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DIGITAL SYSTEMS AND NETWORKS

Digital networks – General aspects

Characteristics of transport equipment – Description methodology and generic functionality

Recommendation ITU-T G.806



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For further details, please refer to the list of ITU-T Recommendations.



Recommendation ITU-T G.806

Characteristics of transport equipment – Description methodology and generic functionality

Summary

Recommendation ITU-T G.806 specifies the methodology, generic functionality and components that should be used in order to specify transport network functionality of network elements; it does not specify individual transport network equipment as such. It is the baseline Recommendation for other standards that specify the characteristics of equipment for specific transport networks (e.g., synchronous digital hierarchy (SDH), plesiochronous digital hierarchy (PDH)).

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Recommendation ITU-T G.806

Characteristics of transport equipment – Description methodology and generic functionality

1 Scope

This Recommendation specifies a methodology for describing equipment for transport networks based on the transport processing functions and architectural entities defined in [ITU-T G.805]. It defines the set of generic atomic and compound functions and the set of rules for how to combine them. The detailed characteristics of equipment functional blocks of specific transport networks (e.g., SDH, OTN) will be defined in follow-up Recommendations based on this methodology. Equipment can then be described by an equipment functional specification (EFS) which lists the atomic functions and their interconnection.

In addition, generic functionality, processes and overall performance objectives for transport networks are defined in this Recommendation.

The internal structure of the implementation of this functionality (equipment design) need not be identical to the structure of the functional model, as long as all the details of the externally observable behaviour comply with the EFS.

Equipment which is normally stated to be compliant with this Recommendation may not fulfil all the requirements in the case that it is interworking with old equipment that is not compliant with this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T E.862] Recommendation ITU-T E.862 (1992), *Dependability planning of telecommunication networks*.
- [ITU-T G.664] Recommendation ITU-T G.664 (2006), *Optical safety procedures and requirements for optical transport systems*.
- [ITU-T G.703] Recommendation ITU-T G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [ITU-T G.704] Recommendation ITU-T G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.
- [ITU-T G.705] Recommendation ITU-T G.705 (2000), *Characteristics of plesiochronous digital hierarchy (PDH) equipment functional blocks*.
- [ITU-T G.707] Recommendation ITU-T G.707/Y.1322 (2003), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2009), *Interfaces for the Optical Transport Network (OTN)*.

- [ITU-T G.775] Recommendation ITU-T G.775 (1998), *Loss of Signal (LOS), Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) defect detection and clearance criteria for PDH signals.*
- [ITU-T G.781] Recommendation ITU-T G.781 (2008), *Synchronization layer functions.*
- [ITU-T G.783] Recommendation ITU-T G.783 (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks.*
- [ITU-T G.784] Recommendation ITU-T G.784 (1999), *Synchronous digital hierarchy (SDH) management.*
- [ITU-T G.798] Recommendation ITU-T G.798 (2010), *Characteristics of optical transport network hierarchy equipment functional blocks.*
- [ITU-T G.803] Recommendation ITU-T G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH).*
- [ITU-T G.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks.*
- [ITU-T G.808.1] Recommendation ITU-T G.808.1 (2010), *Generic protection switching – Linear trail and subnetwork protection.*
- [ITU-T G.826] Recommendation ITU-T G.826 (2002), *End-to-end error performance parameters and objectives for international, constant bit-rate digital paths and connections.*
- [ITU-T G.831] Recommendation ITU-T G.831 (2000), *Management capabilities of transport networks based on the synchronous digital hierarchy (SDH).*
- [ITU-T G.832] Recommendation ITU-T G.832 (1998), *Transport of SDH elements on PDH networks – Frame and multiplexing structures.*
- [ITU-T G.842] Recommendation ITU-T G.842 (1997), *Interworking of SDH network protection architectures.*
- [ITU-T G.911] Recommendation ITU-T G.911 (1997), *Parameters and calculation methodologies for reliability and availability of fibre optic systems.*
- [ITU-T G.7041] Recommendation ITU-T G.7041/Y.1303 (2011), *Generic framing procedure.*
- [ITU-T G.7042] Recommendation ITU-T G.7042/Y.1305 (2006), *Link capacity adjustment scheme (LCAS) for virtual concatenated signals.*
- [ITU-T G.7710] Recommendation ITU-T G.7710/Y.1701 (2010), *Common equipment management function requirements.*
- [ITU-T G.8001] Recommendation ITU-T G.8001/Y.1354 (2011), *Terms and definitions for Ethernet frames over transport.*
- [ITU-T G.8010] Recommendation ITU-T G.8010/Y.1306 (2004), *Architecture of Ethernet layer networks.*
- [ITU-T G.8021] Recommendation ITU-T G.8021/Y.1341 (2010), *Characteristics of Ethernet transport network equipment functional blocks.*
- [ITU-T I.732] Recommendation ITU-T I.732 (2000), *Functional characteristics of ATM equipment.*
- [ITU-T M.20] Recommendation ITU-T M.20 (1992), *Maintenance philosophy for telecommunication networks.*
- [ITU-T M.125] Recommendation ITU-T M.125 (1988), *Digital loopback mechanisms.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

- 3.1.1 **access point (AP)**: [ITU-T G.805].
- 3.1.2 **access point identifier (API)**: [ITU-T G.831].
- 3.1.3 **automatic laser shutdown (ALS)**: [ITU-T G.664].
- 3.1.4 **automatic power shutdown (APSD)**: [ITU-T G.664].
- 3.1.5 **channel identifier (CID)**: [ITU-T G.7041].
- 3.1.6 **client data frame**: [ITU-T G.7041].
- 3.1.7 **client management frame**: [ITU-T G.7041].
- 3.1.8 **connection**: [ITU-T G.805].
- 3.1.9 **flow termination**: [ITU-T G.8021].
- 3.1.10 **frame-mapped generic framing procedure (GFP)**: [ITU-T G.7041].
- 3.1.11 **layer network**: [ITU-T G.805].
- 3.1.12 **maintenance entity**: [ITU-T G.8001].
- 3.1.13 **maintenance entity group**: [ITU-T G.8001].
- 3.1.14 **MEG end point (MEP)**: [ITU-T G.8001].
- 3.1.15 **MEG intermediate point (MIP)**: [ITU-T G.8001].
- 3.1.16 **member**: [ITU-T G.7042].
- 3.1.17 **network connection (NC)**: [ITU-T G.805].
- 3.1.18 **subnetwork connection (SNC)**: [ITU-T G.805].
- 3.1.19 **superblock**: [ITU-T G.7041].
- 3.1.20 **termination flow point**: [ITU-T G.8021].
- 3.1.21 **traffic conditioning function**: [ITU-T G.8001].
- 3.1.22 **trail**: [ITU-T G.805].
- 3.1.23 **transparent generic framing procedure (GFP)**: [ITU-T G.7041].
- 3.1.24 **virtual concatenation group (VCG)**: [ITU-T G.7042].

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

- 3.2.1 **adaptation function (A)**: An atomic function that performs the adaptation between client and server layer network.
- 3.2.2 **adapted information (AI)**: The information passing across an AP (see also [ITU-T G.805]).
- 3.2.3 **alarm**: A human-observable indication that draws attention to a failure (detected fault) usually giving an indication of the severity of the fault.
- 3.2.4 **all-ones**: The entire capacity of the adapted or characteristic information is set to logic "1".

3.2.5 anomaly: The smallest discrepancy which can be observed between the actual and desired characteristics of an item. The occurrence of a single anomaly does not constitute an interruption in the ability to perform a required function. Anomalies are used as the input for the performance monitoring (PM) process and for the detection of defects.

3.2.6 atomic function: A function that, if divided into simpler functions, would cease to be uniquely defined for digital transmission hierarchies. It is, therefore, indivisible from a network point of view.

3.2.7 bidirectional trail/connection type: A two-way trail/connection through a transport network.

3.2.8 broadcast connection type: An input connection point is connected to more than one output connection point.

3.2.9 characteristic information (CI): The information passing across a connection point or termination connection point (see also [ITU-T G.805]).

3.2.10 client/server layer: Any two adjacent network layers are associated in a client/server relationship. Each transport network layer provides transport to the layer above and uses transport from the layers below. The layer providing transport is termed a server; the layer using transport is termed client.

3.2.11 compound function: A function that represents a collection of atomic functions within one or more layer(s).

3.2.12 connection function (C): An atomic function within a layer which, if connectivity exists, relays a collection of items of information between groups of atomic functions. It does not modify the members of this collection of items of information, although it may terminate any switching protocol information and act upon it. Any connectivity restrictions between inputs and outputs shall be stated.

3.2.13 connection matrix (CM): A connection matrix is a matrix of appropriate dimensions which describes the connection pattern for assigning VC-ns on one side of a lower order path connection or higher order path connection function to VC-n capacities on the other side and vice versa.

3.2.14 connection point (CP): A reference point where the output of a trail termination source or a connection is bound to the input of another connection, or where the output of a connection is bound to the input of a trail termination sink or another connection.

3.2.15 consolidation: The allocation of server layer trails to client layer connections which ensures that each server layer trail is full before the next is allocated. Consolidation minimizes the number of partially filled server layer trails. It therefore maximizes the fill factor (e.g., a number of partially filled VC-4 paths may be consolidated into a single, fully filled VC-4).

3.2.16 defect: The density of anomalies has reached a level where the ability to perform a required function has been interrupted. Defects are used as input for performance monitoring, the control of consequent actions and for the determination of fault causes.

3.2.17 failure: The fault cause persisted long enough to consider the ability of an item to perform a required function to be terminated. The item may be considered as failed; a fault has now been detected.

3.2.18 fault: A fault is the inability of a function to perform a required action. This does not include an inability due to preventive maintenance, lack of external resources or planned actions.

3.2.19 fault cause: A single disturbance or fault may lead to the detection of multiple defects. A fault cause is the result of a correlation process which is intended to identify the defect that is representative of the disturbance or fault that is causing the problem.

3.2.20 function: A process defined for digital transmission hierarchies (e.g., plesiochronous digital hierarchy (PDH), synchronous digital hierarchy (SDH)) which acts on a collection of input information to produce a collection of output information. A function is distinguished by the way in which characteristics of the collection of output information differ from the collection of input information.

3.2.21 grooming: The allocation of server layer trails to client layer connections which groups together client layer connections whose characteristics are similar or related (e.g., it is possible to groom VC-12 paths by service type, by destination or by protection category into particular VC-4 paths which can then be managed accordingly).

3.2.22 layer network interworking function: An atomic function that provides interworking of characteristic information between two layer networks.

3.2.23 management information (MI): The signal passing across an access point.

3.2.24 management point (MP): A reference point where the output of an atomic function is bound to the input of the element management function, or where the output of the element management function is bound to the input of an atomic function. The MP is not the TMN Q3 interface.

3.2.25 MST_Range: The highest possible sequence number value in a particular path-layer technology. This parameter depends only upon the path-layer technology being used and is independent of any implementation details. This parameter is used to define how many member status signals (MSTs) are available in a particular technology. As an example, this parameter equals 255 for SDH Sn-layer and OTN OPUk-layer functions, 63 for SDH Sm-layer.

3.2.26 path: A trail in a path layer.

3.2.27 process: A generic term for an action or a collection of actions.

3.2.28 protection information (PI): The information passing across a protection point.

3.2.29 protection point (PP): A reference point where the output of a trail termination sink function of a bidirectional trail termination is bound to the input of its trail termination source function for the purpose of conveying information to the protection end.

3.2.30 reference point: The delimiter of a function.

3.2.31 remote defect indication (RDI): A signal that conveys the defect status of the characteristic information received by the trail termination sink function back to the network element which originated the characteristic information.

3.2.32 remote error indication (REI): A signal which conveys either the exact or truncated number of error detection code violations of the characteristic information as detected by the trail termination sink function back to the network element which originated the characteristic information.

3.2.33 remote information (RI): The information passing across a remote point; e.g., remote defect indication (RDI) and remote error indication (REI).

3.2.34 remote point (RP): A reference point where the output of a trail termination sink function of a bidirectional trail termination is bound to the input of its trail termination source function for the purpose of conveying information to the remote end.

3.2.35 replication information (PI): The information delivered across a replication point.

3.2.36 replication point (PP): A reference point between an adaptation source and sink. Characteristic information from a source flow point is replicated and delivered across a flow replication point to a termination flow point.

3.2.37 section: A trail in a section layer.

