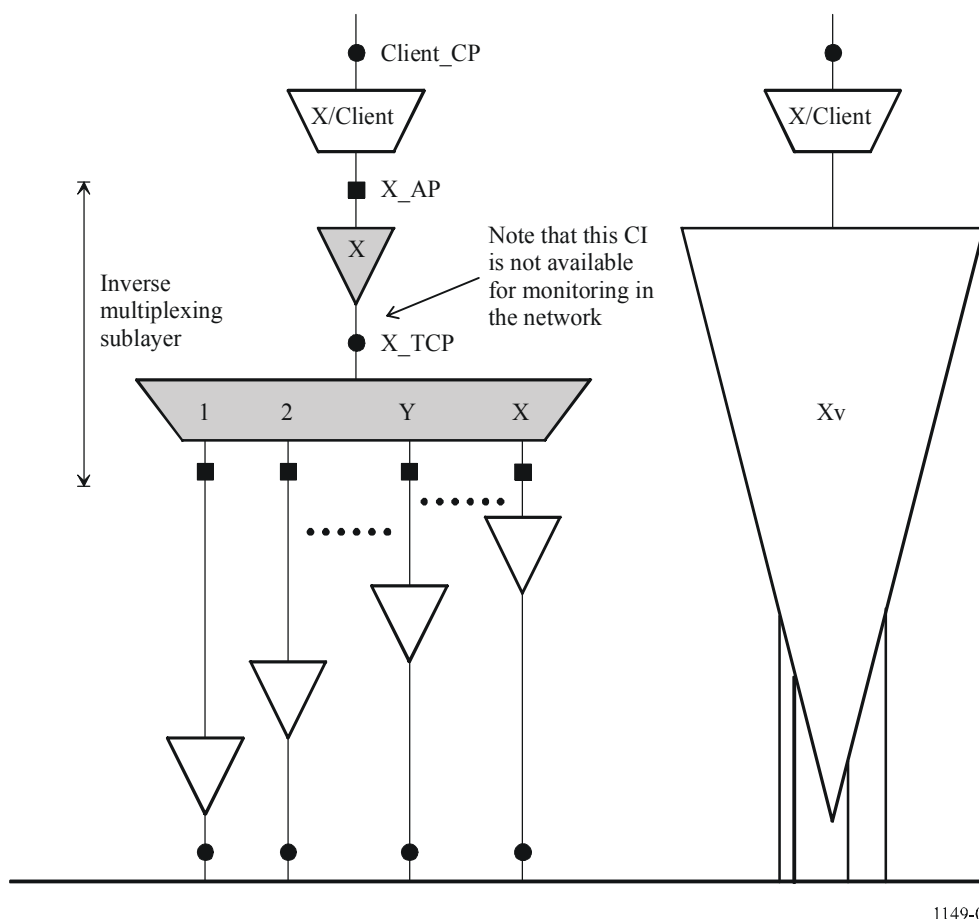


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If the inverse multiplexing were applied at the SDH layer then it would be illustrated as in Fig. 6.

FIGURE 6

Inverse multiplexing sublayer



3 Applications of the FSS in SDH transport networks

3.1 Service aspects

To explain the advantages of employing satellite transmission technology in the SDH, three scenarios have been created and are described as the basis for the rest of this Recommendation.

Firstly some of the background technology of SDH is discussed to simplify the later description of the scenarios.

3.2 Network management aspects

With such an integration it should be simpler to include the satellite aspects in the overall SDH network management system and thus enhance the management functionality for the end user's benefit.

3.2.1 General

It is proposed to incorporate the SDH multiplex equipment functions as part of the satellite system synchronous baseband equipment.