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TITLE: Draft New Recommendation X.msr: "Multiple Services Ring (MSR)"

Summary

This draft Recommendation specifies Multiple Service Ring (MSR) and associated protocols. MSR is defined for use on a bi-directional symmetric counter-rotating two fibre optical rings. Primary optical transport mechanism is defined to leverage the low cost Wide Area Interface Sublayer (WIS) of 10Gigabit Ethernet (IEEEP802.3ae)®. SDH/SONET physical transport is also supported. The service tributary interfaces of MSR are defined to support Ethernet, Digital Video Broadcasting, ATM, Packet over SONET/SDH (POS)(X.85 IP over SDH using LAPS) and X.86 Ethernet over LAPS. MSR data node is defined to support forwarding of the MSR data link frame similar to functionality found in a more complex routing data system. MSR is targeted for market areas of the world having a low cost labour force, provisioning and support requirements.

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Introduction

The expansion of business and personal use of data network services are driving the need to deploy data services infrastructure facilities in parts of the world that have yet to be deployed. MSR has the capability of providing low cost deployment of multiple broadband services to locations in previously undeveloped areas. MSR, as a data delivery services system does not have the complexity of multiple layers of equipment and support systems. MSR provides a major cost benefit by leveraging the relationship of fewer automation features and lower cost labour force. The simplicity of MSR is achieved by integrating the functionality of multiple levels of system (e.g., router, data switch and transport system). This produces a new kind of data system that incorporate some of the functions of routers, bridges, data switches, and transport systems. This also provides a new economic model for deploying and supporting data services in undeveloped markets.

MSR does provide for data link layer services fault protection, point-to-point, multicast and broadcast data functions. Continued compatibility with all existing requirements and standards from ITU-T and other organizations is required. MSR is designated to achieve all of these.

DRAFT NEW RECOMMENDATION X.MSR

MULTIPLE SERVICES RING

1 Scope

This draft Recommendation specifies Multiple Service Ring (MSR) and associated protocols. MSR is defined for use on a bi-directional symmetric counter-rotating two fibre optical rings. Primary optical transport mechanism is defined to leverage the low cost Wide Area Interface Sublayer (WIS) of 10Gigabit Ethernet (IEEEP802.3ae)®. SDH/SONET physical transport is also supported. The service tributary interfaces of MSR are defined to support Ethernet, Digital Video Broadcasting, ATM, Packet over SONET/SDH (POS)(X.85 IP over SDH using LAPS) and X.86 Ethernet over LAPS. MSR data node is defined to support forwarding of the MSR data link frame similar to functionality found in a more complex routing data system. MSR is targeted for market areas of the world having a low cost labour force, provisioning and support requirements. Aggregate pipe can be any kind of STM-4/OC-12, STM-16/OC-48, STM-64/OC-192, Gigabit Ethernet and 10Gigabit Ethernet. A data node can be inserted or removed online form the ring while other data nodes and related services will be operated normally without frame loss and service loss.

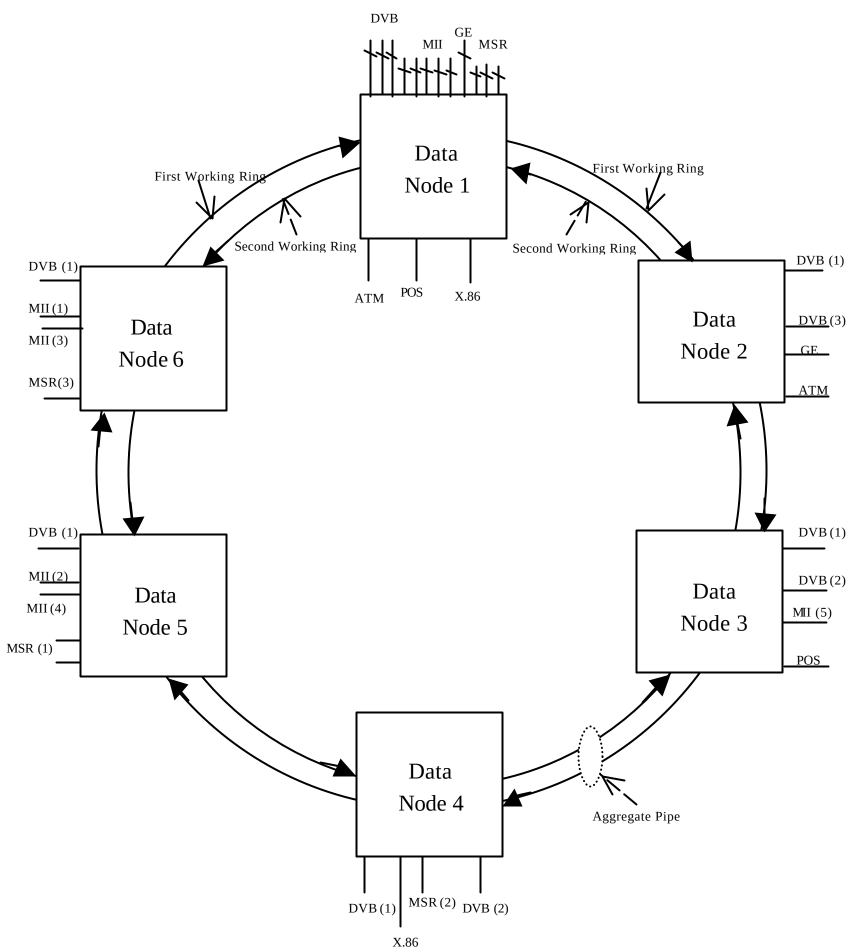


FIGURE 1/X.MSR

The Topology of Multiple Services Ring

This Recommendation does not specify the method of mapping MSR protocol to SDH/SONET or Ethernet. No change is made for all Ethernet-based protocols (including IEEE 802.3 Ethernet), all SDH/SONET standards, ATM standards, POS standards and ETSI DVB specifications.

NOTE 1 - It is intended that MSR protocol can be extended, in future amendments, to support additional new types of data service.

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: all 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 currently valid ITU-T Recommendations is regularly published.

2.1 ITU-T Recommendations

[1] ITU-T Recommendation X.85/Y.1321, *IP over SDH using LAPS*.

[2] ITU-T Recommendation X.86/Y.1323, *Ethernet over LAPS*.

[3] ITU-T Recommendation X.211 (1995) | ISO/IEC 10022 (1996), *Information technology - Open Systems Interconnection - Physical service definition*.

[4] ITU-T Recommendation X.212 (1995) | ISO/IEC 8886 (1996), *Information technology - Open Systems Interconnection - Data link service definition*.

[5] ITU-T Recommendation G.707 (1996), *Network node interface for the synchronous digital hierarchy (SDH)*.

[6] ITU-T Recommendation G.708 (1999), *Sub STM-0 network node interface for the synchronous digital hierarchy (SDH)*.

[7] ITU-T Recommendation G.957 (1995), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

[8] ITU-T Recommendation X.200 (1994) | ISO/IEC 7498-1 (1994), Information technology - *Open System Interconnection - Basic reference model: The basic model*.

[9] ITU-T Recommendation H.261 (1993), *Video codec for audiovisual services at p x 64kbit/s*.

[10] ITU-T Recommendation H.262 (1995), Information technology – *Generic coding of moving pictures and associated audio information: Video Common text with ISO/IEC*.

[11] ITU-T Recommendation I.321 (1991), B-ISDN protocol reference model and its application.

[12] ITU-T Recommendation I.361 (1999), B-ISDN ATM Layer specification.

2.2 IEEE Specifications

[13] IEEE 802.3 *CSMA/CD Access Method and Physical Layer Specifications, 1998 Edition*.

2.3 ETSI

[14] EN 300 429: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

[15] EN 300 814: "Digital Video Broadcasting (DVB); DVB interfaces to Synchronous Digital Hierarchy (SDH) networks".

[16] EN 500 83: "Cabled distribution systems for television, sound and interactive multimedia signals; Part 9: Interfaces for CATV/SMATV headends and similar professional equipment for DVB/MPEG2 transport streams" (CENELEC)".

[17] ETR 290: "ETR 290: "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems".

2.4 ANSI

[18] ANSI T1.105 - 1991, *"Digital Hierarchy – Optical Interface Rates and Formats Specification", American National Standard for Telecommunications, 1991.*

2.5 IETF

[19] RFC 2615, *"PPP over SONET/SDH"*, A. Malis, *Internet Engineering Task Force, 1999*.

3 Definitions

For the purposes of this Recommendation, the following definitions apply:

3.1 Aggregate Pipe: two symmetric counter fiber channels used to connect adjacent MSR data nodes along the First and Second Working Ring. Aggregate pipe is a channel of STM-16/OC-48, STM-64/OC-192, contiguous concatenation of 16 VC4 or 48VC3 or 64 VC4 or 192 VC4, or virtual concatenation of a set of VC4 or VC3, Gigabit Ethernet or10Gigabit Ethernet. It is recommended that the same bandwidth of Aggregate Pipe in different span along the same ring is required. When SDH/SONET is applied to Aggregate Pipe, the overhead and other specifications of regeneration, multiplex section and high-order VC specified in ITU-T G.707 is used.

Note: 10Gigabit Ethernet uses SONET based WAN solution only in this Recommendation.

3.2 Control Signalling Frame: a Frame used to Topology Discovery, Layer 2 Protection Switching of Manual Switch or Forced Switch etc in a node.

3.3 CT_Request Frame: a frame used to send a configuration table request from Node A to Node B.

3.4 CT_Response Frame : a frame used to send a configuration table response from Node B to Node A.

3.5 Configuration Table (CT): a mapping table reflecting the actual and using value of TT and TSN in a node and TCCR between nodes on the MSR ring during engineering operation.

3.6 Configuration Table Inquiry (CTI): a function to get CT from a node. CT_Request frame with a CTI parameter reflecting changing part of TCCR of a node on MSR ring is sent to other nodes (called one of them Node B) by unicasting/multicasting/broadcasting mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame with a CTI parameter will give a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on MSR ring to Node A.

3.7 Configuration Updating Table (CUT): a mapping table reflecting the available value modification of TT and TSN in a node and TCCR between nodes on the MSR ring during engineering operation. The CUT is applied during MSR engineering operation. The incorrect ICT will lead to fault of Tributary on MSR ring. CT_Request frame with an CUT parameter reflecting changed part of TCCR of all node on MSR ring is sent to other nodes by broadcasting mode from a node (e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to that node sending CT_Request frame. After getting CT-Response frame, that node sourcing CT_Request frame issues a CT_Confirm frame to that remote node sending CT_Response frame.

3.8 First Working Ring (FWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of First Working Ring is set to outer ring. It is programmable and is also set to the inner ring when the Second Working Ring is set to the outer ring. In the case of fiber facility or node failure, First Working Ring can be seen as bypass channel of Second Working Ring.

3.9 Forced Switch: operator does by network management or software debug facility, perform L2PS on the target span. Operational priority is higher than Manual Switching.