- 3.2.38 server signal degrade (SSD):** A signal degrade indication output at the connection point of an adaptation function.
- 3.2.39 server signal fail (SSF):** A signal fail indication output at the connection point of an adaptation function.
- 3.2.40 signal degrade (SD):** A signal indicating that the associated data has degraded in the sense that a degraded defect (dDEG) condition is active.
- 3.2.41 signal fail (SF):** A signal indicating that the associated data has failed in the sense that a near-end defect condition (not being the degraded defect) is active.
- 3.2.42 termination connection point (TCP):** A special case of a connection point where a trail termination function is bound to an adaptation function or a connection function. In the information model, the termination connection point is called the trail termination point (TTP).
- 3.2.43 timing information (TI):** The information passing across a timing point.
- 3.2.44 timing point (TP):** A reference point where an output of the synchronization distribution layer is bound to the input of an adaptation source or connection function, or where the output of an adaptation sink function is bound to an input of the synchronization distribution layer.
- 3.2.45 trail signal degrade (TSD):** A signal degrade indication output at the access point of a termination function.
- 3.2.46 trail signal fail (TSF):** A signal fail indication output at the access point of a termination function.
- 3.2.47 trail termination function (TT):** An atomic function within a layer that generates, adds and monitors information concerning the integrity and supervision of adapted information.
- 3.2.48 transit delay:** Transit delay is defined as the period of time taken for an information bit arriving at a network element input port to reappear at an output port on the same network element via a defect free trail.
- 3.2.49 undefined bit:** If a bit is undefined, its value is set to a logical "0" or a logical "1". See regional standards for further specifications of the value of undefined bits.
- 3.2.50 undefined byte:** If a byte is undefined, it contains eight undefined bits.
- 3.2.51 unidirectional trail/connection type:** A one-way trail/connection through a transport network.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

A	Adaptation function
AcCID	Accepted Channel Identifier
AcEXI	Accepted Extension header Identifier
Ack	Acknowledge
AcPFI	Accepted Payload Frame check sequence Identifier
AcPTI	Accepted Payload Type Identifier
AcSL	Accepted Signal Label
AcSQ	Accepted Sequence indicator
AcTI	Accepted Trace Identifier
AcUPI	Accepted User Payload Identifier

AI	Adapted Information
AIS	Alarm Indication Signal
ALS	Automatic Laser Shutdown
AP	Access Point
API	Access Point Identifier
APS	Automatic Protection Switching
APSD	Automatic Power ShutDown
AU	Administrative Unit
AU-n	Administrative Unit, level n
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
C	Connection function
cHEC	core Header Error Check
CI	Characteristic Information
CID	Channel Identifier
CK	Clock
CM	Connection Matrix
COMMS	Communication access
COMMS_AC	COMMS access function
CP	Connection Point
CRC	Cyclic Redundancy Check
CRC16Err	Cyclic Redundancy Check-16 Errors
CRC-n	Cyclic Redundancy Check, width N
CSF	Client Signal Fail
CTRL	Control field sent from source to sink
D	Data
D	Delay
D_FT	Diagnostic Flow Termination
D_TT	Diagnostic Trail Termination
DCC	Data Communication Channel
DCI	Defect Clear Indication
DE	Drop Eligible
DEG	Degraded
DEGTHR	Degraded Threshold
DMFI	relative ('Differential') delay in Multiframe Indicator units
DNU	Do Not Use
DS	Defect Second

EBC	Errored Block Count
ECEnabled	Error Correction enabled
EDC	Error Detection Code
EDCV	Error Detection Code Violation
EFS	Equipment Functional Specification
eHEC	extension Header Error Check
EMF	Equipment Management Function
EOS	End Of Sequence
EQ	Equipment
Eq	PDH Electrical signal, bit rate order q
ES	Electrical Section
ES	Errored Second
ES1	Electrical Section, level 1
ETCn	Ethernet physical coding sublayer
ETH	Ethernet VLAN
ETYn	Ethernet physical
EXI	Extension header Identifier
EXM	Extension header Mismatch
ExSL	Expected Signal Label
ExSQ	Expected Sequence indicator
ExtCmd	External Command
ExTI	Expected Trace Identifier
F_B	Far-end Block
F_DS	Far-end Defect Second
F_EBC	Far-end Errored Block Count
FAS	Frame Alignment Signal
FDI	Forward Defect Indication
FDis	Frames Discarded
FIT	Failure In Time
FM	Fault Management
FOP	Failure Of Protocol
FOP-CM	Failure Of Protocol Configuration Mismatch
FOP-NR	Failure Of Protocol No Response
FOP-PM	Failure Of Protocol Provisioning Mismatch
FOPR	Failure Of Protocol, sink (Receive) direction
FOPT	Failure Of Protocol, source (Transmit) direction
FOP-TO	Failure Of Protocol Timeout

FP	Flow Point
FS	Frame Start
FT	Flow Termination
GFP	Generic Framing Procedure
GFP-F	Frame-mapped Generic Framing Procedure
GFP-T	Transparent Generic Framing Procedure
GID	Group Identifier
HEC	Header Error Check
HO	Higher Order
HO	Hold Off
I	layer network Interworking function
ID	Identifier
IEC	Incoming Error Count
IF	In Frame state
IM	In Multiframe state
LBC	Lost Block Count
LC	Link Connection
LCAS	Link Capacity Adjustment Scheme
LCK	Locked
LCS	Loss of Character Synchronization
LFD	Loss of Frame Delineation
LO	Lower Order
LOA	Loss Of Alignment; also generic for loss of frame, loss of multiframe and loss of pointer
LOC	Loss Of Continuity
LOF	Loss Of Frame
LOM	Loss Of Multiframe
LOP	Loss Of Pointer
LOS	Loss Of Signal
ME	Maintenance Entity
MEG	Maintenance Entity Group
MEP	MEG End Point
MFI	Multiframe Indicator
MI	Management Information
MIP	MEG Intermediate Point
MMG	Mismerge
MND	Member Not Deskewable

MON	Monitored
MP	Management Point
MS	Multiplex Section
MSB	Most Significant Bit
MSn	Multiplex Section layer, level n
MSnP	Multiplex Section trail Protection layer, level n
MSOH	Multiplex Section Overhead
MST	Member Status (signal)
MSU	Member Signal Unavailable
MSU_L	Member Signal Unavailable, LCAS-enabled criteria
MTBF	Mean Time Between Failures
MTU	Maximum Transmission Unit
N_B	Near-end Block
N_DS	Near-end Defect Second
N_EBC	Near-end Errored Block Count
NCM	Network Connection Monitoring
NE	Network Element
NMON	Not Monitored
NNI	Network Node Interface
OAM	Operation, Administration and Maintenance
OCh	OTN optical Channel
ODI	Outgoing Defect Indication
ODU	OTN optical channel Data Unit
OEI	Outgoing Error Indication
OMSn	OTN optical Multiplex Section
OOF	Out Of Frame state
OOM	Out Of Multiframe state
OPSn	OTN optical Physical Section
OPUk	Optical channel Payload Unit-k
OS	Operation System
OS	Optical Section
OSn	Optical Section layer, level n
OTSn	OTN optical Transmission Section
OTU	OTN optical channel Transport Unit
P	Priority
P0x	64 kbit/s layer (transparent)
P11x	1544 kbit/s layer (transparent)

P12s	2048 kbit/s PDH path layer with synchronous 125 µs frame structure
P12x	2048 kbit/s layer (transparent)
P21x	6312 kbit/s layer (transparent)
P22e	8448 kbit/s PDH path layer with 4 plesiochronous 2048 kbit/s
P22x	8448 kbit/s layer (transparent)
P31e	34 368 kbit/s PDH path layer with 4 plesiochronous 8448 kbit/s
P31s	34 368 kbit/s PDH path layer with synchronous 125 µs frame
P31x	34 368 kbit/s layer (transparent)
P32x	44 736 kbit/s layer (transparent)
P4a	139 264 kbit/s PDH path layer with 3 plesiochronous 44 736 kbit/s
P4e	139 264 kbit/s PDH path layer with 4 plesiochronous 34 368 kbit/s
P4s	139 264 kbit/s PDH path layer with synchronous 125 µs frame structure
P4x	139 264 kbit/s layer (transparent)
PC	Payload-Carrying
PDH	Plesiochronous Digital Hierarchy
pFCS	payload Frame Check Sequence
PFI	Payload Frame check sequence Indication
PI	Protection reference point Information
PI	Replication Information
PLCR	Partial Loss of Capacity Receive
PLCT	Partial Loss of Capacity Transmit
PLM	Payload Mismatch
PM	Performance Monitoring
POH	Path Overhead
PP	Protection reference Point
PP	Replication Point
Pq	PDH path layer, bit rate order q
Prov	Provisioned
ProvM	Provisioned Member
PTI	Payload Type Identifier
PTR	Pointer
P-Xv-L	LCAS-capable virtual concatenated path layer
RDI	Remote Defect Indication
rec	received
REI	Remote Error Indication
RI	Remote Information

RP	Remote Point
RS	Regenerator Section
RS	Re-Sequence
RS-Ack	Re-Sequence Acknowledge
RSn	Regenerator Section layer, level n
RSOH	Regenerator Section OverHead
RxSL	Received Signal Label
RxTI	Received Trace Identifier
S11	VC-11 path layer
S11D	VC-11 tandem connection sublayer
S11P	VC-11 path protection sublayer
S12	VC-12 path layer
S12D	VC-12 tandem connection sublayer
S12P	VC-12 path protection sublayer
S2	VC-2 path layer
S2D	VC-2 tandem connection sublayer
S2P	VC-2 path protection sublayer
S3	VC-3 path layer
S3D	VC-3 tandem connection sublayer using TCM option 2
S3P	VC-3 path protection sublayer
S3T	VC-3 tandem connection sublayer using TCM option 1
S4	VC-4 path layer
S4D	VC-4 tandem connection sublayer using TCM option 2
S4P	VC-4 path protection sublayer
S4T	VC-4 tandem connection sublayer using TCM option 1
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy
SF	Signal Fail
Sk	Sink
Sn	higher order VC-n layer
SNC	Subnetwork Connection
SNC/I	Inherently monitored Subnetwork Connection protection
SNC/N	Non-intrusively monitored Subnetwork Connection protection
SNC/S	Sublayer (tandem connection) monitored Subnetwork Connection protection
So	Source
SOH	Section Overhead
SQ	Sequence indicator

SQM	Sequence indicator Mismatch
SQv	validated Sequence indication
SSD	Server Signal Degrade
SSF	Server Signal Fail
SSM	Synchronization Status Message
STM	Synchronous Transport Module
TCM	Tandem Connection Monitor
TCP	Termination Connection Point
TCS	Traffic Conditioning and Shaping
TDM	Time Division Multiplexing
TF	Transmit Fail
TFAS	trail Trace identifier Frame Alignment Signal
TFP	Termination Flow Point
tHEC	type Header Error Check
TI	Timing Information
TIM	Trace Identifier Mismatch
TLCR	Total Loss of Capacity Receive
TLCT	Total Loss of Capacity Transmit
TP	Timing Point
TPmode	Termination Point mode
TS	Time Slot
TSD	Trail Signal Degrade
TSF	Trail Signal Fail
TSL	Trail Signal Label
TSx	Trail Signal status, x = F (fail) or D (degraded)
TT	Trail Termination function
TTI	Trail Trace Identifier
TTP	Trail Termination Point
TU	Tributary Unit
TUG	Tributary Unit Group
TU-m	Tributary Unit, level m
TxSL	Transmitted Signal Label
TxSQ	Transmitted Sequence number
TxTI	Transmitted Trace Identifier
UMST	(persistent) Unexpected Member Status (signal)
UNEQ	UNEQuipped
UNP	Unexpected Priority

UNPr	Unexpected Period
UPI	User Payload Identifier
UPM	User Payload Mismatch
VC	ATM Virtual Channel
VC	Virtual Container
VCAT	Virtual Concatenation
VCG	Virtual Concatenation Group
VC-n	Virtual Container, level n
VL	Virtual concatenation/Link capacity adjustment scheme (VCAT/LCAS) Information
VP	ATM Virtual Path
WDM	Wavelength Division Multiplexing
WTR	Wait to Restore

5 Methodology

5.1 Basic methodology

The methodology used to describe transport network functionality of network elements is based on the generic functional architecture of transport networks, the architectural entities and transport processing functions defined in [ITU-T G.805].

The functionality of transport processing functions within network elements is represented by atomic functions for each layer of the transport network and a set of combination rules for these functions. The basic set of atomic functions of a layer is shown in Figure 5-1 and consists of:

- trail and flow termination functions
- adaptation functions
- connection functions.

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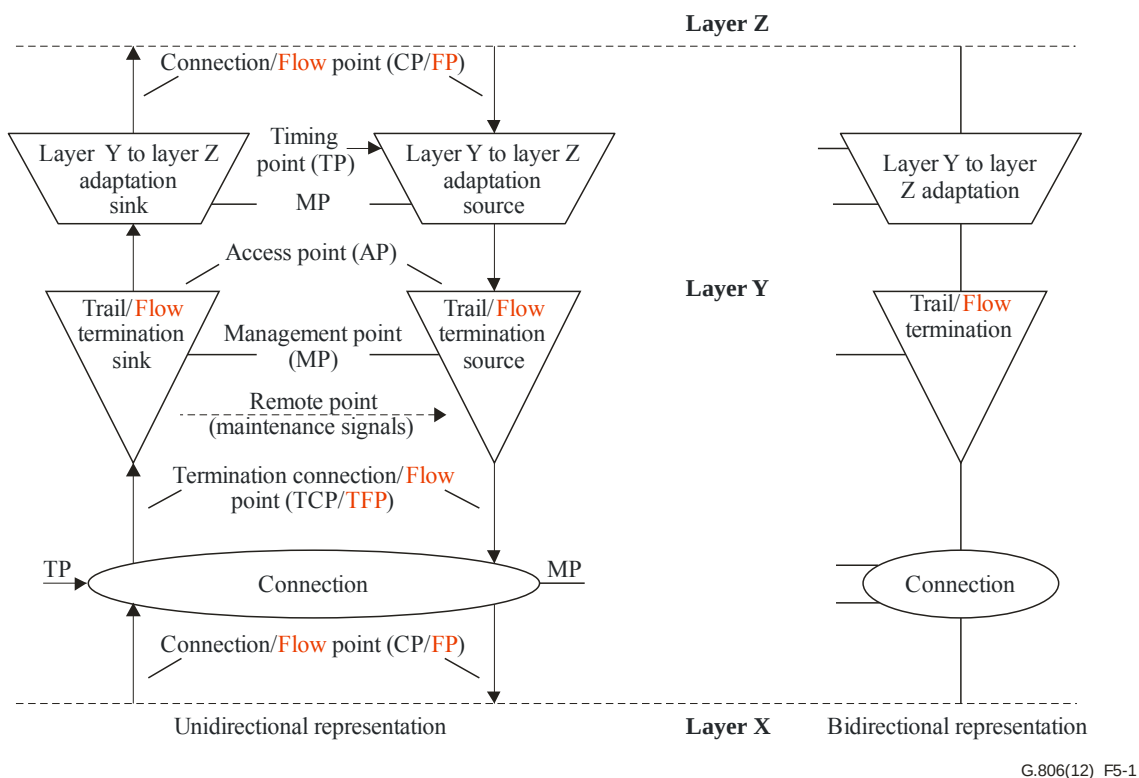


Figure 5-1 – Atomic functions and reference points

The interworking atomic function shown in Figure 5-2 is used for the special application of interworking between two network layers with similar characteristic information.