3.10 FWR-Fiber-Cut: a parameter of L2PS_Request Frame, used to stand for status indication of single fiber cut on FWR.

3.11 Initial Configuration Table (ICT): a mapping table reflecting the initial and available value of TT and TSN in a node and TCCR between nodes on the MSR ring during engineering installation. The ICT must be pre-installed by (NVROM or FLASH RAM) before MSR engineering operation. The incorrect ICT will lead to fault of Trib utary services on MSR ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on MSR ring is sent to other nodes by broadcasting mode from a node (e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to that node sending CT_Request frame. After getting CT-Response frame, that node sourcing CT_Request frame issues a CT_Confirm frame to that remote node sending CT_Response frame.

3.12 L2 Protection Switching (L2PS): a powerful self-healing feature that allows to recovery from fiber facility or node failure within 50ms. Analogous to the K1/K2 protocol mechanism that SONET/SDH ring does. L2PS entity in a node detects link status. If neither flag nor frame is received by a node in Rx direction within 20ms (its value is programmable) in the FWR or SWR of aggregate pipe, or if fiber facility or a node is failure (e.g. PSD or PSF), two nodes on failure span will enter L2PS State.

3.13 Layer 3 Forwarding Packet: a packet used to forward data packet in a node. This packet is different from those packets of reaching all Tributary in a node, is also different from network management frames and control signalling frames. Logically, a node can be treated as a router of performing Layer 3 forwarding when a Layer 3 forwarding Packet is forwarded according to routing table and routing protocols of Ipv4/6 in a node from the node to other node along the MSR

3.14 L2PS_ Request Frame: a frame used to send a Manual Switch or Forced Switch request from Node A to two adjacent nodes (Node B and C) of targeted span or to two adjacent nodes (Node B and C) of failure node.

3.15 L2PS State: If neither flag nor frame is received by a node within 20ms (its value is programmable) in the FWR or SWR of aggregate pipe, or if fiber facility or a node is failure (e.g. PSD or PSF), two nodes on failure span will enter L2PS State.

When a node enters L2PS State, forwarding means that received frame from a side of node will be forwarded to same side of this node (that is, received frame from westward on FWR will be forwarded to westward on SWR.). It does not look like a node in Normal State, forwarding means that received frame from westward on FWR will be forwarded to eastward on FWR.

3.16 Manual Switch: operator does by network management or software debugging facility, perform L2PS on the target span.

3.17 Multiple Services Ring (MSR): a bi-directional symmetric counter-rotating fiber rings consisted of at least two nodes (refer to Figure 1), each node could add and drop one or more independent Tributary. MSR supports multiple nodes transmit simultaneously and traffic engineering. A node can be inserted or removed online form the ring while other nodes and services will be operated normally without packet loss and service loss.

3.18 MSR Broadcast: a frame transmitted from a node can be sent to all other nodes along FWR or SWR by using MSR protocol.

3.19 MSR Filter Unit: a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

3.20 MSR Multicast: a frame transmitted from a node can be sent to several different nodes along First or Second Working Ring by using MSR protocol.

3.21 MSR Data Node : a system equipment that has an eastward Rx, eastward Tx, westward Rx and westward Tx Aggregate Pipe connections, and one or more adding and dropping independent Tributaries. It also has functions of receiving, transmitting and forwarding of network management frame, control signalling and data frame in a Node.

3.22 MSR Protocol (MSRP) : a data link protocol between MAC/DVB/ATM (or PPP/Ipv4/Ipv6) frame (or packet) and the physical layer, used to communication between different nodes on the Multiple Services Ring. The MSR protocol does operate by sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also. When SDH/SONET is applied to Aggregate Pipe, MSRP is octet oriented. For GE and 10GE, MSRP is bit oriented.

3.23 MSRP Rx Processor: a set of functions used to MSRP protocol processing in Rx direction. It includes Rx Filter Unit, discrimination of multicasting/broadcasting and TT/TSN value and other associated MSRP protocol processing.

3.24 MSRP Tx Processor: a set of functions used to MSRP protocol processing in Tx direction. It includes Tx Schedule Unit, functions of determination of NA, TTL, TT, TSN, FCS, multicasting/broadcasting according to types and ports configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. The other associated MSRP protocol processing is also covered.

3.25 MSR Schedule Unit: a control function for transmitted frame in a node according to the priority level of forwarded frames from upstream station, multicasting/broadcasting frames and transmitted frame from the local station. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring.

3.26 N_ct: a count of retransmission used to Configuration Table Operation. All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit Timer_ct (it is programmable) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N times of retransmission (N_ct is programmable also). N_ct is also used by CUT operation.

3.27 Network Management Frame: a frame used to performance and fault monitoring, node configuration management etc in a node.

3.28 Node Address (NA): an address of Node Link on the MSR ring. NA is a local address and has local meaning only along the MSR ring. It contains 4 octets. Each bit (binary "0" or "1") corresponds to a node. For example, the binary "00100000 00000000 00000000 00000000" stands for the 3rd Node Address (station), the binary "00000100 00000000 00000000 00000000" stands for the 6th Node Address (station) (refer to Figure 1). You may also use binary "00000010 00000000

00000000 00000000" to stand for 7th Node Address of new insertion and the actual sequence location of the 7th Node Address may be corresponded to middle position between Station 1 and Station 2 shown in Figure 1 since the MSR supports online node insertion. All Node Address must be leftward alignment and be pre-installed by (NVROM) before operation. The maximum node number of the MSR Ring is 32. For implementation, people can use Ethernet MAC and Ipv4 address to perform external network management.

3.29 Normal State: a state used to describe a node that has normal Tx and Rx function on MSR ring and does not work on L2PS State. In Normal State, forwarding means that received frame from westward on FWR will be forwarded to eastward on FWR.

3.30 Physical Signal Degrade (PSD): random or automatic, caused by a physical signal degrade (e.g. excessive block or bit error rate). Once it happens, L2PS will be applied on the failure span.

3.31 Physical Signal Failure (PSF): random or automatic, caused by a physical signal failure (e.g. fiber facility failure). Once it happens, L2PS will be applied on the failure span.

3.32 Reference Point G1: a reference point between Rx Framer and RX Filter. It stands for termination of processing of MAC/GMAC physical layer before MII/GMII, or/and stands for termination of processing of SDH/SONET regeneration and multiplex section in receive direction. Please refer to Figure 3 – 12.

3.33 Reference Point G2: a reference point between Tx Framer and TX Schedule. It stands for source of processing of MAC/GMAC physical layer before MII/GMII, or source of processing of SDH/SONET regeneration and multiplex section in receive direction. Please refer to Figure 3 – 12.

3.34 Reference Point T1: a reference point between Tributary Rx Framer and MSRP processor. It stands for termination of processing of MSRP before encapsulation of physical tributary of MII/GMII/DVB/POS/ATM etc. Please refer to Figure 3 – 12.

3.35 Reference Point T2: a reference point between Tributary Rx Framer and MSRP processor. It stands for source of processing of MSRP after stripping of physical tributary of MII/GMII/DVB/POS/ATM etc. Please refer to Figure 3 – 12.

3.36 Rx Framer: an abstract of physical framer of Aggregate Pipe at Rx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, or physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192 or STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate of signal channel at the Reference Point G1 (refer to Figure 2) is VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G1.

3.37 Second Working Ring (SWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of Second Working Ring is set to inner ring. It is programmable and is also set to the outer ring when the First Working Ring is set to the inner ring. In the case of fiber facility or node failure, Second Working Ring can be seen as bypass channel of First Working Ring.

3.38 SWR-Fiber-Cut: a parameter of L2PS_Request Frame, used to stand for status indication of single fiber cut on SWR.

3.39 Timer_ct: a Timer of retransmission used to Configuration Table Operation. All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmission Timer_ct (it is programmable) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N times of retransmission (N_ct is programmable also). N_ct is also used by CUT operation.

3.40 Timer_WTR: a Timer used to prevent L2PS oscillation, the L2PS can waits Timer_WTR period (its value is programmable) before MSR enters Normal State.

3.41 Tributary: an independent adding/dropping tributary channel to/from the MSR data nodes, just like a series "Private Line or Private Circuit for Renting from Carrier". Tributary can be an Ethernet, Gigabit Ethernet (defined in IEEE802.3), DVB (Digital Video Broadcasting, specified in [8]) and/or ATM port. The different tributary can be assigned to different priority. The bandwidth of aggregate pipe depends on deployment service requirements the aggregate Tributary bandwidth be half the aggregate pipe bandwidth to provide protection bandwidth availability where needed. Where services requirements allow the aggregate Tributary bandwidth can exceed the aggregate bandwidth.

3.42 Tributary Adaptation Function Unit: an adaptation function from/to various independent tributary type signals to/from reference point T1/T2. It has Tributary Adaptation Source Function and Tributary Adaptation Sink Function. Sink corresponds to reference point T1, source to reference point T2. This adaptation function can include the signal and rate transform, synchronous function between two sides.

3.43 Tributary Cross-connection Relationship (TCCR): a table reflecting Tributary cross-connection relationship of all nodes on MSR ring. It is global table of MSR, that is, source and sink relationship of all available Tributaries.

3.44 Tributary Rx Framer: an abstract of physical framer of Tributary at Rx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s), POS and ATM framer of STM-1/OC-12 and/or DVB framers. If Tributary is STM-1/OC-3 POS for example, the rate and signal at the Reference Point T1 (refer to Figure 2) is POS PHY Level 1 or SPI-1 (defined by OIF) before Filter unit. If Tributary is Ethernet for example, the data at the Reference Point T1 is the payload of Ethernet MAC frame and interface is MII.

3.45 Tributary Tx Framer: an abstract of physical framer of Tributary at Tx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s), POS and ATM framer of STM-1/OC-12 and/or DVB framers. If Tributary is STM-1/OC-3 POS for example, the rate and signal at the Reference Point T2 (refer to Figure 2) is POS PHY Level 1 or SPI-1 (defined by OIF) before Filter unit. If Tributary is Ethernet for example, the data at the Reference Point T2 is the payload of Ethernet MAC frame and interface is MII.

3.46 Tributary Sequence Number (TSN): a sequence number of same type of Tributary Port on a node. This number is 7 if the 7th Ethernet is provided in a node. Please refer to Table 4 on page 35.

3.47 Tributary Type (TT): a type of an independent adding/dropping tributary channel to/from the MSR data nodes. This type can be Ethernet, Gigabit Ethernet, DVB, POS and ATM etc. Please refer to Table 4 on page 35.

3.48 Topology Discovery: A data link control function in the MSRP, used to find out who is its neighbor and how many nodes is been working on the MSR (to ensure transmitted frame must be received by same station, destination address of frame is pointed to itself). Each station appends its NA as parameter to this Topology Discovery Frame by order, update the length of parameter and passes this frame to the neighbor along the MSR ring as shown in Table 6. It is not necessary to know what is mapping relationship between Node Address and the physical position along FWR and SWR. Each node performs topology discovery function periodically (The value of Timer is programmable) by sending topology discovery frame on the first or second working ring. Topology Discovery uses control signalling format in Figure 15 on page 37.

3.49 Time to Live: this 6-bit field is a hop-count that must decremented every time a node forwards a frame. The maximum number of nodes that are supported by MSR is 32. In the wrapped case, the total node space can be 64 nodes on a ring.