The diagrammatic convention for a communication access (COMMS) atomic function is shown in Figure 5-3b. The COMMS function provides access at intermediate connection points along a connection to general purpose communication channels.

The diagrammatic convention for a traffic conditioning and shaping (TCS) atomic function is shown in Figure 5-3c. The TCS sink function provides the traffic conditioning process. The TCS source function provides the shaping process.

An atomic function is described by the processes within the function, its reference points and the information flow via these reference points.

Within a network element, transport processing functions may interact with equipment management functions (EMFs) for fault, performance and configuration management. For the common EMF requirements, see [ITU-T G.7710].

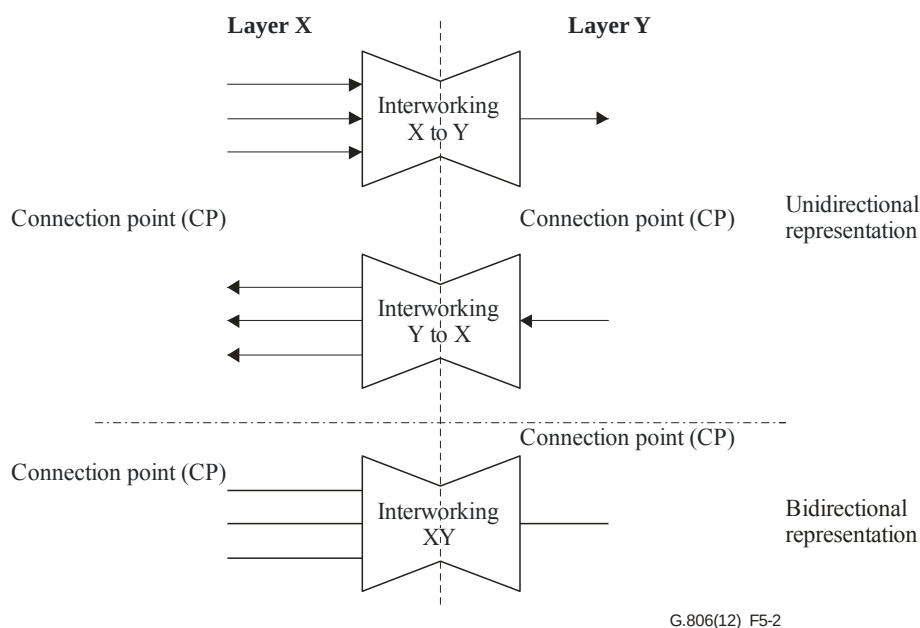


Figure 5-2 – Layer network interworking function

An atomic function may have several transmission reference points as input or output as shown in Figure 5-2.

5.2 Transmission layer naming

In order to identify the numerous transmission layers of the transport network hierarchies, a specific naming scheme is defined. The naming scheme consists of:

- one or more letters to identify the hierarchy and/or, if necessary, a specific layer type;
- a number or a number/letter combination that indicates the hierarchy level;
- one or more letters for further details on layer, sublayer or specific frame structure.

Table 5-1 shows the currently defined layer names.

Table 5-1 – Transmission layers

Name	Layer	Defined in
OSn	STM-n optical section	[ITU-T G.783]
ES1	STM-1 electrical section	[ITU-T G.783]
RSn	STM-n regenerator section	[ITU-T G.783]
MSn	STM-n multiplex section	[ITU-T G.783]
MSnP	STM-n multiplex section protection sublayer	[ITU-T G.783]
Sn	SDH VC-n path layer	[ITU-T G.783]
SnP	SDH VC-n trail protection sublayer	[ITU-T G.783]
SnD	SDH VC-n TCM option 2 sublayer	[ITU-T G.783]
SnT	SDH VC-n TCM option 1 sublayer	[ITU-T G.783]
Eq	PDH electrical section	[ITU-T G.705]
Pqe	Plesiochronous framed PDH layer	[ITU-T G.705]
Pqs	Synchronous framed PDH layer	[ITU-T G.705]
Pqx	Unframed PDH layer	[ITU-T G.705]

Table 5-1 – Transmission layers

Name	Layer	Defined in
NS	Network synchronization layer	[ITU-T G.781]
SD	Synchronization distribution layer	[ITU-T G.781]
VC	ATM virtual channel	[ITU-T I.732]
VP	ATM virtual path	[ITU-T I.732]
ODU	OTN optical channel data unit	[ITU-T G.798]
OTU	OTN optical channel transport unit	[ITU-T G.798]
OCh	OTN optical channel	[ITU-T G.798]
OMS _n	OTN optical multiplex section	[ITU-T G.798]
OTS _n	OTN optical transmission section	[ITU-T G.798]
OPSn	OTN optical physical section	[ITU-T G.798]
ETH	Ethernet VLAN	[ITU-T G.8021]
ETY _n	Ethernet physical	[ITU-T G.8021]
ETC _n	Ethernet physical coding sublayer	[ITU-T G.8021]

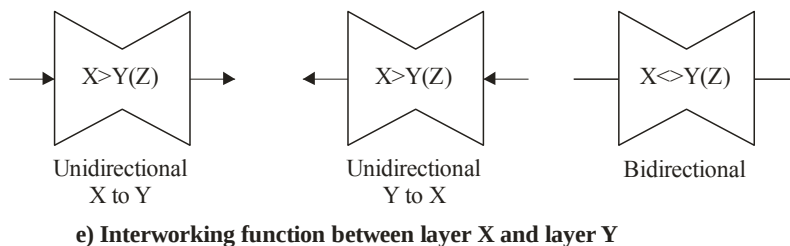
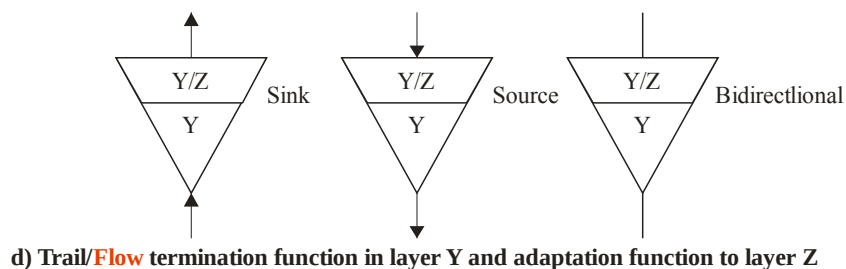
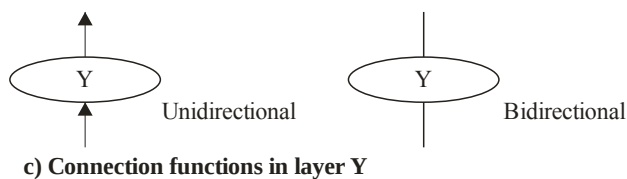
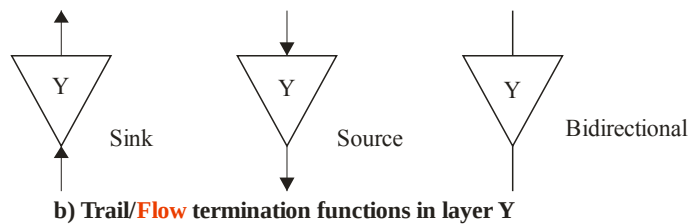
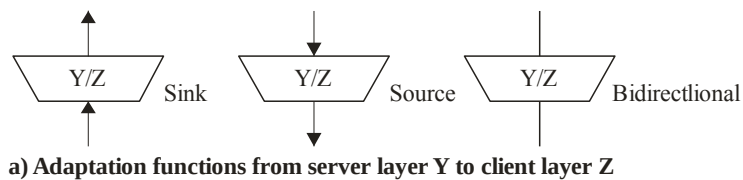
5.3 Atomic function naming and diagrammatic conventions

The naming of adaptation, trail and flow termination and connection functions follow the following rules:

Adaptation function	<layer>/<client layer>_A[_<direction>]
Trail termination function	<layer>_TT[_<direction>]
Flow termination function	<layer>_FT[_<direction>]
Tandem connection trail termination function	<layer>T_TT[_<direction>]
Diagnostic trail termination function	<layer>D_TT[_<direction>]
Diagnostic flow termination function	<layer>D_FT[_<direction>]
Connection function	<layer>_C
Layer network interworking function	<layer>[</>/<]<layer>[(set of accepted client layers X)]_I
Communication access function	<layer>/COMMS_AC[_<direction>]
Traffic conditioning and shaping function	<layer>_TCS[_<direction>]

Examples are: MS1/S4_A, S12/P12s_A_So, S4_TT, RS16_TT_Sk, S3_C, ETH_FT, ETY/ETH_A.

The diagrammatic conventions and nomenclature for adaptation, termination, connection layer interworking, communication access, and traffic conditioning functions (used to describe the atomic functions) are shown in Figures 5-3.

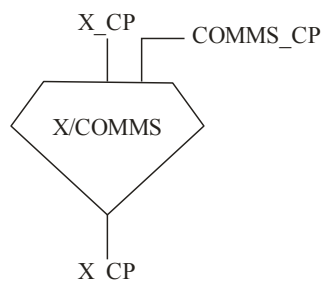


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NOTE 1 – If the above symbols are used for generic figures, i.e., not for specific layers, the layer references Y and Z may be omitted. Alternatively, the references may be to the type of function or layer, e.g., supervision, protection.

NOTE 2 – The order of the layers in the name of an interworking function can be changed (e.g., X>Y is identical to Y<X).

Figure 5-3a – Symbols and diagrammatic conventions



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Figure 5-3b – Diagrammatic convention for communication access function

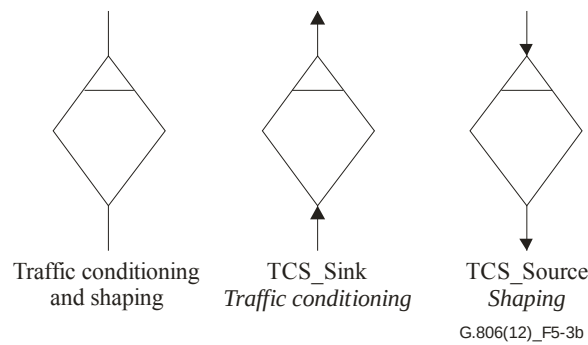


Figure 5-3c – Diagrammatic convention for traffic conditioning and shaping function

As an example of the use of this diagrammatic nomenclature, Figure 5-4 shows a unidirectional VC-4 path in an SDH network.