3.50 Tx Framer: an abstract of physical framer of Aggregate Pipe at Tx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192, STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate and signal at the Reference Point G2 (refer to Figure 2) are VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G2.

3.51 Wait to Restore (WTR): random or automatic, activated after the node entered L2 protection switching meets the restoration criteria once the condition of the PSF, PSD or fiber facility failure disappears. To prevent L2PS oscillation, the L2PS can waits Timer_WTR period (its value is programmable) before MSR enters Normal State.

3.52 WTR_Request Frame: a frame used to transition to Normal State from L2PS State. After the node entered L2PS meets the restoration criteria once the condition of the PSF, PSD or fiber facility failure disappears. To prevent L2PS oscillation, the L2PS entity can waits Timer_WTR period (its value is programmable) to enter Normal State by using this frame.

4 Abbreviations

4.1 Abbreviations specified in IEEE 802.3

This Recommendation makes use of the following abbreviations specified in IEEE 802.3:

a) LAN Local area network

b) MAC Media access control.

c) MII Media Independent Interface.

c) GE Gigabit Ethernet

4.2 Abbreviations specified in ITU-T Recommendation G.707

This Recommendation makes use of the following abbreviations specified in ITU-T Recommendation G.707:

a) SDH Synchronous Digital Hierarchy

b) STM Synchronous Transfer Module

c) VC Virtual Container.

4.3 Abbreviations specified in ITU-T I.321 and I.361

This Recommendation makes use of the following abbreviations specified in ITU-T Recommendation:

a) ATM Asynchronous Transfer Mode

4.4 Abbreviations specified in ETSI

This Recommendation makes use of the following abbreviations specified in ETSI Recommendation EN 300 429:

a) DVB Digital Video Broadcasting

4.5 Abbreviations specified in IETF

This Recommendation makes use of the following abbreviations specified in IETF RFC2615:

a) PPP Point-to-point Protocol

b) POS Packet Over SONET/SDH

4.6 Abbreviations specified in ANSI

This Recommendation makes use of the following abbreviations specified in ANSI T1.105-1991:

a) SONET Synchronous Optical Network

4.7 Abbreviations specified in this Recommendation

a) FWR First Working Ring

b) CS&NM Control Signalling and Network Management

c) CT Configuration Table

d) CTI Configuration Table Inquiry

e) CUT Configuration Updating Table

f) GMAC Gigabit Ethernet Media Access Control

g) ICT Initial Configuration Table

h) L2PS Layer 2 Protection Switch

i) MAC Media Access Control

j) MSR Multiple Services Ring

k) MSRP Multiple Services Ring Protocol

l) PSD Physical Signal Degrade

m) PSF Physical Signal Failure

n) NA Node Address

o) Rx Receive data

p) SWR Second Working Ring

q) TCCR Tributary Cross-Connection Relationship

r) TSN Tributary Sequence Number

s) TT Tributary Type

t) Tx Transmission data

u) WTR Wait to Restore

5 MSR Network Framework

5.1 Elements of Ring

MSR is a bi-directional symmetric counter-rotating fiber rings consisted of at least two nodes (refer to Figure 1), each node could add and drop one or more independent Tributary (e.g. Ethernet, Gigabit Ethernet, DVB, POS and/or ATM port, also could transmit and receive Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (just like router), Control Signalling Frame and Network Management Frame. MSR supports multicast and broadcast of these Tributary service and forwarding data packet. Aggregate pipe can be any kind of STM-4/OC-12, STM-16/OC-48, STM-64/OC-192, Gigabit Ethernet and 10Gigabit Ethernet. A node can be inserted or removed online from the ring while other nodes and services will be operated normally without packet loss and service loss.

5.2 Frame Types on a Ring and Multiple Service in Tributary

Each node has ability of adding and dropping one or more independent Tributary services defined in Table 1.

TABLE 1/X.msr – Types of multi-service in Tributary

Tributary types	Capabilities		
Ethernet (specified in IEEE802.3)	Full duplex point-to-point	Multicasting	Broadcasting
GE (specified in IEEE802.3)	Full duplex point-to-point	Multicasting	Broadcasting
DVB (specified in ETSI EN 300 429)	Simplex	Multicasting	Broadcasting
STM-1/OC-3c ATM	Full duplex point-to-point		
STM-4c/OC-12c ATM	Full duplex point-to-point		
STM-1/OC-3c POS	Full duplex point-to-point	Multicasting	Broadcasting
STM-4c/OC-12c POS	Full duplex point-to-point	Multicasting	Broadcasting

Note 1: The bandwidth of aggregate pipe depends on deployment service requirements the aggregate Tributary bandwidth be half the aggregate pipe bandwidth to provide protection bandwidth availability where needed. Where services requirements allow the aggregate Tributary bandwidth can exceed the aggregate bandwidth.

Note 2: Multicasting is half duplex point-to-multipoint, Broadcasting is half duplex point to all other points on a ring.

Note 3: The mechanism of Ethernet/GE over SDH/SONET transport along MSR ring is almost the same as that of ITU-T Recommendation X.86/Y.1323 when LAPS is replaced by MSRP in the protocol stack.

Transmitted and received frames on a ring have four types: frames of multi-service to Tributary, Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (just like router), Control Signalling Frame and Network Management Frame specified in Table 2. They have full capabilities of point-to-point, multicasting and broadcasting along a ring.

TABLE 2/X.msr – Frame types

Frame types	**Capabilities**		
Frames of multi-service to Tributary	Point-to-point	Multicasting	Broadcasting
Layer 3 (Ipv4/Ipv6 packet) forwarding data packet (a node operates just like a router)	Point-to-point	Multicasting	Broadcasting
Control Signalling Frame	Point-to-point	Multicasting	Broadcasting
Network Management Frame	Point-to-point	Multicasting	Broadcasting

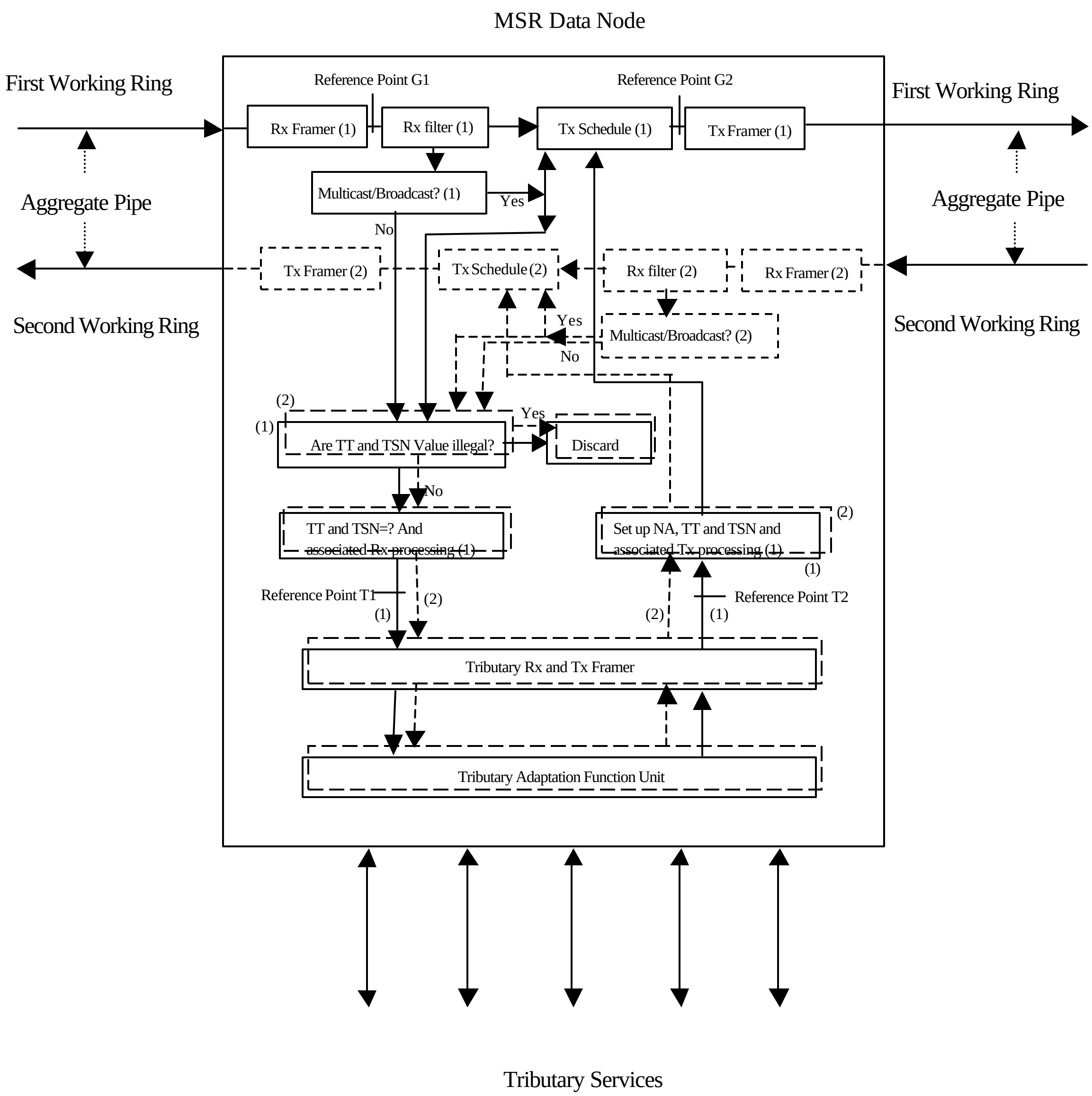


FIGURE 2/X.MSR

Tx and Rx Function Diagram of MSR Data Node

5.3 Components of Data Node

A MSR data node is a system equipment that has an eastward Rx, eastward Tx, westward Rx and westward Tx Aggregate Pipe connections, and one or more adding and dropping independent Tributaries. A MSR data node also has functions of receiving, transmitting and forwarding of network management frame, control signalling and data frame in a Node. The basic components of a MSR data node are as follows:

5.3.1 Aggregate Pipe: two symmetric counter fiber channels used to connect adjacent MSR data nodes along the First and Second Working Ring. The Aggregate Pipe has two methods of implementation, SDH/SONET and GE/10GE. In the SDH/SONET implementation, the Aggregate pipe is a channel of STM-16/OC-48, STM-64/OC-192, contiguous concatenation of 16 VC4 or 48VC3 or 64 VC4 or 192 VC3, or virtual concatenation of a set of VC4 or VC3. In the GE/10GE implementation, the Aggregate Pipe is GE or 10Gigabit Ethernet. It is recommended that the same bandwidth of Aggregate Pipe in different span along the same ring is required. When SDH/SONET is applied to Aggregate Pipe, the overhead and other specifications of regeneration, multiplex section and high-order VC specified in ITU-T G.707 is used.

5.3.2 Tributary: an independent adding/dropping tributary channel to/from the MSR data nodes, just like a series "Private Line or Private Circuit for Renting from Carrie r". Tributary can be an Ethernet, Gigabit Ethernet (defined in IEEE802.3), DVB (Digital Video Broadcasting, specified in [8]) and/or ATM port. The different tributary can be assigned to different priority.

5.3.3 First Working Ring (FWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of FWR is set to outer ring. It is programmable and can be changed to the inner ring.

5.3.4 Second Working Ring (SWR): an outer or inner ring on the MSR. It can be defined as one of two symmetric counter-rotating rings. Default configuration of SWR is set to inner ring. It is programmable and is also set to the outer ring when the FWR is set to the inner ring. In the case of fiber facility or node failure, SWR can be seen as bypass channel of First Working Ring. But in normal case, it is working channel also.

5.3.5 MSR filter Unit: a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

5.3.6 MSR Schedule Unit: a control function for transmitted frame in a node according to the priority level of forwarded frames from upstream station, multicasting/broadcasting frames and transmitted frame from the local station. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring.

5.3.7 Rx Framer: an abstract of physical framer of Aggregate Pipe at Rx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, or physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192 or STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate of signal channel at the Reference Point G1 (refer to Figure 2) is VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G1.

5.3.8 Tx Framer: an abstract of physical framer of Aggregate Pipe at Tx side, it stands for a framer of Gigabit Ethernet, 10G Ethernet, physical layer framer of STM-1/OC-12, STM-16/OC-48, STM-64/OC-192, STM-192/OC-768. If Aggregate Pipe is STM-16/OC-48 for example, the rate and signal at the Reference Point G2 (refer to Figure 2) are VC-4-16c/VC-3-48c in the parallel way (just like POS PHY level 3 or SPI-3 defined by OIF) before Filter unit. If Aggregate Pipe is Gigabit Ethernet for example, the rate and signal are GMII at the Reference Point G2.

5.3.9 Tributary Rx Framer: an abstract of physical framer of Tributary at Rx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s), POS and ATM framer of STM-1/OC-3, STM-4/OC-12 and/or DVB framers. If Tributary is STM-1/OC-3 POS for example, the rate and signal at the Reference Point T1 (refer to Figure 2) is POS PHY Level 1 or SPI-1 (defined by OIF) before Filter unit. If Tributary is Ethernet for example, the data at the Reference Point T1 is the payload of Ethernet MAC frame and interface is MII.

5.3.10 Tributary Tx Framer: an abstract of physical framer of Tributary at Tx side, it stands for a framer of Gigabit Ethernet, Ethernet (10/100Mb/s), POS and ATM framer of STM-1/OC-3, STM-4/OC-12 and/or DVB framers. If Tributary is STM-1/OC-3 POS for example, the rate and signal at the Reference Point T2 (refer to Figure 2) is POS PHY Level 1 or SPI-1 (defined by OIF) before Filter unit. If Tributary is Ethernet for example, the data at the Reference Point T2 is the payload of Ethernet MAC frame and interface is MII.

5.4 Reference Point in Data Node

The four different Reference Points are defined in a node.

5.4.1 Reference Point G1: a reference point between Rx Framer and RX Filter. It stands for termination of processing of MAC/GMAC physical layer of Aggregate Pipe implemented with GE or 10GE before MII/GMII, or/and stands for termination of processing of SDH/SONET regeneration and multiplex section of Aggregate Pipe implemented with SDH/SONET in receive direction. Please refer to Figures 3 – 12.

5.4.2 Reference Point G2: a reference point between Tx Framer and TX Schedule. It stands for source of processing of MAC/GMAC physical layer of Aggregate Pipe implemented with GE or 10GE before MII/GMII, or source of processing of SDH/SONET regeneration and multiplex section of Aggregate Pipe implemented with SDH/SONET in transmit direction. Please refer to Figures 3 – 12.

5.4.3 Reference Point T1: a reference point between Tributary Rx Framer and MSRP Rx processor. It stands for termination of processing of MSRP before encapsulation of physical tributary of MII/GMII/DVB/POS/ATM etc. Please refer to Figures 3 – 12.

5.4.4 Reference Point T2: a reference point between Tributary Tx Framer and MSRP Tx processor. It stands for source of processing of MSRP after stripping of physical tributary of MII/GMII/DVB/POS/ATM etc. Please refer to Figures 3 – 12.

5.5 Data Flow of Tx and Rx to Tributary

5.5.1 Rx direction: Rx frames entering a node at the Reference Point G1 are sent to Rx Filter Unit after performing Rx framer. Rx Filter Unit will check and filter TTL, FCS and NA of frame. All frames reaching to the MSR Filter Unit will be sent first to a buffer in the Node. The MSR Filter Unit will check TTL, FCS and NA of frame and perform XOR function with local NA. This frame will be taken away and discarded if TTL is zero or FCS is error.

If its NA is match, those frames reaching destination will not be sent to neighbor along the same ring (e.g. FWR). Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field.

If the received frame is multicasting or broadcasting frames, it will be sent first to Tx Schedule Unit to downstream node after decrementing TTL field, and it is coped to other buffer for further related processing in the local node at the same time.

After checked the aspects of TTL, NA and multicasting/broadcasting, a frame to reach destination is operated second procedure in the local node (station). That is, are TT and TSN illegal? If yes, this frame will be discarded. If no, this will be transferred to the corresponding Tributary port, Layer 3 forwarding unit, control signalling unit or network management unit at the Reference Point T1 according its value of TT and TSN.

5.5.2 Tx direction: Rx frames entering a MSRP Tx processor from a Tributary port, Layer 3 forwarding unit, control signalling unit or network management unit at the Reference Point T2,

will be got TTL, TCS, TT, TSN values and multicasting/broadcasting requirement first, and then got NA value according to types and ports configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. After that, these frames will be sent to TX Schedule Unit. There are three types input: multicasting/broadcasting frames from upstream from other node, point-to-point frame for transferring from upstream and transmitted frame from local station. They are all went into TX Schedule Unit. Schedule Unit will operate a control function for these transmitted frames in a node according to the priority level of these frames. If there are several frames to be sent in a node at the same time, the schedule unit will decide which frame will go first to the downstream along the ring. It is also possible to discard those frames of lower priority level during burst Tx period.

5.6 Operation of Layer 3 forwarding Packets

MSR data node can be used as a router to forward route packets to other node on MSR ring according to relationship between Ipv4/Ipv6 routing table and its NA/TT/TSN while this node could provide Tributary port for renting just like private line or circuit. When MSR data node is taken a role of router, the control plan (e.g. operation of routing protocols), network management plan (e.g. Simple Network Management Protocol) and traffic plan of said router (MSR data node) will share the same logical channel corresponding to the value of NA, TT and TSN along the ring. That is, the control signalling frames of said router (MSR data node) will be operated on the different channel from the control signalling frames of MSR ring.

5.7 Operation of Control Signalling Frames

5.7.1 Operation of Topology Discovery Frame

5.7.1.1 Operation of Topology Discovery Frame in normal state

Topology Discovery Frame is a control frame in the MSRP, used to figure out who is its neighbor and how many nodes are been working on the MSR (to ensure transmitted frame must be received by same station sending Topology Discovery Frame, destination address of frame is pointed to itself). Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), each station (e.g. Node A) broadcasts Topology_Discovery_Request Frame with a Null parameter along a FWR and SWR respectively. All stations (e.g. Node B) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node B) to that station (e.g. Node A). Node A appends received NA and TTL value to its Topology Address Library in Node A by order of stations after getting Topology_Discover_Response frame. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node B, Ring state (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node B together as a record of Topology Address Library in Node A. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node A. The records of Topology Address Library of FWR and SWR are operated separately.

If FWR The operation of topology discovery frame is valid and topology status in a node is refreshed if the same results are got after consecutive 3 times transmission of topology discovery frame. Otherwise, the previous record of topology status will be kept unchanged. The operation and record of FWR and SWR topology discovery in a node are carried out separately.

5.7.1.2 Operation of Topology Discovery Frame in the case of FWR Fiber Cut

The MSR protocol does work by sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also.

If single fiber is cut or PSF occurs on FWR from Node 1 to Node 2 in Figure 1 for example, Node 2 detects PSF on FWR. Node 1 and Node 2 enter L2PS state from Node 1 to Node 2 on FWR and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, data frame and the corresponding network management /control frames in SWR, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along a FWR first. When and if it reaches Node 1 or Node 2, or transmitted from Node 1 to Node 2, the route of this Topology_Discovery_Request Frame will be changed to FWR in the opposite direction. If FWR is involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.3 Operation of Topology Discovery Frame in the case of SWR Fiber Cut

If single fiber is cut or PSF occurs on SWR from Node 2 to Node 1 in Figure 1 for example, Node 1 detects PSF on SWR. Node 2 and Node 1 enter L2PS state from Node 2 to Node 1 on SWR and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, data frame and the corresponding network management /control frames in SWR, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along a SWR first. When and if it reaches Node 2 or Node 1, or transmitted from Node 2 to Node 1, the route of this Topology_Discovery_Request Frame will be changed to FWR in the opposite direction. If SWR is involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.4 Operation of Topology Discovery Frame in the case of Bidirectional Fiber Cut

If bidirectional fiber are cut or PSF occurs on both FWR and SWR from Node 1 to Node 2 in Figure 1 for example, Node 1 and Node 2 detect PSF on SWR and FWR respectively. Node 1 and Node 2 enter L2PS state from Node 1 to Node 2 on FWR and from Node 2 to Node 1 on SWR, and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, Node 3, 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 2, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along both FWR and SWR. When and if it reaches Node 1 or Node 2, or transmitted from Node 1 to Node 2, the route of this Topology_Discovery_Request Frame will be changed from FWR to SWR or from SWR to FWR in the opposite direction. If both FWR and SWR are involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on both FWR and SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.1.5 Operation of Topology Discovery Frame in the case of Bidirectional Failure on Both Sides of Node

If bidirectional Failure on Both Sides of Node 2 for example, Node 1 and Node 3 detect PSF on SWR and FWR respectively. Node 1 and Node 3 enter L2PS state from Node 1 to Node 3 on FWR and from Node 3 to Node 1 on SWR, and an L2PS_Event_Report Frame is broadcasted to all stations in a ring. At this moment, Node 4, 5 and 6 are kept in normal state as usually. Periodically (Timer_topology_discovery defaults to 3 seconds and is programmable), any station of Node 1, 3, 4, 5 and 6 (e.g. Node C) broadcasts Topology_Discovery_Request Frame with a Null parameter along both FWR and SWR. When and if it reaches Node 1 or Node 3, or transmitted from Node 1 to Node 3, the route of this Topology_Discovery_Request Frame will be changed from FWR to SWR or from SWR to FWR in the opposite direction. If both FWR and SWR are involved in L2PS state, TTL value of those nodes sending frame and not being in L2PS state on both FWR and SWR should be double of that in normal state when a frame is sent from these nodes. All stations (e.g. Node D) received Topology_Discovery_Request Frame give a response by Topology_Discovery_Response Frame with a local NA (e.g. NA of Node D) to that station (e.g. Node C). Node C appends received NA and TTL value to its Topology Address Library in Node C by order of stations. The order of stations along a ring is dependent on difference of TTL value. TTL value, state (Normal State or L2PS State) of Node D, state of ring (Normal State or L2PS State) and value of FWR/SWR are bound to NA of Node D together as a record of Topology Address Library in Node C. The maximum and minimum values of TTL in a record of FWR or SWR correspond to two neighbors of Node C. The records of Topology Address Library of SWR and FWR are operated separately.