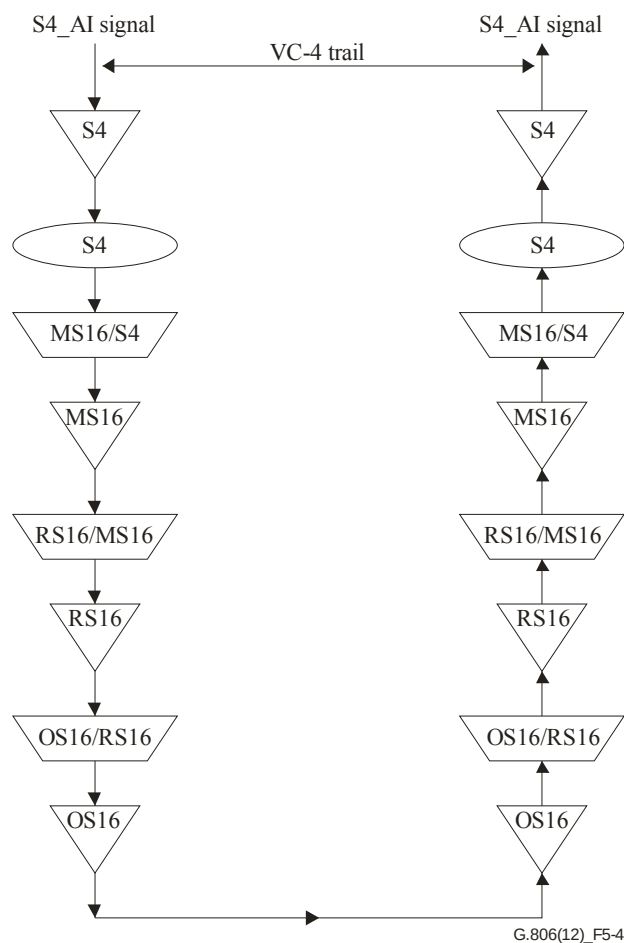
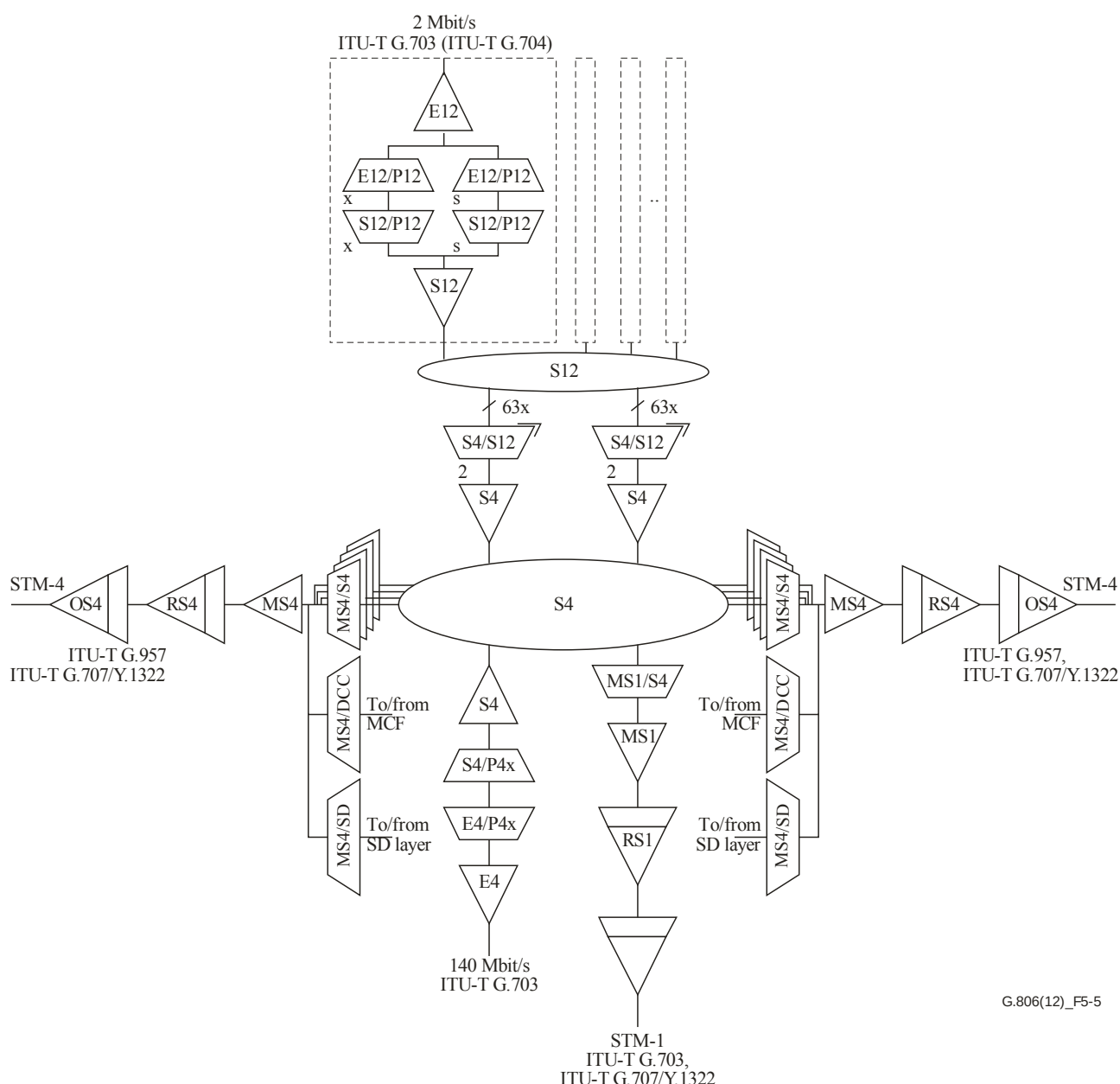


Figure 5-4 – Example of a unidirectional VC-4 path in an SDH network

As an example of the use of this diagrammatic nomenclature, Figure 5-5 shows an example of a transport level fragment of an equipment functional specification (EFS).



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Figure 5-5 – Example of an SDH equipment functional specification

The equipment represented by the EFS supports the following interfaces: two optical STM-4, one electrical STM-1, one 140 Mbit/s, a number of 2 Mbit/s.

The STM-4 interfaces contain the MS-DCC signal and SSM signal. The STM-4 interfaces can contribute to the synchronization reference selection process in synchronization layers.

NOTE 1 – RS-DCC, RS-USER, RS-OW and MS-OW signals are not supported by the STM-4 interfaces.

NOTE 2 – RS-DCC, RS-USER, RS-OW, MS-DCC, MS-OW and contribution to the synchronization reference selection process are not supported by the STM-1 interface. Nor is the SSM supported on the output STM-1 signal.

The 140 Mbit/s signal is asynchronous mapped into a VC-4.

NOTE 3 – VC4-USER signals are not supported by the VC-4 processing.

The 2 Mbit/s signal is either asynchronous or byte synchronous mapped into the VC-12.

The VC-4 matrix contains twelve inputs and outputs: three towards a VC-4 termination function and the other nine to MSn to VC-4 adaptation functions.

NOTE 4 – Connectivity restrictions related to the VC-4 connection function are not represented in this presentation of the EFS. If applicable, connectivity restrictions can be presented in a further decomposed connection function representation, or by means of connectivity tables as shown in Appendix I.

NOTE 5 – The VC-4 connection function can support SNC protection switching. Such can be represented by means of a "rounded box" around the ellipse, as defined in [ITU-T G.803].

Two VC-4 signals can be terminated when they contain a TUG structure with sixty-three TU-12s. The resulting one hundred and twenty six VC-12 signals are connected to the VC-12 connection function that is also connected to a number of VC-12 termination functions.

NOTE 6 – Connectivity restrictions related to the VC-12 connection function are not represented in this presentation of the EFS. If applicable, connectivity restrictions can be presented in a further decomposed connection function representation, or by means of connectivity tables as shown in Appendix I.

NOTE 7 – The VC-12 connection function can support SNC protection switching. Such can be represented by means of a "rounded box" around the ellipse, as defined in [ITU-T G.803].

Examples of possible connectivity are:

- a VC-4 from an STM-4 interface can be passed through to the other STM-4 interface, with or without time slot interchange;
- a VC-4 from an STM-4 interface can be passed through (or dropped) to the STM-1 interface;
- a VC-4 from an STM-4 interface can be terminated, making the 140 Mbit/s payload available at the 140 Mbit/s interface;
- a VC-4 from an STM-4 interface can be terminated, making the TUG payload accessible for further processing;
- a VC-12 from an STM-4 interface can be passed through to the other STM-4 interface, with or without time slot interchange between the VC-4 server signals;
- a VC-12 from an STM-4 or the STM-1 interface can be terminated (after VC-4 termination), making the 2 Mbit/s payload available at a 2 Mbit/s interface. Either asynchronous or byte synchronous mapping into the VC-12 is supported;
- a VC-12 from an STM-4 interface can be passed through (dropped) to the STM-1 interface (after VC-4 termination), with or without time slot interchange between the VC-4 server signals;
- VC-4 SNC/I protection could be supported between e.g., two VC-4s within the two STM-4 signals, or between a VC-4 within an STM-4 signal and the VC-4 in the STM-1 signal;
- VC-12 SNC/I protection could be supported between two VC-12s within the two TUG structured terminated VC-4 signals. These two VC-4 signals can come from the two STM-4 signals or one STM-4 signal and the STM-1 signal.

5.4 Reference point naming

The atomic functions are defined between fixed reference points at which defined information is assumed to be present. That is, at a given reference point, specific types of information can always be assumed to be present. There are several different types of reference points within the functional model, including reference points for:

- transmission signals
- management information
- timing references
- remote information
- protection information
- replication information.

5.4.1 Transmission reference points

Because they are so numerous, and their detailed characteristics are so important to the functional model, transmission reference points are designated with a more complex naming convention. A transmission reference point name is formed by a transmission layer designation, followed by an underscore character, followed by either AP or CP or FP, depending on whether that reference point is an access point (AP) or a connection/flow point (CP/FP). As described in [ITU-T G.805], the information at an access point is a signal into which the client signal(s) has been mapped, but which does not include the full complement of overhead or OAM information for the given layer. The information at a connection/flow point is a signal that includes the full complement of overhead or OAM information. The access point is at the server side of adaptation functions and the client side of termination functions. The connection/flow point is at the client side of adaptation functions and the server side of termination functions (Figure 5-1). Thus, a transmission reference point name is formed according to the syntax:

$$\langle \text{TransmissionReferencePointName} \rangle = \langle \text{LayerName} \rangle _ \langle \text{AP or CP or FP} \rangle$$
$$\langle \text{TransmissionReferencePointNameDiagnostic} \rangle = \langle \text{LayerName} \rangle \text{D} _ \langle \text{AP} \rangle$$
$$\langle \text{TransmissionReferencePointNameTandem} \rangle = \langle \text{LayerName} \rangle \text{T} _ \langle \text{AP} \rangle$$

Connection and flow points represent the same type of reference points in two types of layer networks. The term connection point is used in layer networks which support unidirectional and bidirectional 2-port point-to-point and n-port ($n > 2$) unidirectional point-to-multipoint connections in which the forwarding of information applied at the input port is performed by means of broadcasting/flooding that information towards all output ports with the exception of the output port associated with the input port. The term flow point is used in layer networks which support unidirectional and bidirectional 2-port point-to-point and n-port ($n > 2$) unidirectional point-to-multipoint connections, as well as supporting bidirectional n-port ($n > 2$) rooted-multipoint and n-port ($n > 2$) multipoint-to-multipoint connections in which the forwarding of information applied at one of the input ports is performed by means of either unicasting towards a single output port, multicasting towards a subset of the output ports, or broadcasting/flooding that information towards all output ports (with the exception of the output port associated with the input port).

5.4.2 Management reference points

Management reference points are also quite numerous and are, therefore, named directly after the name of the associated function according to the syntax:

$$\langle \text{ManagementReferencePointName} \rangle = \langle \text{FunctionName} \rangle _ \text{MP}$$

Thus, for example, the management reference point for the OS_TT function is named OS_TT_MP.

5.4.3 Timing reference points

Timing reference points are named directly after the name of the associated layer according to the syntax:

$$\langle \text{TimingReferencePointName} \rangle = \langle \text{LayerName} \rangle _ \text{TP}$$

Thus, for example, the timing reference point for the VC-4 layer is named S4_TP.

5.4.4 Remote reference points

Remote reference points are named directly after the name of the associated layer according to the syntax:

$$\langle \text{RemoteReferencePointName} \rangle = \langle \text{LayerName} \rangle _ \text{RP}$$

Thus, for example, the remote reference point for the VC-12 layer is named S12_RP.

5.4.5 Protection reference points

Protection reference points are named directly after the name of the associated layer according to the syntax:

`<ProtectionReferencePointName> = <LayerName>_PP`

Thus, for example, the protection reference point for the ODU layer is named ODU_PP. The protection reference point is used to transport automatic protection switching (APS) information between a layer's connection function and its server adaptation function in the case of compound link subnetwork connection group protection with inherent monitoring (CL-SNCG/I).

5.4.6 Replication reference points

Replication reference points are named directly after the name of the associated layer according to the syntax:

`<ReplicationReferencePointName> = <LayerName>_PP`

5.5 Reference point information naming

The information passing a CP is called characteristic information (CI), the information passing an AP is called adapted information (AI), the information passing a MP is called management information (MI), and the information passing a TP is called timing information (TI).

5.5.1 Transmission reference point information naming

The coding of the characteristic information (CI) and adapted information (AI) in the model follows the following rules:

`<layer>_<information type>_<signal type>[/<number>].`

[...] optional term

<layer> represents one of the layer names (e.g., RS1)

<information type> CI or AI

<signal type> CK (clock), or
D (data), or FS (frame start), or
SSF (server signal fail), or
TSF (trail signal fail), or
SSD (server signal degrade), or
TSD (trail signal degrade), or
APS (automatic protection switching), or
P (priority), or
DE (drop eligible)

<number> indication of multiplex/inverse multiplex number; e.g., (1,1,1) for the case of a TU-12 within a VC-4

AI and CI coding examples are: MS1_CI_D, RS16_AI_CK, P12x_AI_D, S2_AI_So_D(2,3,0).

Within the network each access point is uniquely identified by means of its access point identifier (API) (see [ITU-T G.831]). The termination connection/flow point (TCP/TFP) (see Figure 5-1), can be uniquely identified by means of the same API. The connection/flow point (CP/FP) (see Figure 5-1), can be uniquely identified by the API extended with the multiplex number, e.g., the AU or TU number, the VPI or VCI, or the VLAN ID, the VPI or VCI, or the VLAN ID.

Example: a VC12 CP (S12_CP) can be identified by means of the API of the S4_AP, extended with the TU12 TUG number (K,L,M) and an ETH FP (ETH_FP) can be identified by means of the API of the ETH_AP, extended with the VLAN Identifier (VID).

5.5.2 Management reference point information naming

The coding of the MI signals follows the following rule:

<atomic function>_MI_<MI signal type>

5.5.3 Timing reference point information naming

The coding of the TI signals follows the following rule:

<layer>_TI_<TI signal type: CK or FS>

5.5.4 Remote reference point information naming

The coding of the RI signals follows the following rule:

<layer>_RI_<RI signal type: RDI, REI, ODI or OEI>

5.5.5 Protection reference point information naming

The coding of the PI signals follows the following rule:

<layer>_PI_<PI signal type: APS>

5.5.6 Replication reference point information naming

The coding of the PI signals follows the following rule:

<layer>_PI_<PI signal type: D, DE, P>

5.6 Atomic function process allocation

5.6.1 Connection function

The connection function provides flexibility within a layer. It may be used by the network operator to provide routing, grooming, protection and restoration.