5.7.2 Operation of Manual Switch and Forced Switch Frames

L2PS_Request frame with a Manual_Switch or Forced_Switch parameter targeting one or two spans on MSR ring is sent to other nodes by unicasting or multicasting mode from a node (called Node A, e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes (called Node B) received L2PS_Request frame will perform corresponding switching operation in the adjacent nodes (Node B and C) of targeted span and give a point-to-point response by L2PS_Response frame with a parameter of

Successful_Switch or Unsuccessful_Switch to Node A, and issues L2PS_Event_Report frame with a set parameters of Forced_Switch/Manual_Switch and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. It is successful operation if Node A receives two correct responses from both Node B and Node C. Otherwise, it is not successful operation.

5.7.3 Operation of L2PS in the case of PSF/PSD and Node failure

5.7.3.1 Operation of FWR Fiber Cut

If single fiber is cut or PSF occurs on FWR from Node 1 to Node 2 in Figure 1 for example, Node 2 detects PSF on FWR. That is, neither flag nor frame is received within 30ms (the values of T200 and N200 are programmable) in the FWR of short path. L2PS entity in a Node 2 will start L2PS function and perform following sub-functions:
(1)Node 2 goes into L2PS State and passes L2PS_Request Frame with a parameter of FWR_Fiber_Cut along short path of SWR to Node 1. After getting this frame, Node 1 enters L2PS State also, and issues L2PS_Event_Report frame with a set parameters of SWR_Fiber_Cut/FWR_Fiber_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State, all frames from Node 1 to Node 2 along short path of FWR are switched to the longest path of SWR in opposite direction.

(2)When PSF on Node 2 clears, Node 2 goes to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 2 sends WTR-Request Frame with a parameter of Successful_WTR to Node 1 along both short path and the longest path at once. Node 1 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.2 Operation of SWR Fiber Cut

If single fiber is cut or PSF occurs on SWR from Node 2 to Node 1 in Figure 1 for example, Node 1 detects PSF on SWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in the SWR of short path. L2PS entity in a Node 1 will start L2PS function and perform following sub-functions:
(1)Node 1 goes into L2PS State and passes L2PS_Request Frame with a parameter of SWR-Fiber-Cut along short path of FWR to Node 2. After getting this frame, Node 2 enters L2PS State also, and issues L2PS_Event_Report frame with a set parameters of SWR_Fiber_Cut/FWR_Fiber_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State, all frames from Node 2 to Node 1 along short path of FWR are switched to the longest path of SWR in opposite direction.

(2)When PSF on Node 1 clears, Node 1 goes to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1 sends WTR-Request Frame with a parameter of Successful_WTR to Node 2 along both short path of SWR and the longest path of FWR at once. Node 2 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.3 Operation of Bidirectional Fiber Cut

If bidirectional fiber is cut or PSF occurs on both FWR and SWR from Node 1 to Node 2 in Figure 1 for example, Node 1/Node 2 detects PSF on SWR/FWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in both FWR and SWR of short path. L2PS entity in both Node 1 and Node 2 will start L2PS function and perform following sub-functions:
(1)Node 1/Node 2 goes into L2PS State itself and passes L2PS_Request Frame with a parameter of SWR_Fiber_Cut/FWR_Fiber_Cut along the longest path of FWR/SWR to Node 2/Node 1. After getting this frame, both Node 2 and Node 1 enters L2PS State, and issues L2PS_Event_Report frame with a set parameters of SWR_Fiber_Cut/FWR_Fiber_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal

state in a ring. In L2PS State, all frames from Node 1 to Node 2 or from Node 2 to Node 1 along short path of FWR/SWR are switched to the longest path of SWR/FWR in opposite direction.

(2)When PSF on Node 1 and Node 2 clears, Node 1 and Node 2 go to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1/Node 2 sends WTR_Request Frame with a parameter of Successful_WTR to Node 2/Node 1 along the longest path at once. Node 1/Node 2 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.4 Operation of Bidirectional Failure on Both Sides of Node

Bidirectional Failure on Both Sides of Node is complete node failure. If it is Node 2 in Figure 1 for example, Node 1 and Node 3 detect PSF on both SWR and FWR. That is, neither flag nor frame is received within 20ms (its value is programmable) in both FWR and SWR of shorter path via Node 2. L2PS entity in both Node 1 and Node 3 will start L2PS function and perform following sub-functions:
(1)Node 1/Node 3 goes into L2PS State itself in both directions and passes L2PS_Request Frame with a parameter of SWR_Fiber_Cut/FWR_Fiber_Cut along the longer path of FWR/SWR to Node 3/Node 1. After getting this frame, both Node 3 and Node 1 enters L2PS State in both directions, and issues L2PS_Event_Report frame with a set parameters of SWR_Fiber_Cut/FWR_Fiber_Cut, PSF/PSD and L2PS-State to designated node (connected to Network management) and/or broadcasts to all stations in normal state in a ring. In L2PS State of both directions, all frames from Node 1 to Node 3 or from Node 3 to Node 1 along shorter path of FWR/SWR are switched to the longer path of SWR/FWR in opposite direction.

(2)When PSF on Node 1 and Node 3 clears or Node 2 is restored, Node 1 and Node 3 go to Normal State, starts Timer_WTR (it is programmable). Once Timer_WTR expires, Node 1/Node 3 sends WTR-Request Frame with a parameter of Successful_WTR to Node 3/Node 1 along the longer path at once. Node 1/Node 3 goes back to Normal State from L2PS State after receiving this frame.

5.7.3.5 Operation of Bidirectional Failure on One Side of Node

This case is the same as 5.7.3.3.

5.8 Operation of Network Management Frames

5.8.1 Initial Configuration Table (ICT) Operation

ICT is a mapping table reflecting the initial and available value of TT and TSN in a node and TCCR between nodes on the MSR ring during engineering installation. The ICT must be pre-installed by (NVROM or FLASH RAM) before MSR engineering operation. The incorrect ICT will lead to fault of Tributary services on MSR ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on MSR ring is sent to other nodes by broadcasting mode from a node (called Node A, e.g. Central station in the most case) by network management interface during initial engineering operation period. All nodes (called Node B) received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to Node A.

All nodes on a ring will wait to be assigned ICT during engineering installation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit timer (it is programmable, named for Timer_ct) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N times of retransmission (N_ct is programmable also).

If Node A has received a message of CT_Response frame with a Null parameter from Node B either before CT retransmit expired or before N times of retransmission, it is believed that ICT operation for Node B is successful.

5.8.2 Configuration Updating Table (CUT) Operation

CUT is a mapping table reflecting the available value modification of TT and TSN in a node and TCCR between nodes on the MSR ring during the engineering operation. The CUT is applied during MSR engineering operation. The incorrect ICT will lead to fault of Tributary on MSR ring. CT_Request frame with a CUT parameter reflecting changed part of TCCR of all nodes on MSR ring is sent to other nodes (called one of them Node B) by broadcasting mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame will build corresponding mapping relations of TCCR in the local node and give a point-to-point response by CT_Response frame to Node A.

All nodes on a ring will wait to be assigned CUT during engineering operation period. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmit timer (it is programmable, named for Timer_ct) if Node A does not receive corresponding CT_Response frame. It is believed that Node B is not reachable after N times of retransmission (N_ct is programmable also).

If Node A has received a message of CT_Response frame with a Null parameter from Node B either before CT retransmit expired or before N times of retransmission, it is believed that ICT operation for Node B is successful.

5.8.3 Configuration Table Inquiry (CTI) Operation

CT_Request frame with a Null parameter is sent to other nodes (called one of them Node B) by unicasting/multicasting/broadcasting mode from a node (called Node A, e.g. Central station in the most case) by network management interface during normal engineering operation period. All nodes received CT_Request frame with a Null parameter will give a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on MSR ring to Node A.

5.9 Fault Management

If a fault occurs, Fault_Report frame with a fault parameter defined in 7.9.2 is sent to designated node (connected to network management interface). The network management entity can pass Fault_Request Frame with a fault parameter defined in 7.9.2 from designated node to a targeted node. The targeted node issues Fault_Response Frame with a fault parameter defined in 7.9.2 to designated node as a responding.

5.10 Performance Management

Once 15 minutes or 24 hours expired, each node in a ring will issue Performance_Report frame with a performance parameter defined in 7.9.2 to designated node (connected to network management interface). The network management entity can pass Performance_Request Frame with a performance parameter defined in 7.9.2 from designated node to a targeted node if needed anytime. The targeted node responds by Performance_Response Frame with a performance parameter defined in 7.9.2 to designated node.

6 The Protocol Framework of Aggregate Pipe

6.1 The protocol framework of SDH/SONET based Aggregate Pipe

Figure 3 is the protocol framework of MSRP (Octet-oriented) of SDH/SONET aggregate pipe. It is the same as X.86/Y.1323 when LAPS is replaced by MSRP. This Recommendation treats SDH transport as an octet-oriented synchronous point-to-point full-duplex link. The SDH frame is an octet-oriented synchronous multiplex mapping structure that specifies a series of standard rates, formats and mapping methods. The use of control signals is not required. The self-synchronous scrambling/descrambling ($x^{43}+1$) function is applied during insertion/extraction into/from the synchronous payload envelope. Communication service facilities between MSRP (Octet-oriented) and physical layer are accomplished by means of primitives (PH-DATA request and PH-DATA indication) according to the principle of ITU-T Recommendation X.211. Specification of Primitives specifies the interaction between MSRP and physical layer to invoke and provide a service, and presents the elements.

The data link protocol is MSRP (Octet-oriented), which provides point-to-point transferring over SDH virtual containers (including contiguous concatenation or virtual concatenation) and interface rates. The supported MSRP is connection-less-mode service. Communications between data link and the associated upper protocols are accomplished by means of primitives according to the principle of ITU-T Recommendation X.212.

The service facility of MSRP (Octet-oriented) provided to other upper protocols via SAP (Service Access Point) is the DL-UNACK- DATA request primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter set in a node from configuration, and the DL-UNACK-DATA indication primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter from received frame. "User data" is the outgoing/incoming upper layer packet. The default maximum frame size of MSRP shall be capable of supporting an information field of 1 600 octets (at least).

All frames start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The flag preceding the destination node address field is defined as the opening flag. The flag following the Frame Check Sequence (4-octet FCS) field is defined as the closing flag. The closing flag also serves as the opening flag of the next frame, in some applications. However, all receivers shall be able to accommodate receipt of one or more consecutive flags. The Flag Sequence shall be transmitted during inter-frame time fill.

An octet stuffing procedure is applied for SDH/SONET Aggregate Pipe. Each frame begins and ends with the flag 0x7E. A transmitting data link layer entity of MSRP (Octet-oriented) shall examine the frame content between the opening and closing flag sequences (Destination Node Address, Time to Live, U/M/B, FWR/SWR, Priority, TT, TSN, CS & NM, Payload or CS & NM parameters, and FCS fields) during transmission; if the flag sequence occurs, it shall be converted to the sequence 0x7D 0x5E. Occurrence of 0x7D is transformed to 0x7D 0x5D also. At the receiver, the stuff patterns are removed and replaced with the original fields. An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TSN which are mismatched or not supported by the receiver.

e) has an invalid control sequence, i.e. {0x7d, ZZ} where ZZ octet is not 5d, 5e, 7e, dd (Rate Adaptation).

Invalid frame shall be discarded without notification to the sender. No action is taken as the result of that frame.

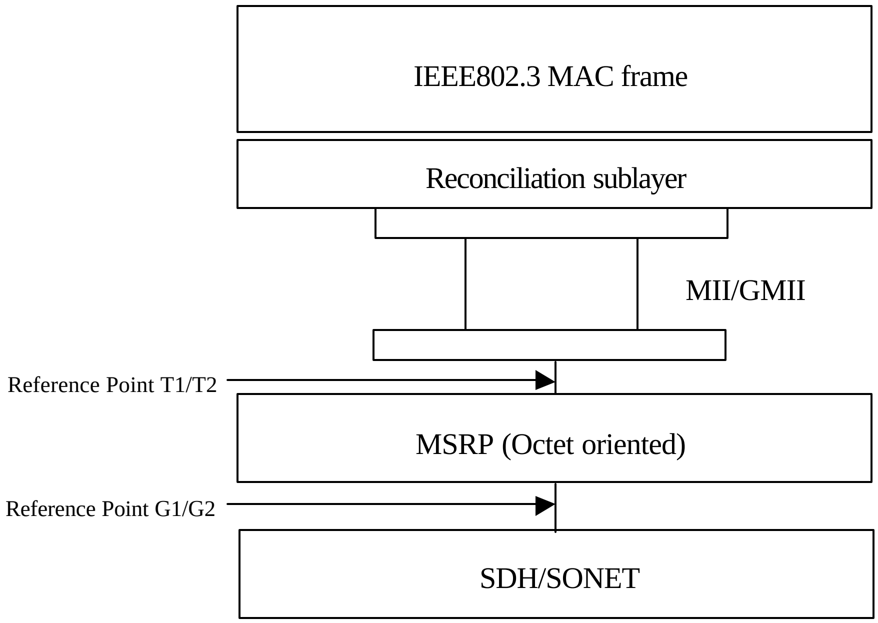


Figure 3/X.msr

Protocol Stack of Ethernet over SDH/SONET using MSRP in SDH/SONET based Aggregate Pipe

The connection management entity is used optionally to monitor the link status of receiving the peer link frame. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T200 and N200 are set to 10 milliseconds and 3 respectively), the MSRP entity enters the normal way of transmitter and receiver.

--If the timer T200 expires before any frame (including data/CS & NM frame and inter- frame time fill) is received, the MSRP entity shall restart timer T200 and decrement the retransmission counter N200.

--If timer T200 expires and retransmission counter N200 has been decremented to zero before any frame is received, the MSRP entity shall indicate this to the local connection management entity by means of the MDL-ERROR indication primitive, and restart timer T200 and recover the value of N200.

--The value of T200 and N200 shall be configurable. The minimum unit configured of T200 and N200 is 5 milliseconds and 1 respectively.

MSRP (Octet-oriented) entity accepts frames from the MAC layer through the Reconciliation sublayer and an equivalent MII (Media Independent Interface). No address filtering function is used here. The format of MSRP (Octet-oriented) payload field is defined in the shaded region of Figure 6 in ITU-T X.86/Y.1323. The order of those octets and bits shaded area as shown is kept intact. The function unit of MSRP forwards all incoming MSRP frames to its peer connected to link along a ring except the originating link port, and is permitted to buffer one or more incoming frames before forwarding them.

Protocol stacks of DVB frame over SDH/SONET, POS frame over SDH/SONET, ATM Cell Frame over SDH/SONET and IP over SDH/SONET using MSRP (Octet-oriented) are shown in Figure 4, Figure 5, Figure 6 and Figure 7 respectively. The reference point G1/G2 and T1/T2 is reflected in and is corresponded to Figure 2 and section 5.4.

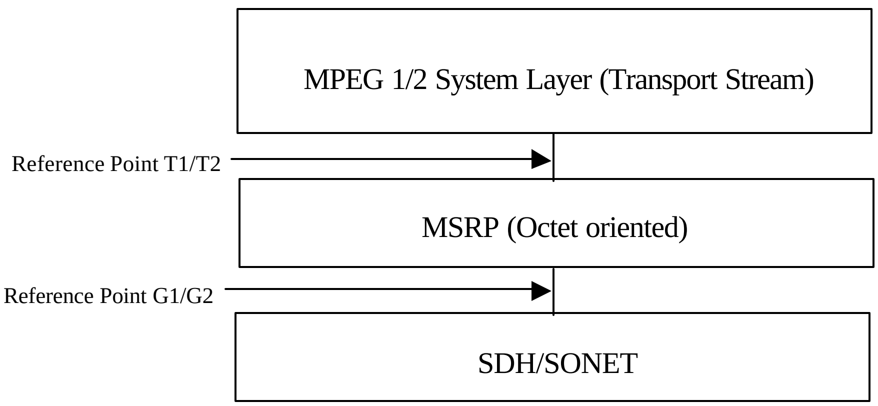


Figure 4/X.msr

Protocol Stack of DVB frame over SDH/SONET in SDH/SONET based Aggregate Pipe

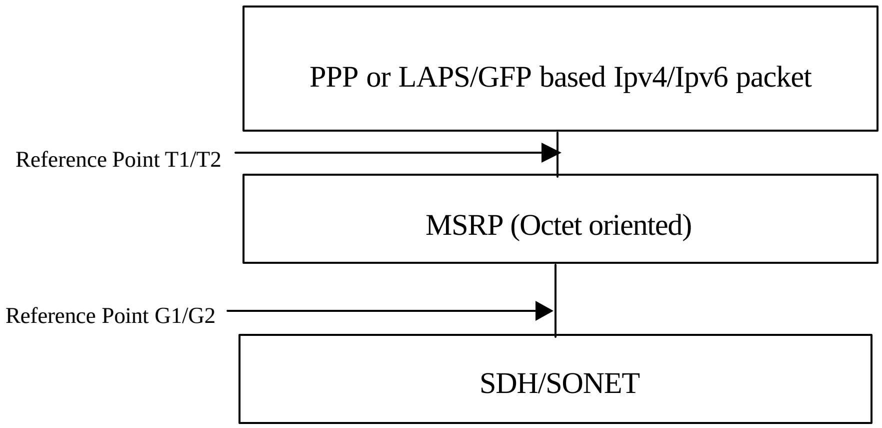


Figure 5/X.msr

Protocol Stack of POS frame over SDH/SONET in SDH/SONET based Aggregate Pipe

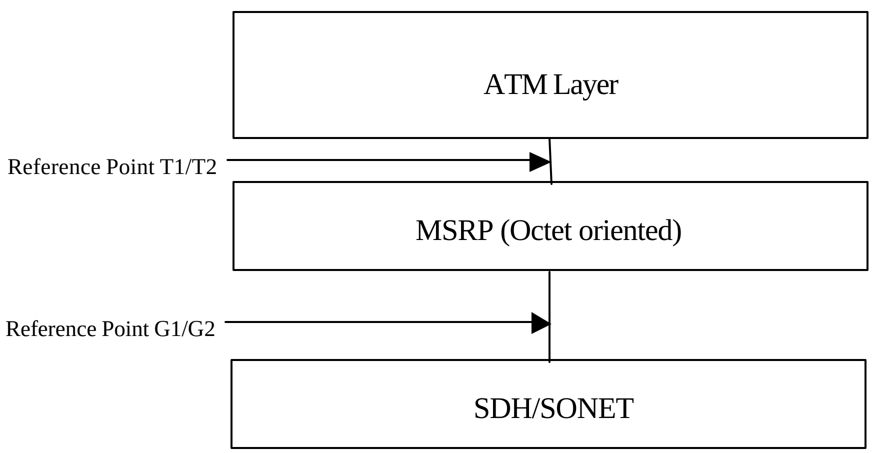


Figure 6/X.msr

Protocol Stack of ATM frame over SDH/SONET in SDH/SONET based Aggregate Pipe

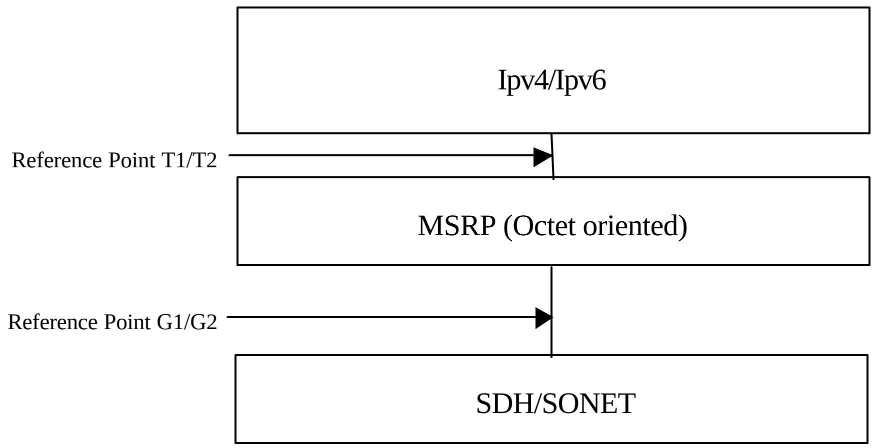


Figure 7/X.msr

Protocol Stack of IP over SDH/SONET using MSRP in SDH/SONET based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

6.2 The protocol framework of GE and 10GE based Aggregate Pipe

Figure 8 is the protocol framework of MSRP (Bit-oriented) of GE and 10GE based. It has the same position as Logical Link Control protocol defined in IEEE802.2. This Recommendation treats MSRP as a upper layer protocol of Ethernet MAC of point-to-point full-duplex. The use of control signals is not required. The self-synchronous scrambling/descrambling ($x^{43}+ 1$) function is not applied during insertion/extraction into/from the MAC payload. Communication service facilities between MSRP (Bit-oriented) and MAC layer are accomplished by means of primitives (MAC-DATA request and MAC-DATA indication) according to the principle of ITU-T Recommendation X.211. Specification of Primitives specifies the interaction between MSRP and MAC layer to invoke and provide a service, and presents the elements.

The supported MSRP (Bit-oriented) is connection-less-mode service. Communications between data link and the associated upper protocols are accomplished by means of primitives according to the principle of ITU-T Recommendation X.212.

The service facility of MSRP (Bit-oriented) provided to other upper protocols via SAP (Service Access Point) is the DL-UNACK- DATA request primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter set in a node from configuration, and the DL-UNACK-DATA indication primitive with "User data" (data frame in Tributary and L3 forwarding part or frame of CS & NM) and "Priority" parameter from received frame. "User data" is the outgoing/incoming upper layer packet. The default maximum frame size of MSRP shall be capable of supporting an information field of 1 500 octets in this case.