The model describes the connection function as a space switch that provides connectivity between its inputs and outputs. Connections might be set up, modified or torn down based on management commands via the MI interface. A connection is supported by a flow forwarding (FF) process. Multiple types of flow forwarding processes are illustrated in Appendix IX.

The connectivity between inputs and outputs of the connection function might be limited due to implementation constraints. Several examples are given in Appendix I.

NOTE – The connection function's flexibility process is modelled as a timing-transparent switch, also referred to as "space switch". In case of time division multiplexing, the switch matrix type may be either a "space switch" or a combination of "space and time switches". If a time switch is involved, the adaptation source functionality that performs the alignment to a common time base (clock) shall be located at the input of the switch matrix (connection function) rather than at the output (as in the functional model).

For the case of SDH, the location of the adaptation source functionality (i.e., elastic store and pointer generator) with respect to the connection functionality (i.e., switch matrix) is observable at the STM-N interface when the matrix connection is changed (e.g., due to SNC protection switching). A pointer with "enabled NDF" is generated when the adaptation source functionality is located at the output of the connection functionality. A pointer without "enabled NDF" is generated when the adaptation source functionality is located at the input of the connection functionality.

5.6.2 Trail termination function

The trail termination function performs the signal integrity supervision of the layer. This includes:

- connectivity supervision;
- continuity supervision;

- signal quality supervision;
- processing of maintenance information (forward/backward indications).

In the source direction, it generates and adds some or all of the following:

- error detection code or forward error indication (e.g., bit interleaved parity (BIP), cyclic redundancy check (CRC), incoming error count);
- frame or packet loss measurement information;
- synthetic frame or packet loss measurement information;
- frame or packet delay and delay variation measurement information;
- trail trace identifier (i.e., source address);
- maintenance entity group identifier;
- maintenance entity group end point identifier;

It conveys back the following remote information:

- remote error indicator signal (e.g., REI, OEI, E-bit), containing the number of detected error detection code violations in the received signal;
- remote defect indicator signal (e.g., RDI, ODI, A-bit), representing the defect status of the received signal;
- remote frame or packet loss measurement information;
- remote synthetic frame or packet loss measurement information;
- remote frame or packet delay and delay variation measurement information.

In the sink direction, it monitors for some or all of the following:

- signal quality (e.g., bit errors);
- (mis-)connection;
- near-end performance;
- far-end performance;
- server signal fail (i.e., alarm indication signal (AIS) instead of data);
- signal loss (disconnection, idle signal, unequipped signal).

NOTE – Functionality is reduced in the physical section layer termination functions, which can only monitor the signal loss. In addition, the physical section termination source function performs logical/optical or logical/electrical conversion. In addition, the physical section termination sink function performs optical/logical or electrical/logical conversion.

Bit errors are detectable via line code violations, parity violations or CRC violations; i.e., error detection code violations. Frame or packet loss is detectable via comparison of transmitted frame or packet count and received frame or packet count information. Synthetic frame or packet loss is detectable via comparison of transmitted synthetic frame or packet identifiers and received synthetic frame or packet identifiers. Frame or packet delay is detectable via comparison of transmitted frame or packet timestamps and received frame or packet timestamps.

To monitor the provisioning of flexibility within a network, access points (APs) will be identified (named/numbered). The API is inserted in the signal, by the trail termination source function, in the trail trace identifier (TTI). The trail termination sink function checks the received name/number with the expected one (provisioned by the network manager).

To enable single-ended maintenance, the defect status and number of error detection code violations detected at the sink trail termination are conveyed back to the source trail termination; the defect status via the remote defect indicator (RDI) signal and the number of error detection code violations via the remote error indicator (REI) signal. The RDI and REI signals are part of the trail overhead.

Degradation of the signal results in the detection of anomalies and defects. As a consequent action of the detection of certain near-end defects, the signal is replaced by the all-ones (AIS) signal and RDI is inserted in the return direction. The defects are reported to the fault management process.

The number of near-end block errors¹ per second is counted. The number of far-end block errors² per second is counted. A second is indicated as a near-end defect second in cases where a signal fail condition was detected in that second. A second is indicated as a far-end defect second in cases where a RDI defect was detected in that second.

Refer to the supervision process description (see clause 6) for detailed descriptions.

5.6.3 Adaptation function

An adaptation function represents the conversion process between server and client layers. One or more of the following processes may be present in an adaptation function:

- scrambling/descrambling
- encoding/decoding
- alignment (framing, pointer interpretation, FAS/PTR generation)
- bit rate adaptation
- frequency justification
- time slot/wavelength assignment/access
- multiplexing/demultiplexing
- timing recovery
- smoothing
- payload type identification
- payload composition selection
- administrative locking
- forward error correction
- port identification.

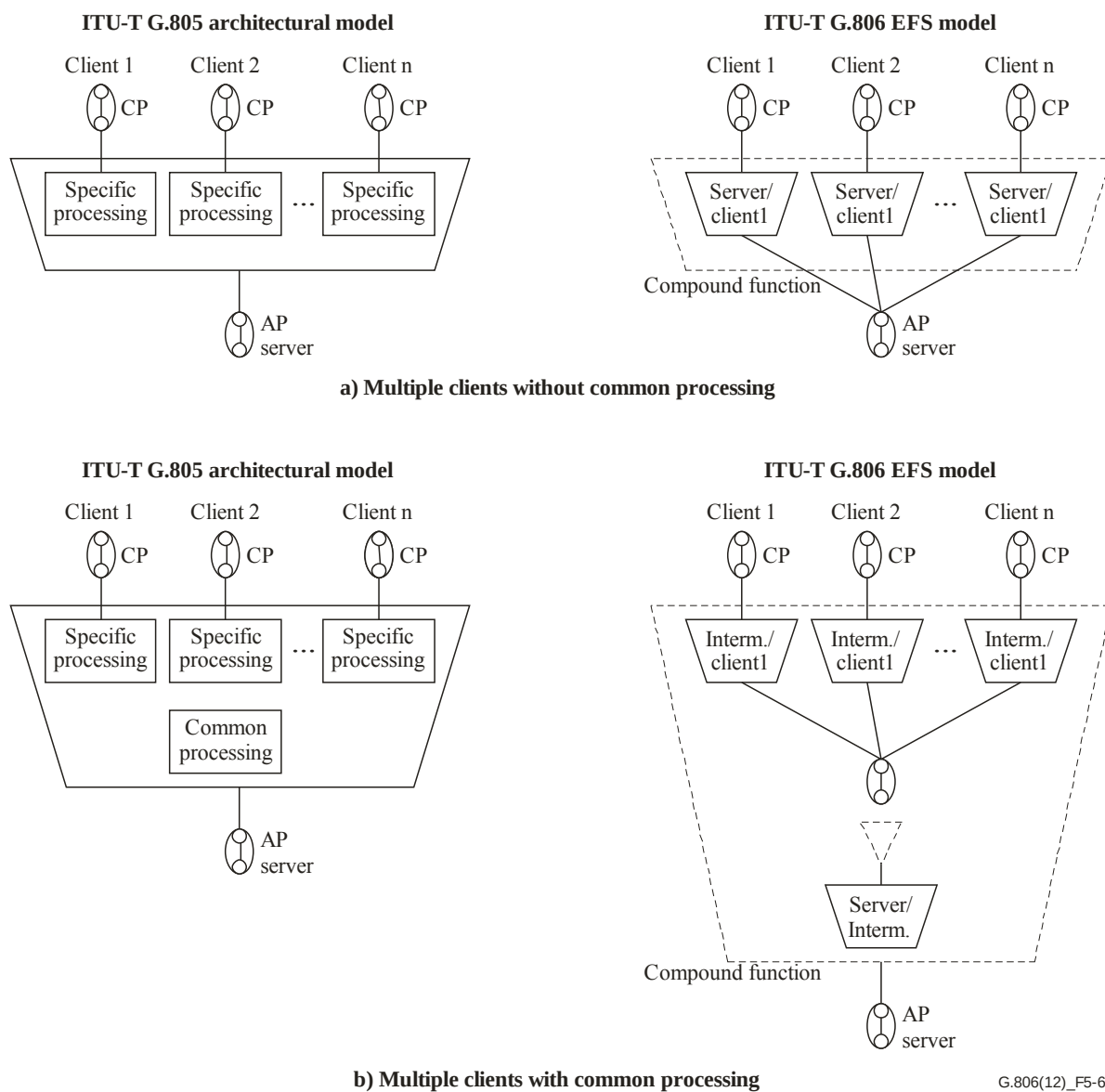
A server layer may provide transport for several client layer signals in parallel (e.g., n VC-4 in an STM- n signal), which is referred to as multiplexing. These client layer signals could be of different layer network types (e.g., mixture of VC-11/12/2/3 within a VC-4, DCCM, EOW, VC-4s in an STM- N multiplex section). According to [ITU-T G.805], this is represented in the functional model by one adaptation function that includes specific processes for each client layer signal. In addition, common processes for all or a set of client signals could be part of the adaptation function. For the equipment functional specification, a different approach is used which provides more flexibility. An adaptation function is defined for each client/server combination. This adaptation function performs the specific processing for this client/server relationship, including the time slot/wavelength assignment/access required for the multiplexing/demultiplexing. The individual adaptation functions are then connected to one AP as shown in Figure 5-6a. This can be viewed in the source direction as each adaptation function sends its AI on a different time slot/wavelength, and the AP just combines this information. In the sink direction, the full AI is distributed to all adaptation functions and each accesses only its specific time slot/wavelength.

¹ Detected by means of error detection code violation monitoring.

² Received via REI.

In the case of common processes, an intermediate signal is defined between the specific and common processes. The specific adaptation functions are between the client and the intermediate signal, and the common adaptation function is between the server and the intermediate signal, as shown in Figure 5-6b. The dotted trail termination function might be used due to historical reasons when a sublayer approach was used for this kind of modelling.

Note that the individual adaptation functions could be combined into a compound function as defined in clause 5.7.7.



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Interm. Intermediate signal

Figure 5-6 – Comparison with the ITU-T G.805 multiplexing model

A client layer signal might be distributed via several server layer signals; this is referred to as inverse multiplexing. According to [ITU-T G.805] this is done by creating an inverse multiplexing sublayer with an adaptation function to the set of server layers as shown in Figure 5-7.

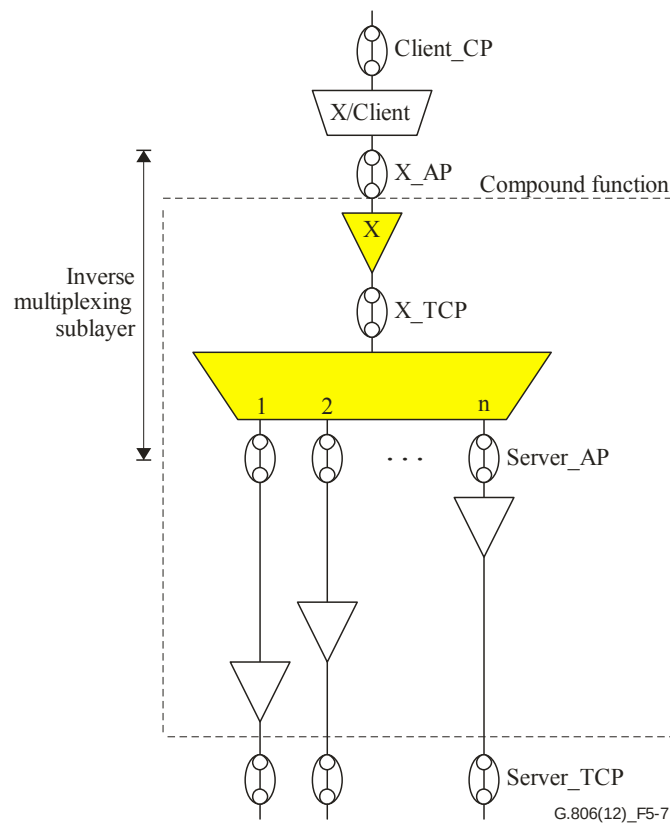


Figure 5-7 – Inverse multiplexing

The **scrambling** process alters digital data in a predefined way to ensure the resulting bit stream has a sufficient density of $0 \rightarrow 1$ and $1 \rightarrow 0$ transitions to allow bit clock recovery from it. The **descrambling** process recovers the original digital data from the scrambled bit stream.

NOTE 1 – The scrambling/descrambling process would be an adaptation process. The historical definition of signals in existing standards causes a violation of this process allocation, hence the scrambling/descrambling processes are often located in the trail termination functions. Refer to the individual atomic functions for details.

The **encoding/decoding** process adapts a digital data stream to the characteristics of the physical medium over which it is meant to be transported. The **decoding** process recovers the original digital data from the medium-specific form in which it is received.

The **alignment** process locates the first bit/byte of the framed signal (frame start (FS)) by means of a search for the frame alignment signal (FAS) or the interpretation of the pointer (PTR). If the FAS cannot be found, or the PTR is corrupted for a specific period, an alignment defect is detected (LOF, LOP). The alignment defect may be the result of the reception of the all-ones (AIS) signal. If so, the AIS defect is detected also. The defects are reported to the fault management layer/process.

NOTE 2 – The insertion of a frame alignment signal would be an A_So process. The (historical) definition of the many signals in existing standards causes a violation of this process allocation, hence the frame alignment insertion process is often located in the TT_So function. Refer to the individual atomic functions for details.

A second kind of alignment process aligns several input signals to a common frame start, as is the case for inverse multiplexing.

The **bit-rate adaptation** process accepts input information at a certain bit rate and outputs that same information at a different bit rate. In the source direction, this process creates gaps in which other functions can add their signals. An example is the S12/P12s_A_So function; the 2 Mbit/s signal input to this function is output at a higher bit rate. The created gaps will be filled with the VC-12 POH.

The **frequency justification** process accepts an input information at a certain frequency and outputs that same information either at the same or at a different frequency. In the source direction, in order to accommodate any frequency (and/or phase) differences between input and output signals, this process may write data into a specific "justification" bit/byte in the outgoing frame structure when the elastic store (buffer) is going to overflow. It will skip data writing when the elastic store is going to underflow. Examples are the S4/S12_A_So and P4e/P31e_A_So functions.

NOTE 3 – The commonly used terms "mapping" and "demapping" are covered by bit-rate adaptation and frequency justification processes.

The **time slot/wavelength assignment/access** process assigns the adapted client layer information to specific time slots/wavelength of the server layer in source direction. In the sink direction, the process provides access to the specific time slot/wavelength of the server layer. Time slots are used in TDM systems. Wavelengths are used in WDM systems. The specific time slot/wavelength is normally fixed for the adaptation function and indicated by an index numbering.

NOTE 4 – Variable connection of client signals to different time slots/wavelengths can be provided by the client layer connection function.

The **multiplexing/demultiplexing** process is modelled by means of multiple adaptation functions, connected to one AP as described above.

In the case where multiple adaptation functions are connected to the same AP and accessing the same time slots (bits/bytes), a **selection** process controls the actual access to the AP. In the atomic functions, this is modelled via the activation/deactivation signal (MI_Active). In the case where only one adaptation function is present, it is selected. Control is not required.

The **timing recovery** process extracts a clock signal, the "recovered clock", from the incoming data signal. The timing recovery process is performed in the adaptation sink function in the physical section layer; e.g., in OS16/RS16_A_Sk.

The **smoothing** process filters the phase step of "gapped input signals". The smoothing process is performed in the adaptation sink functions; e.g., in Sm/Xm_A_Sk, Pn/Pm_A_Sk.

Many layers are able to transport a variety of client signals applied to the layer via different adaptation functions. To monitor the provisioning process, the source adaptation inserts the appropriate code in the trail signal label (TSL). The sink adaptation will check the **composition of the payload**, comparing the received TSL number with its own.

The **administrative locking** process controls the forwarding of the characteristic information signals in an adaptation function depending on the administrative state (refer to [b-ITU-T X.731]). The forwarding of characteristic information is blocked when the administrative state is LOCKED and forwarding is enabled when the administrative state is UNLOCKED. In a locked condition, the LCK maintenance signal replaces the client's characteristic information.

The **forward error correction** process is a coding process which adds redundancy to the transmitted characteristic information using a predetermined algorithm such that the redundancy added by the coding allows the decoding to detect and correct a limited number of bit errors.

The **port identification** process adds source and destination port identifiers (typically referred to as addresses) to the adapted characteristic information to control delivery of this information to the intended subset of ports on a multipoint connection.

5.6.4 Layer network interworking function

A layer network interworking function represents the semantically transparent conversion of characteristic information between two layer networks. The conversion process maintains the integrity of the end-to-end supervision of the trail. Conversion of the adapted information may also be required. The integrity of the client layer characteristic information has to be maintained in this case. The interworking function may be limited to a set of client layer signals.

The process is specific for the interworked layers and may include processes from the adaptation and termination function.

5.7 Combination rules

5.7.1 General

In general, any functions that share the same characteristic, or adapted information, may be combined.

5.7.2 Binding at connection/flow points

The connection/flow point input (output) of an adaptation function may be bound to the connection/flow point output (input) of either a connection function, layer network interworking function or an adaptation function. The connection/flow point of a layer network interworking function may be bound to the connection/flow point of either a connection function or an adaptation function, as shown in Figure 5-8.

Example: An S12_CP of an S12_C function may be connected to an S12_CP of an S4/S12_A function.

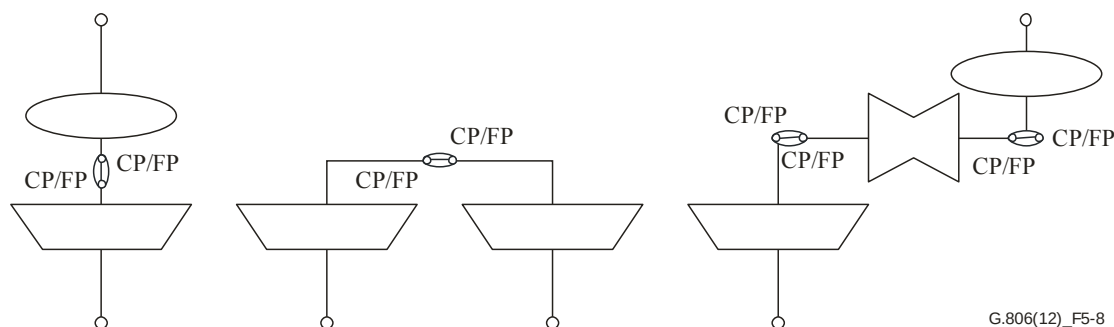


Figure 5-8 – Binding of connection/flow points (CP-CP binding)

5.7.3 Binding at (termination) connection/flow points

The termination connection/flow point output (input) of a trail termination function may be bound to the connection/flow point input (output) of either an adaptation function, layer network interworking function or a connection function or the termination connection/flow point input (output) of a trail termination function, as shown in Figure 5-9.

NOTE – Once bound, the CP/FP and TCP/TFP are referred to as a termination connection/flow point.

Example: An S12_TCP of an S12_TT function may be connected to an S12_CP of an S12_C function.

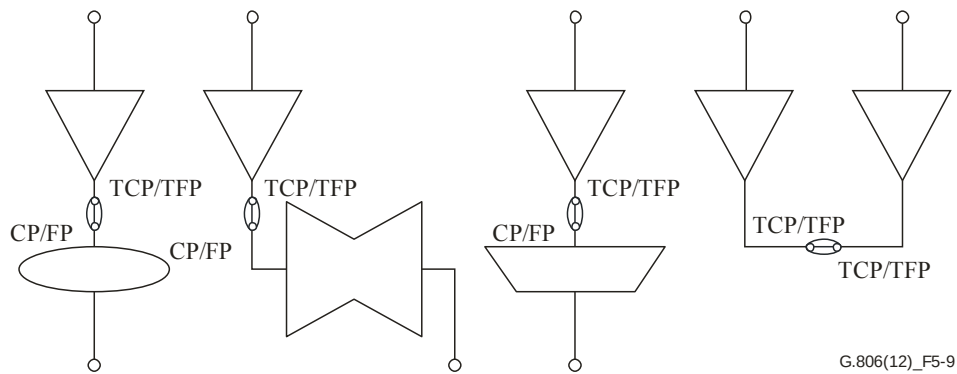


Figure 5-9 – Binding involving a termination of connection/flow points (TCP-CP/TFP-FP and TCP-TCP/TFP-FP binding)

5.7.4 Binding at access points

The AP input (output) of a trail termination function may be bound to the AP output (input) of an adaptation function as shown in Figure 5-10.

Example: An S4_AP of an S4/S12_A function may be connected to an S4_AP of an S4_TT function.

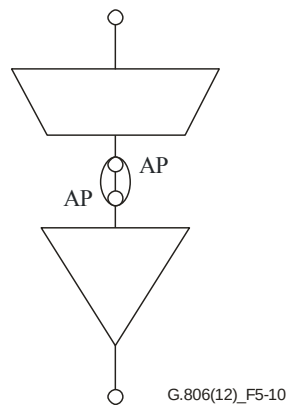


Figure 5-10 – Binding of access points (AP-AP binding)

5.7.5 Alternative binding representations

The binding at reference points can continue, according to the above rules, and create a path such as the one shown in Figures 5-4 and 5-5.

NOTE – The binding at reference points may also be represented as illustrated in Figure 5-11. In an equipment functional specification, the explicit reference to the reference points is not required if the atomic functions are named. In such a case, the names of the reference points are obvious.

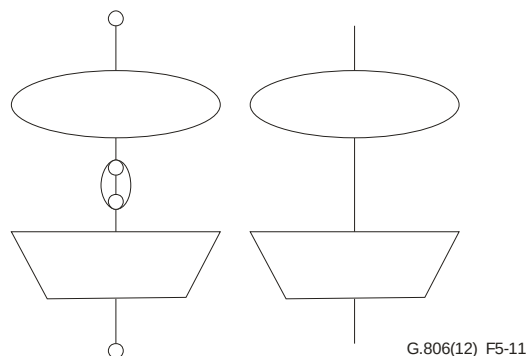


Figure 5-11 – Alternative binding representation

5.7.6 Directionality

Atomic functions are normally defined with unidirectional functionality, except for certain connection functions. The directionality of trail termination and adaptation functions is identified by the directionality identifier sink/source. The directionality of layer network interworking functions is identified by the direction of the arrow (>).

Two unidirectional atomic functions with opposite directionality may be associated as a bidirectional pair (when a function is referred to without the directionality qualifier, it can be taken to be bidirectional). In the case of trail termination functions, their remote information reference points are connected together in this case.

Bidirectional servers may support bidirectional or unidirectional clients, but unidirectional servers may only support unidirectional clients.

5.7.7 Compound functions

Combinations of atomic functions in one or more layer(s) may be identified by a special symbol, a compound function. Three examples are shown in Figures 5-12, 5-13 and 5-14.

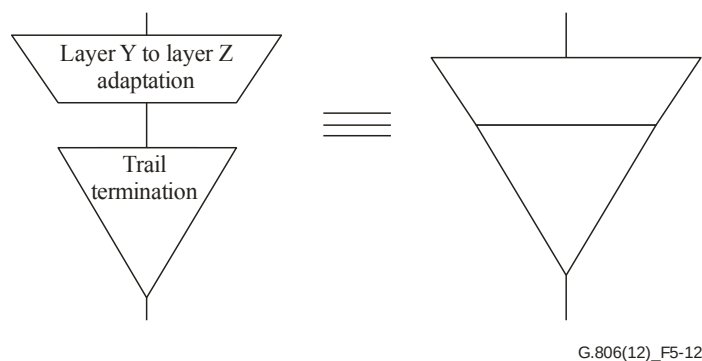


Figure 5-12 – Compound termination/adaptation function

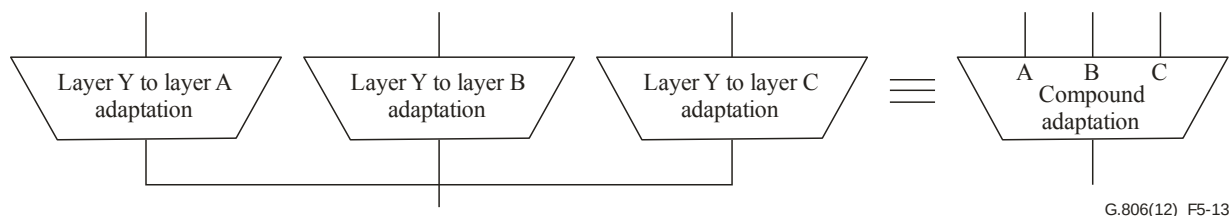


Figure 5-13 – Compound adaptation function

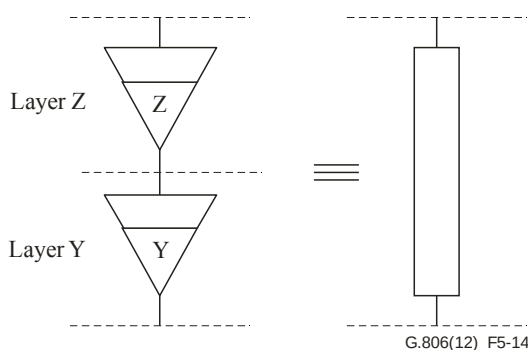
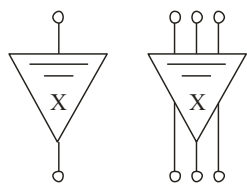


Figure 5-14 – Compound function spanning multiple layers

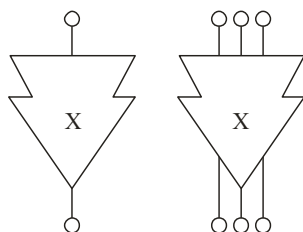
The diagrammatic conventions for NCM MEG end point (NCM MEP) compound functions are shown in Figure 5-15. NCM MEP functions may either have a single termination connection/flow port and access port (left) or multiple termination connection/flow ports and multiple access ports (right).



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Figure 5-15 – Diagrammatic convention for NCM MEP compound functions

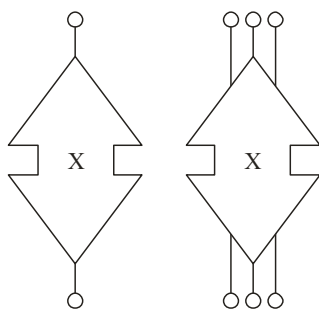
The diagrammatic conventions for TCM MEG end point (TCM MEP) compound functions are shown in Figure 5-16. TCM MEP functions may either have a single termination connection/flow port and access port (left) or multiple termination connection/flow ports and multiple access ports (right).