The opening flag, the closing flag, octet stuffing procedure and Rate Adaptation will not be used in this case.

An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TSN which are mismatched or not supported by the receiver.

Invalid frame shall be discarded without notification to the sender. No action is taken as the result of that frame.

The connection management entity is used optionally to monitor the link status of receiving the peer link frame. It is local matter only and has not any associated frame to be used between the two sides.

--After initialization (the defaults of T200 and N200 are set to 10 milliseconds and 3 respectively), the MSRP entity enters the normal way of transmitter and receiver.

--If the timer T200 expires before any frame (including data/CS & NM frame and inter- frame time fill) is received, the MSRP (Bit-oriented) entity shall restart timer T200 and decrement the retransmission counter N200.

--If timer T200 expires and retransmission counter N200 has been decremented to zero before any frame is received, the MSRP (Bit-oriented) entity shall indicate this to the local connection management entity by means of the MDL-ERROR indication primitive, and restart timer T200 and recover the value of N200.

--The value of T200 and N200 shall be configurable. The minimum unit configured of T200 and N200 is 5 milliseconds and 1 respectively.

MSRP entity accepts DVB/ATM/POS/upper layer frames from the upper layer (e.g. through the Reconciliation sublayer and an equivalent MII for Ethernet of upper layer). No address filtering function is used here. The format of MSRP (Bit-oriented) payload field is defined in the shaded region of Figure 6 in ITU-T X.86/Y.1323. The order of those octets and bits shaded area as shown is kept intact. The function unit of MSRP forwards all incoming MSRP frames to its peer connected to link along a ring except the originating link port, and is permitted to buffer one or more incoming frames before forwarding them.

Protocol stacks of DVB frame over GE or 10GE, POS frame over GE or 10GE, ATM Cell Frame over GE or 10GE and IP over GE or 10GE using MSRP (Bit-oriented) are shown in Figure 9, Figure 10, Figure 11 and Figure 12 respectively. The reference point G1/G2 and T1/T2 is reflected in and is corresponded to Figure 2 and section 5.4 also.

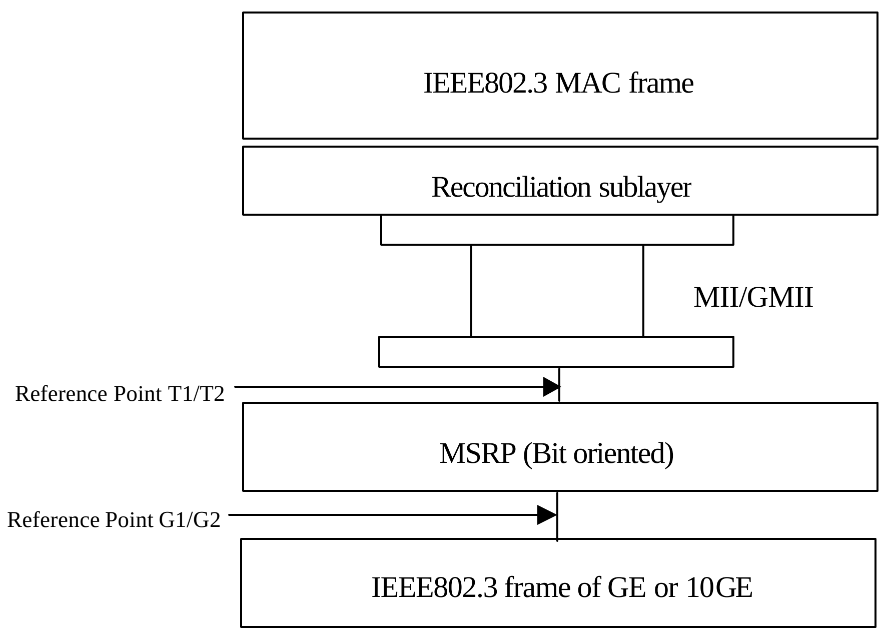


Figure 8/X.msr

Protocol Stack of Ethernet over GE or 10GE in GE or 10GE based Aggregate Pipe

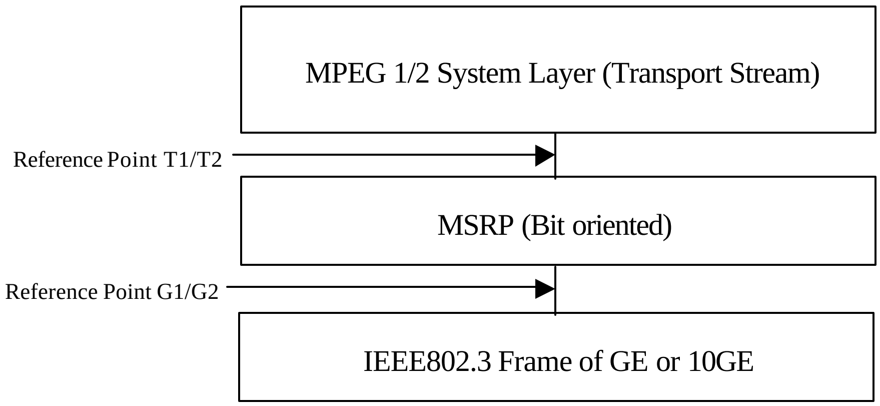


Figure 9/X.msr

Protocol Stack of DVB frame over GE or 10GE in GE or 10GE based Aggregate Pipe

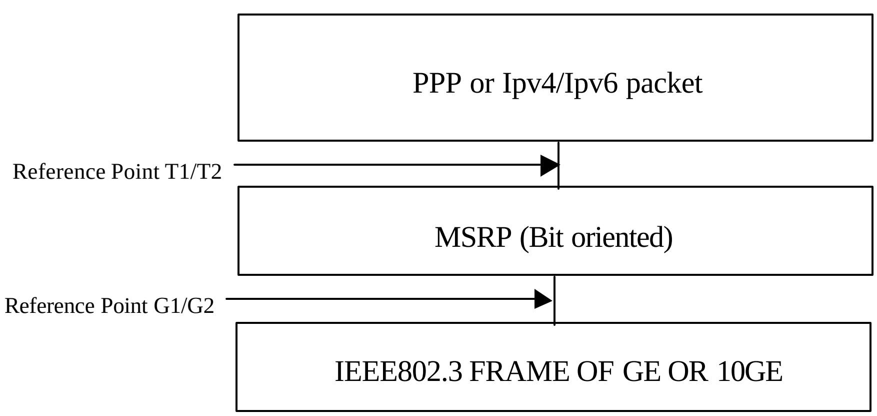


Figure 10/X.msr

Protocol Stack of POS frame over GE or 10GE in GE or 10GE based Aggregate Pipe

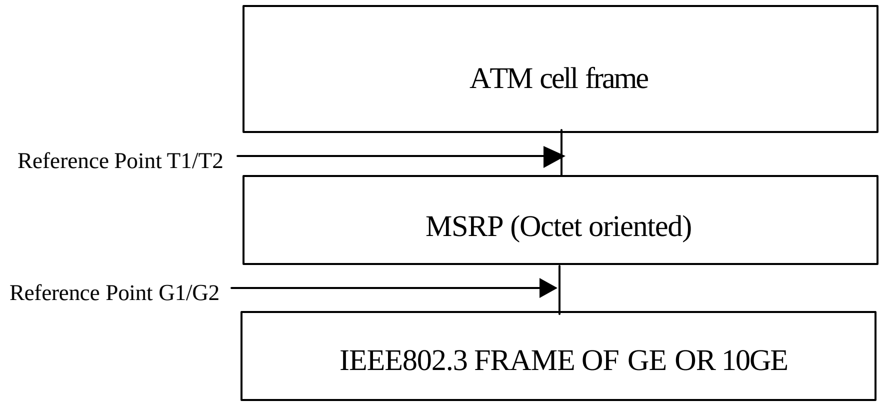


Figure 11/X.msr

Protocol Stack of ATM frame over GE or 10GE in GE or 10GE based Aggregate Pipe

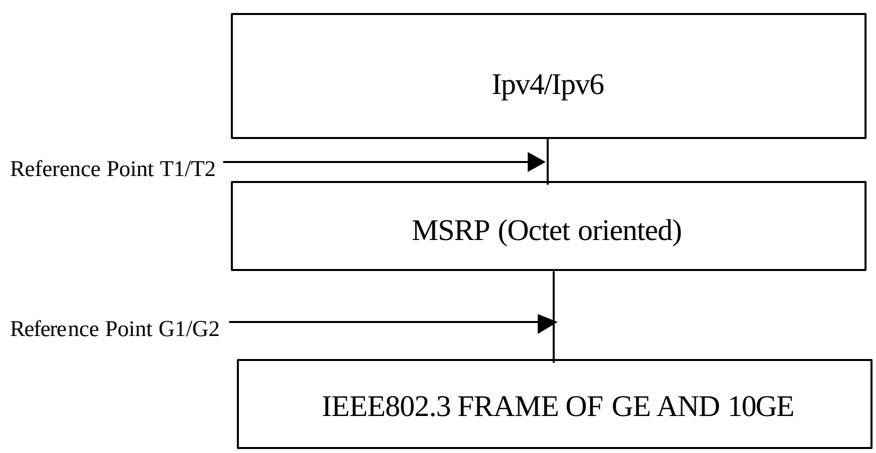


Figure 12/X.msr

Protocol Stack of IP over Ethernet in GE and 10GE based Aggregate Pipe, it will be used to network management, control signalling and Layer 3 forwarding packet

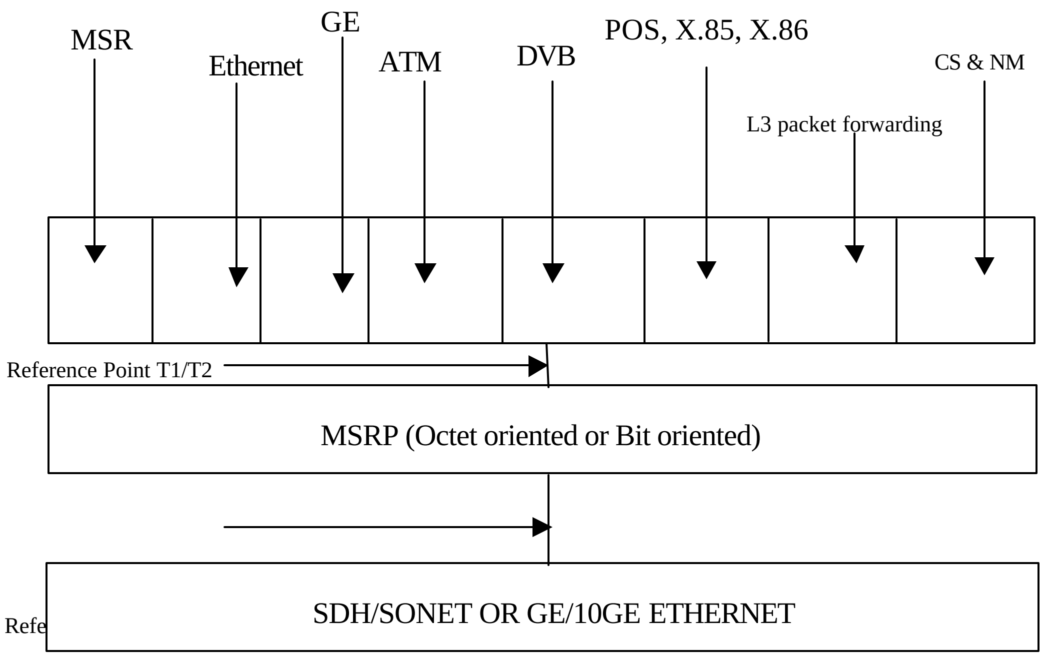


Figure 13

Generic Protocol Stack of MSR

MSR can provide a set facility of access Ethernet (10/100Mb/s), Gigabit Ethernet, DVB (MPEG1/2/4), ATM (STM-1/OC-3 and STM-4/OC-12), POS (STM-1/OC-3 and STM-4/OC-12), other MSR ring, Layer 3 packet forwarding and CS& NM over MSRP as shown in Figure 13. Figure 13 is generic protocol framework of MSR, including MSRP of octet-oriented and bit-oriented.