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Figure 5-16 – Diagrammatic convention for TCM MEP compound functions

The diagrammatic conventions for MEG intermediate point (MIP) compound functions are shown in Figure 5-17. The MIP compound functions consist of two pairs of the diagnostic adaptation and trail/flow termination functions, each facing in opposite directions. MIP functions may either have a single connection/flow port (left) or multiple connection/flow ports (right).



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Figure 5-17 – Diagrammatic convention for MEG intermediate point (MIP) compound functions

A variant of the MIP compound function is the half MIP compound function, which consists of a single pair of the diagnostic adaptation and trail/flow termination functions (Figure 5-18). Half MIP functions may either have a single connection/flow port (left) or multiple connection/flow ports (right).

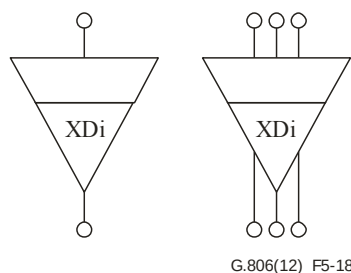


Figure 5-18 – Half MIP compound functions

5.8 Fault management and performance monitoring naming

The naming of supervision variables (see also Figures 6-1 and 6-2) are as follows.

The supervision variables are defined as "yZZZ", with:

y	defect:	y = d
	fault cause (i.e., correlated defect):	y = c
	consequent action request:	y = a
	performance parameter:	y = p
	anomaly:	y = n
ZZZ	kind of defect, fault cause, failure, consequent action, performance parameter or command	

dZZZ and cZZZ represent Boolean variables with states TRUE or FALSE. pZZZ represents an integer variable. aZZZ, except aREI, represents a Boolean variable; aREI represents an integer variable.

5.9 Fault management and performance monitoring specification techniques

The defect correlation and consequent action specifications make use of the following supervision equation techniques:

aX	← A or B or C
cY	← D and (not E) and (not F) and G
pZ	← H or J

"aX" represents the control of consequent action "X". The associated consequent action will be performed if the Boolean equation "A or B or C" is true. Otherwise, if the equation is false, the consequent action will not be performed. Consequent actions are, e.g., insertion of all-ones (AIS) signal, insertion of RDI signal, insertion of REI signal, activation of signal fail or signal degrade signals.

"cY" represents the fault cause "Y" which is (will be) declared if the Boolean expression "D and (not E) and (not F) and G" is true. Otherwise (expression is false), the fault cause is (will be) cleared. MON will often be a term in this equation (see clause 6.1).

"pZ" represents the performance monitoring primitive "Z", a value which, at the end of a one-second period, represents the number of errored blocks (or error detection code violations) or the occurrence of a defect in that second.

"A" to "J" represent either defects (e.g., dLOS), reporting control parameters (e.g., AIS_Reported), consequent actions (e.g., aTSF), or the number of errored blocks over a one-second period (e.g., ΣnN_B).

NOTE – Hardware faults causing signal transfer interruption is represented by "dEQ". Such faults contribute to the near-end performance monitoring primitive pN_DS.

6 Supervision

Transmission and equipment supervision processes are concerned with the management of the transmission resources in the network and they are only interested in the functionality that is being provided by a network element (NE). They require a functional representation of an NE that is implementation independent.

The supervision process describes the way in which the actual occurrence of a disturbance or fault is analysed with the purpose of providing an appropriate indication of performance and/or detected fault condition to maintenance personnel. The following terms are used to describe the supervision process: anomaly, defect, consequent action, fault cause, failure and alarm.

Any equipment faults are represented by the unavailability of the affected functions because the transmission management has no knowledge of the equipment as such. Most functions monitor the signals they are processing for certain characteristics and provide performance information or alarm conditions based on these characteristics. Therefore, transmission supervision processing provides information on the external interface signals that are processed by an NE.

The following basic supervision functions are defined:

- continuity supervision (trail termination)
- connectivity supervision (trail termination)
- signal quality supervision (trail termination)
- payload type supervision (adaptation)
- alignment supervision (adaptation)
- maintenance signal processing (trail termination, adaptation)
- protocol supervision (connection).

The supervision processes and their interrelationships within atomic functions are depicted in Figures 6-1 and 6-2. The interrelations between the supervision processes in atomic functions, and the equipment management function are defined in [ITU-T G.7710] and the corresponding technology-specific Recommendations.

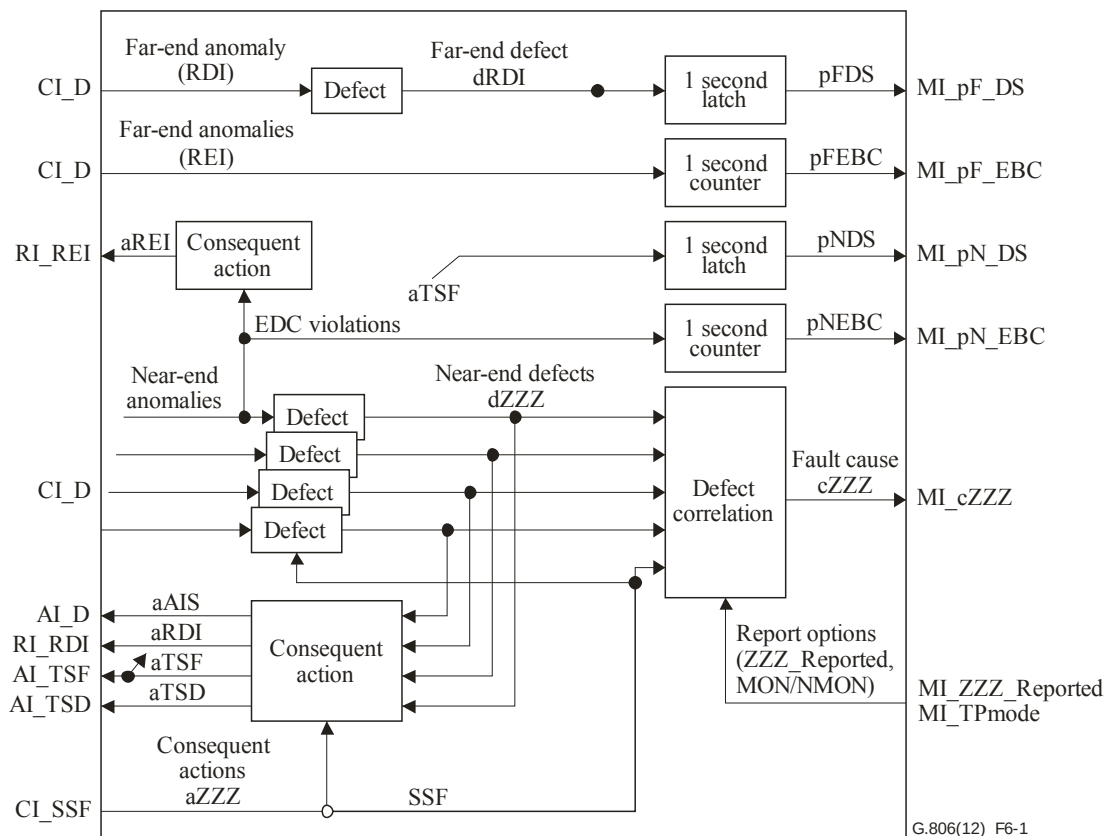


Figure 6-1 – Supervision process within trail termination functions

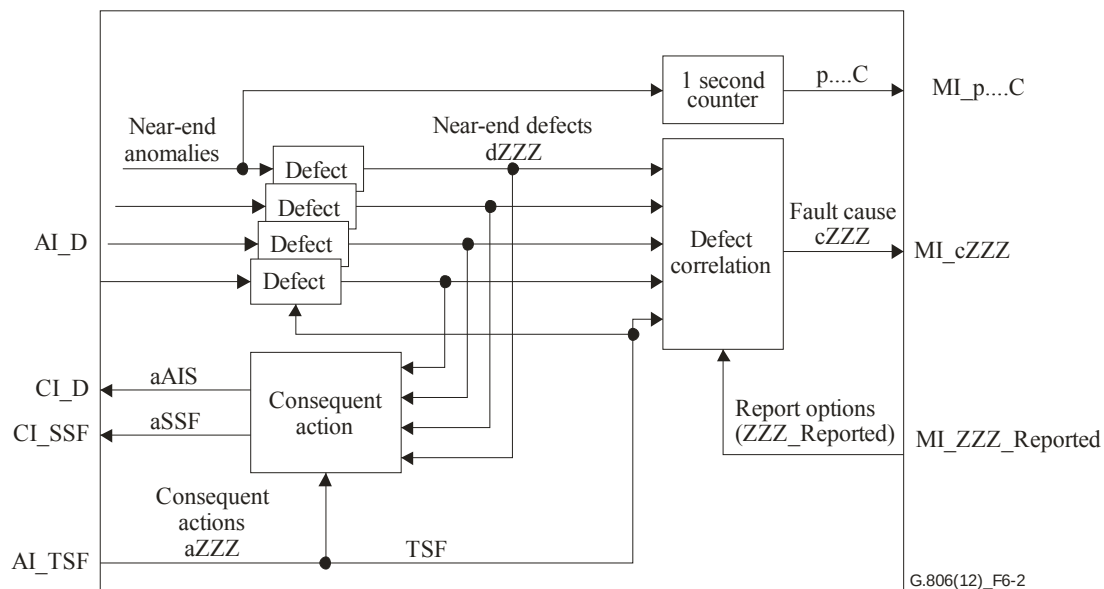


Figure 6-2 – Supervision process within adaptation functions

The filtering functions provide a data reduction mechanism within atomic functions on the anomalies and defects before being presented at the XXX_MP reference points. Four types of techniques can be distinguished:

- trail termination point and port modes
- one second integration

- defect detection
- fault management and performance monitoring correlations.

6.1 Trail termination point mode and port mode

To prevent alarms from being raised and failures being reported during trail provisioning actions, trail termination functions shall have the ability to enable and disable fault cause declaration. This shall be controlled via their termination point mode or port mode parameter.

The termination point mode (see Figure 6-3) shall be either "monitored (MON) or "not monitored" (NMON). The state shall be MON if the termination function is part of a trail and provides service, and NMON if the termination function is not part of a trail or is part of a trail that is in the process of set-up, breakdown or re-arrangement.

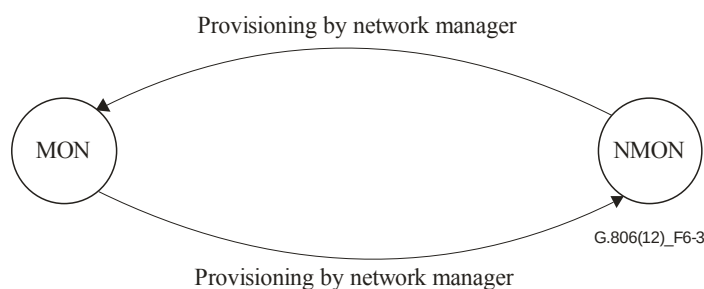


Figure 6-3 – Trail termination point modes

In physical section layers, the termination point mode is called the port mode. It has three modes (Figure 6-4): MON, AUTO and NMON. The AUTO mode is like the NMON mode with one exception: if the LOS defect clears, the port mode is automatically changed to MON. This allows for alarm-free installation without the burden of using a management system to change the monitor mode. The AUTO mode is optional. When it is supported, it shall be the default mode; otherwise, NMON shall be the default mode.

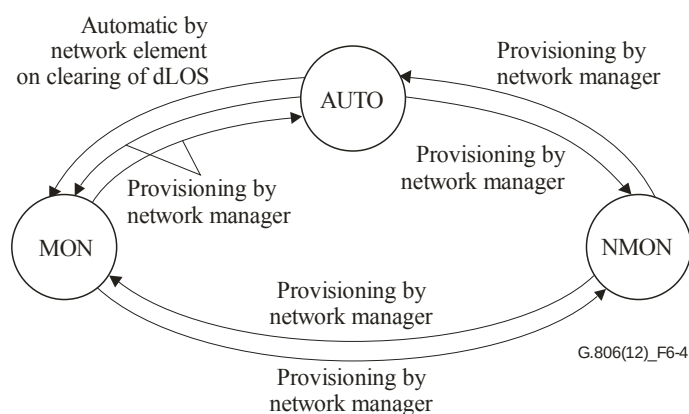


Figure 6-4 – Port modes

6.2 Defect filter

The (anomaly to) defect filter will provide a persistency check on the anomalies that are detected while monitoring the data stream; when passed, the defect is being detected.

Generic defect filters are defined below. Specific defect filter definitions can be found in the Recommendations for the specific hierarchies.

6.2.1 Continuity supervision

6.2.1.1 Generic behaviour

Continuity supervision monitors the integrity of the continuity of a trail. This is done by monitoring the presence/absence of the CI. The monitoring process can check for the whole CI (e.g., LOS at the physical layer) or a specific mandatory part of it (e.g., multiframe indication for SDH TCM). At path layer networks, a replacement signal might be generated by an open connection matrix (e.g., unequipped signal for SDH). The detection of this replacement signal is then an indication of loss of continuity.

Note that a server layer defect will result in a loss of continuity for client layers. This is normally detected via maintenance signalling (AIS, SSF, TSF) at the client layer and reported as an SSF alarm for the client layer (see clause 6.3)

6.2.1.2 Loss of signal defect (dLOS)

LOS signal supervision is used at the physical layer. For the specific detection processes, refer to the Recommendations for the specific hierarchies ([ITU-T G.783], [ITU-T G.705], [ITU-T G.781], [ITU-T G.798], and [ITU-T G.8021]).

6.2.1.3 Unequipped defect (dUNEQ)

Basic function sink direction

The unequipped overhead is recovered from the CP.

The unequipped defect (dUNEQ) shall be detected if z consecutive frames contain the unequipped activation pattern in the unequipped overhead. The dUNEQ defect shall be cleared if, in z consecutive frames, the unequipped deactivation pattern is detected in the unequipped overhead. Details for the UNEQ defect are provided in Table 6-1.

dUNEQ shall be cleared during SSF conditions. A new evaluation period for dUNEQ shall start after SSF is cleared.

NOTE – Some regional standards require a burst-proof algorithm of the UNEQ defect.

Table 6-1 – UNEQ defect details

Hierarchy	Layer	Unequipped overhead	Unequipped activation pattern	Unequipped deactivation pattern	z (Note)
SDH	S3/4 (VC-3/4)	C2 byte	"00000000"	≠ "00000000"	5
	S11/12/2 (VC-11/12/2)	V5, bits 5 to 7	"000"	≠ "000"	5
	S3D/S4D (VC-3/4 TCM option 2)	N1	"00000000"	≠ "00000000"	5
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2	"00000000"	≠ "00000000"	5
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	MA, bits 3 to 5	"000"	≠ "000"	3 to 5
	P4sD/P3sD (140/34 Mbit/s TCM)	NR	"00000000"	≠ "00000000"	5
NOTE – z is not configurable.					

6.2.1.4 Loss of tandem connection defect (dLTC)

The function shall detect for the presence/absence of the tandem connection overhead in the TCM overhead by evaluating the multiframe alignment signal in the TCM multiframe overhead. The loss of tandem connection defect (dLTC) shall be detected if the multiframe alignment process is in the OOM state. The dLTC shall be cleared if the multiframe alignment process is in the IM state. For details on the alignment process, refer to Table 6-2, clause 8.2 and the specific equipment functional Recommendations ([ITU-T G.783] and [ITU-T G.705]).

Table 6-2 – LTC defect details

Hierarchy	Layer	TCM multiframe overhead
SDH	S3D/S4D (VC-3/4 TCM option 2)	N1, bits 7 to 8
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2, bits 7 to 8
PDH with SDH frame	P4sD/3sD (140/34 Mbit/s TCM)	NR, bits 7 to 8

6.2.1.5 Loss of continuity defect (dLOC)

The loss of continuity defect is calculated at the network layer. It monitors the presence of continuity in trails.

Its detection and clearance are defined in Figure 6-5. The 'period' in Figure 6-5 is the period as carried in the CC (continuity check) frame triggering the expCC event that means reception of a CC frame.

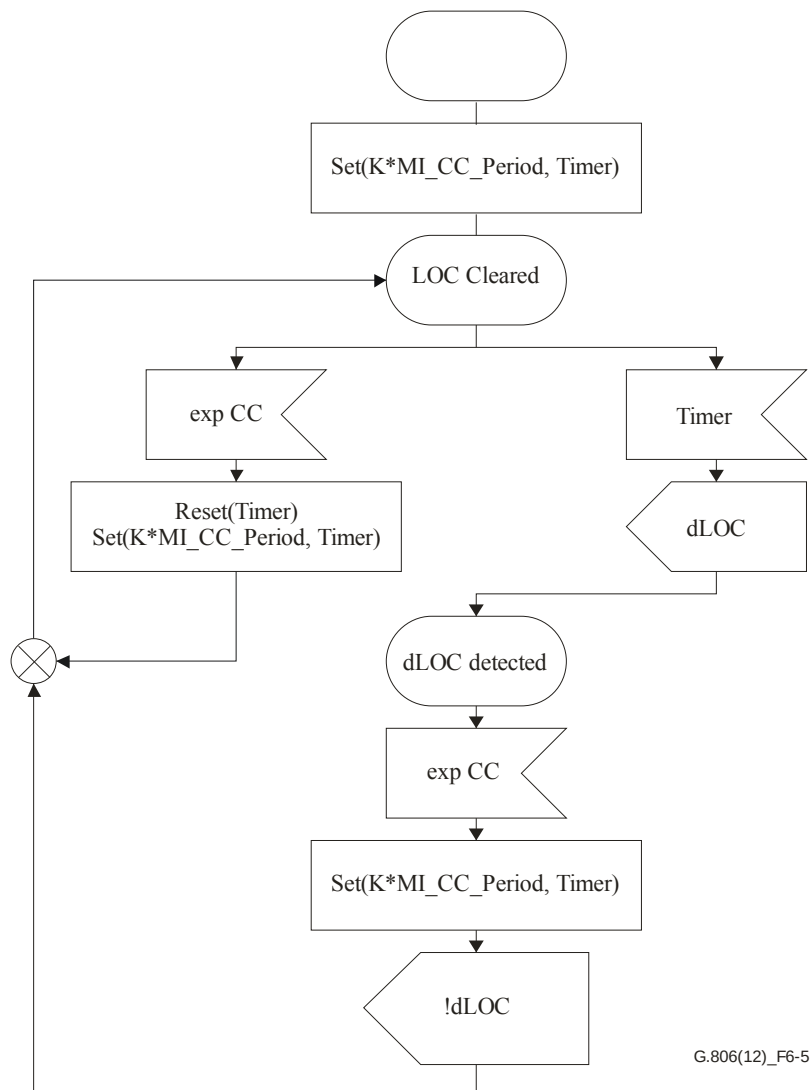


Figure 6-5 – dLOC detection and clearance process

6.2.2 Connectivity supervision

6.2.2.1 Generic behaviour

Connectivity supervision monitors the integrity of the routing of the trail between sink and source. Connectivity is normally only required if the layer provides flexible connectivity, both automatically (e.g., cross-connects controlled by the TMN) or manually (e.g., fibre distribution frame). The connectivity is supervised by attaching a unique identifier at the source. If the received identifier does not match this expected identifier, a connectivity defect has occurred.

6.2.2.2 Trail trace identifier processing and trace identifier mismatch defect (dTIM)

Basic function source direction

The generation of trail trace identifier (TTI) is optional and in the province of regional standards.

If TTI generation is not required, the content of the TTI overhead is not configurable.

If TTI generation is required, the TTI information derived from the management reference point (MI_TxTI) is placed in the TTI overhead position.

Basic function sink direction

The TTI overhead is recovered from the CP.

The detection of a trace identifier mismatch defect (dTIM) is optional and in the province of the regional standards.

In the case where dTIM detection is not required, the receiver shall be able to ignore the received TTI overhead values, and dTIM is considered "false".

In the case where dTIM detection is required, the following applies: the detection of dTIM is based on a comparison between the expected TTI, configured via the management reference point (MI_ExTI), and the accepted TTI (AcTI). If dTIM detection is disabled via an input ("Set") command (MI_TIMdis) at the management reference point, then dTIM is considered "false".

NOTE 1 – Acceptance criteria and defect specification for the TTI are for further study to ensure integrity, and robustness to errors for TIM.

NOTE 2 – A mismatch in the CRC-7 or TFAS signal of the 16-byte trace identifier results in the detection of the dTIM defect.

The accepted TTI shall be reported via the management point (MI_AcTI) to the EMF. The query of the AcTI shall be independent of the dTIM detection process.

NOTE 3 – Some equipment developed prior to the 04/97 revision of [ITU-T G.783] may not support this query in the event that trace identifier mismatch detection is disabled.

dTIM shall be cleared during SSF conditions. A new evaluation period for dTIM shall start after SSF is cleared.

Details on the TIM defect are provided in Table 6-3.

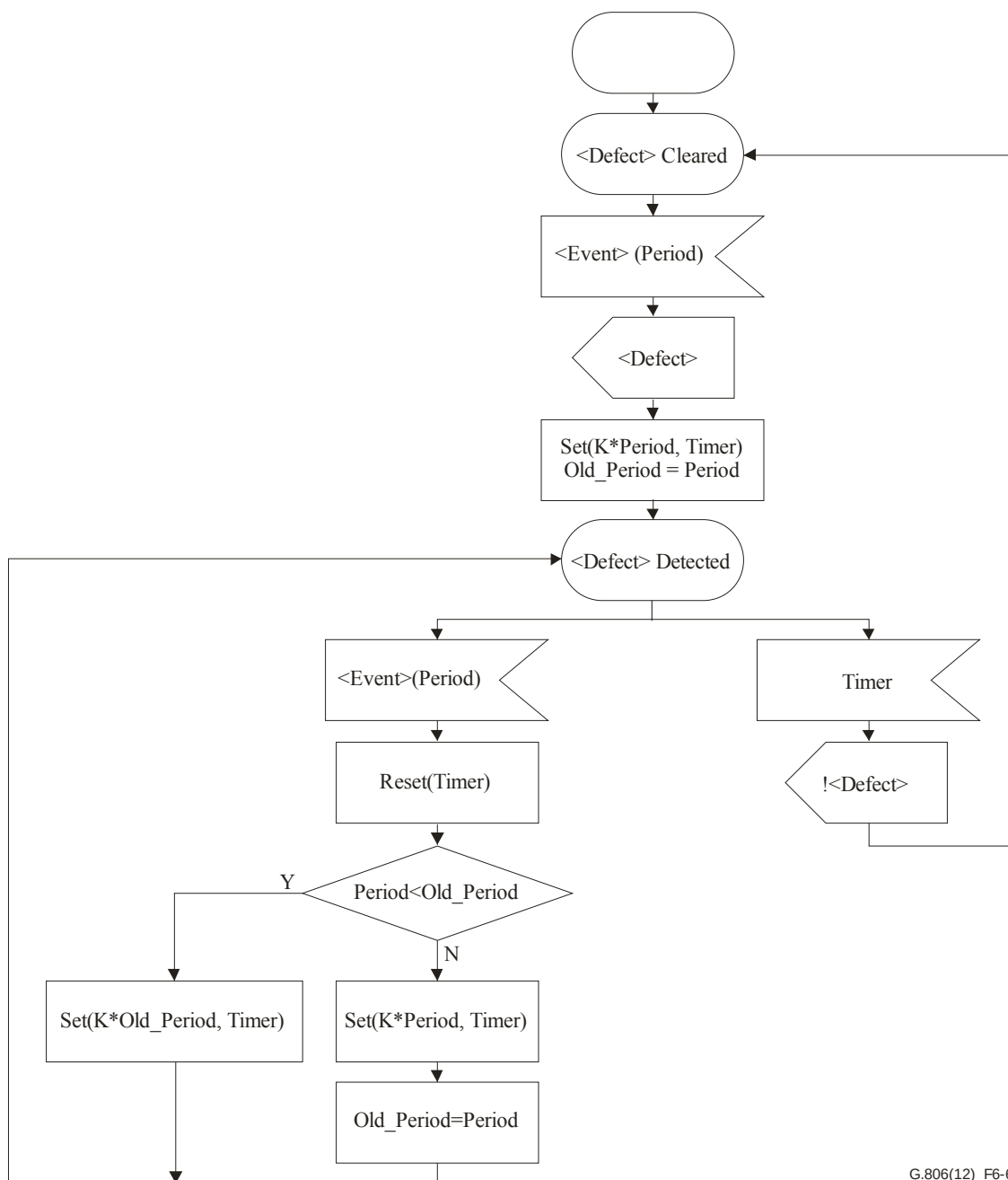
Table 6-3 – TIM defect details

Hierarchy	Layer	TTI overhead	TTI format
SDH	RSn	J0 byte	1/16 byte (see [ITU-T G.707])
	S3/4 (VC-3/4) (see Note)	J1 byte	16/64 byte (see [ITU-T G.707])
	S3D/S4D (VC-3/4 TCM option 2)	N1, bits 7 to 8, frame 9 to 72	16 byte (see [ITU-T G.707])
	S11/12/2 (VC-11/12/2) (see Note)	J2	16 byte (see [ITU-T G.707])
	S11D/S12D/S2D (VC-11/12/2 TCM)	N2, bits 7 to 8, frame 9 to 72	16 byte (see [ITU-T G.707])
PDH with SDH frame	P4s/3s (140/34 Mbit/s)	TR	16 byte (see [ITU-T G.831] and [ITU-T G.832])
	P4sD/3sD (140/34 Mbit/s TCM)	NR, bits 7 to 8, frame 9 to 72	16 byte (see [ITU-T G.831] and [ITU-T G.832])
NOTE – In order to distinguish between unequipped and supervisory unequipped, the fixed code 00000000 in J1/J2 should not be used in the supervisory unequipped termination source function.			

6.2.2.3 Mismatch defect (dMMG)

The mismatch defect is calculated at the layer where the MEG (maintenance entity group) and MEP (MEG end point) are defined. It monitors the connectivity in a maintenance entity group.

Its detection and clearance are defined in Figure 6-6. The <Defect> in Figure 6-6 is dMMG. The <Event> in Figure 6-6 is the Mismatch defect event as generated by the continuous check frame reception process and the Period is the Period carried in the frame that triggered the event, unless an earlier continuous check frame triggering an MMG event carried a greater period.



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Figure 6-6 – Defect detection and clearance process