6.3 Tributary Adaptation Function Unit

Tributary Adaptation Function Unit is an adaptation function from/to various independent tributary type signals to/from reference point T1/T2. It has Tributary Adaptation Source Function and Tributary Adaptation Sink Function. Sink corresponds to reference point T1, source to reference point T2. This adaptation function can include the signal and rate transform, synchronous function between two sides.

7 Generic MSR Frame Format

Each MSRP frame uses a fixed sized header. The generic frame format is shown in Figure 14.

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5

Destination Node Address				
Destination Node Address				
Time to Live	U/M/B	FWR/ SWR	Priority	TT
TSN				CS & NM
Payload or Parameters of CS & NM Packet				
FCS				
FCS				

0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5

Figure 14/X.msr

Generic Frame Format of MSR

The said fields are described below.

7.1 Destination Node Address

This 32-bit field is an address of Node Link on the MSR ring. NA is a local address and has local meaning only along the MSR ring. It contains 4 octets. Each bit (binary "0" or "1") corresponds to a node. For example, the binary "00100000 00000000 00000000 00000000" stands for the 3rd Node Address (station), the binary "00000100 00000000 00000000 00000000" stands for the 6th Node Address (station) (refer to Figure 1). You may also use binary "00000010 00000000 00000000 00000000" to stand for 7th Node Address of new insertion and the actual sequence location of the 7th Node Address may be corresponded to middle position between Node 1 and Node 2 shown in Figure 1 since the MSR supports online node insertion. All Node Address must be leftward alignment and be pre-installed by (NVROM) before engineering operation. The maximum node number of the MSR Ring is 32. For implementation, people can use Ethernet MAC and Ipv4/Ipv6 address to perform external network management.

7.2 Time to Live

This 5-bit field is a count of hops that must be decremented every time of forwarding a frame from a node on MSR ring.

7.3 FWR/SWR Bit

This single bit field indicates on which ring this frame is assigned to run. “0” and “1” stand for FWR and SWR respectively.

7.4 U/M/B field

The U/M/B stands for Unicasting/Multicasting/Broadcast. This 2-bit field is defined as Table 3.

TABLE 3/X.msr – Codes of U/M/B field

U/M/B	Codes
Reserved	00
Unicasting	01
Multicasting	10
Broadcast	11

7.5 Priority

This 3-bit field reflects priority level of MSRP frame from 0 to 7. The value of priority is determined by manual setting of configuration using network management interface before engineering installation according to Service Level Agreement from carrier at the Tx side in a node. The larger the value is, the higher the priority is. It may also be modified online during service operation by using CT_Request and CT_Response frames.

7.6 Tributary Type (TT)

This 5-bit field stands for a type of an independent adding/dropping tributary channel to/from the MSR data nodes, Layer 3 forwarding packet, Control Signalling and Network management frame. Tributary channel can be Ethernet, Gigabit Ethernet, DVB, POS and ATM etc. Its codes are as follows (see Table 4).

TABLE 4/X.msr – TT Code

Tributary types	Code
Reserved	00000-00011
Ethernet (10Mb/s, specified in IEEE802.3)	00100
Ethernet (100M/b/s, specified in IEEE802.3)	00101
GE (specified in IEEE802.3)	00110
DVB, MPEG 1 System Layer (transport stream) DVB, MPEG 2 System Layer (transport stream)	00111 01000
STM-1/OC-3c ATM	01001

STM-4c/OC-12c ATM	01010
STM-1/OC-3c POS	01011
STM-4c/OC-12c POS	01100
L3 Forwarding Packet	01101
CS & NM Frame	01110
Other MSR	01111
Reserved	10000-11111
Note: the code of 10/100M auto-sense Ethernet is "00101" also.	

7.7 Tributary Sequence Number (TSN)

This 11-bit field is a sequence number of same type of Tributary Port on a node. TSN is 7 (Binary 00000000111) if the 7th Ethernet is provided in a node for example.

7.8 CS & NM field

This 5-bit field is used to identify the types of control signalling and network management frame shown in Table 5.

TABLE 5/X.msr – Type of Control Signalling and Network Management Frame

CS&NM Frame Types	Code
MSRP Data Frame (L3 forwarding packet is also included)	00000
Topology_Discovery_Request Frame	00001
Topology_Discovery_Response Frame	00010
L2PS_Request Frame	00011
L2PS_Response Frame L2PS_Event_Report	00100 00101
WTR_Request Frame	00110
CT_Request Frame	00111
CT_Response Frame	01000
Fault_Report Frame	01001
Fault_Inquiry_Request Frame	01010
Fault_Inquiry_Response Frame	01011
Performance_Report Frame	01100
Performance _Inquiry_Request	01101
Performance _Inquiry_Response	01110
Reserved	01111-11111

7.9 Payload

When Tributary or Node Layer 3 Forwarding Packet is applied, payload field is used to encapsulate upper layer protocols listed in Table 4. Payload is octet-oriented and its size is variable. The default maximum frame size shall be capable of supporting an information field of 1 600 octets (at least) for both IPv4-based and IPv6-based applications. Except for Tributary, the payload of Layer 3 forwarding packet, control signalling frame and network management is described below.

7.9.1 Node Layer 3 Forwarding Part

Layer 3 forwarding Packet is a packet used to forward data packet in a node. This packet is different from those packets of reaching all Tributary in a node, is also different from network management frames and control signalling frames. Logically, a MSR data node can be treated as a router of performing Layer 3 forwarding when a Layer 3 forwarding Packet is forwarded according to routing table and routing protocols of IPv4/IPv6 in a node from the node to other node along the MSR ring.

7.9.2 Control Signalling and Network Management Part

<table>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td colspan="16">Destination Node Address</td></tr>
<tr><td colspan="16">Destination Node Address</td></tr>
<tr><td colspan="5">Time to Live</td><td colspan="2">U/M/B</td><td colspan="1">FWR/
SWR</td><td colspan="3">Priority</td><td colspan="5">TT</td></tr>
<tr><td colspan="11">TSN</td><td colspan="5">CS & NM</td></tr>
<tr><td colspan="16">Source Node Address</td></tr>
<tr><td colspan="16">Source Node Address</td></tr>
<tr><td colspan="16">4-Octet based Parameters Field</td></tr>
<tr><td colspan="16">FCS</td></tr>
<tr><td colspan="16">FCS</td></tr>
<tr><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

Figure 15/X.msr

Generic Format of CS & NM Frames

The MSR protocol does work by sending both data frame and the associated network management/control frames in FWR, sending both data frame and the associated network management /control frames in SWR also. Generic format of CS & NM Frames is shown in Figure

15. The parameter field is 4-octet based. The difference of the parameter field indicates various control signalling and network management frames below. The first octet of parameters field is used to identify how many parameters are used by CS & NM frame. Each parameter following 1st octet consists of type (or tag), length and value of parameter. If the total octet number of parameters field is not based on 4-octet, the octet padding (Binary 00000000) will be used.

7.9.2.1 Topology Discovery Frame

The initial TTL value should be the total number of actual working stations and is determined by provisioning during project installation. The operation of Topology_Discovery_Request and Topology_Discovery_Response Frame is shown in 5.7.1 and Table 6 gives a Null parameter. U/M/B field is set to broadcasting and priority is 7 (highest).

Table 6 /X.msr – Parameter Type of Topology_Discovery_Request and Topology_Discovery_Response Frames

Parameter type	Value of Parameter Field
Null	Binary "00000001 00000000 00000000 00000000 +00000000 (padding)"

7.9.2.2 Parameters of L2PS_Request Frame

The First and Second Parameter Type of L2PS_Request Frame has Forced Switch, PSF, PSD and Manual Switch. Its value is defined as Table 7 and Table 8. The corresponding operation can be got in 5.7.2 and 5.7.3.

Table 7 /X.msr – First Parameter Type of L2PS_Request Frame

Parameter type	Value of Parameter Field
Forced_Switch	Binary "00000001 00000100 00000001 00000000"
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"
Manual_Switch	Binary "00000001 00000001 00000001 00000000"

Table 8/X.msr – Second Parameter Type of L2PS_Request Frame

Parameter type	Value of Parameter Field
FWR_Fiber_Cut	Binary "00000001 00000110 00000001 00000000"
SWR_Fiber_Cut	Binary "00000001 00000101 00000001 00000000"

7.9.2.3 Parameters of L2PS_Response Frame

The Parameter Type of L2PS_Request Frame has Successful_Switch, or Unsuccessful_Switch. Its value is defined as Table 9. The corresponding operation can be got in 5.7.3.

Table 9 /X.msr – Parameter Type of L2PS_Response Frame

Parameter type	Value of Parameter Field
Successful_Switch	Binary "00000001 00001000 00000001 00000000"
Unsuccessful_Switch	Binary "00000001 00000111 00000001 00000000"

7.9.2.4 Parameters of L2PS_Event_Report Frame

The Parameter Type of L2PS_Event_Report Frame has Successful_Switch, or Unsuccessful_Switch. Its value is defined as Table 10, Table 11 and Table 12. The corresponding operation can be got in 5.7.3.

Table 10 /X.msr – First Parameter Type of L2PS_Event_Report Frame

Parameter type	Value of Parameter Field
Forced Switch	Binary “00000001 00000100 00000001 00000000”
PSF	Binary “00000001 00000011 00000001 00000000”
PSD	Binary “00000001 00000010 00000001 00000000”
Manual Switch	Binary “00000001 00000001 00000001 00000000”

Table 11/X.msr – Second Parameter Type of L2PS_ Event_Report Frame

Parameter type	Value of Parameter Field
FWR_Fiber_Cut	Binary “00000001 00000110 00000001 00000000”
SWR_Fiber_Cut	Binary “00000001 00000101 00000001 00000000”

Table 12/X.msr – Second Parameter Type of L2PS_ Event_Report Frame

Parameter type	Value of Parameter Field
L2PS_State	Binary “00000001 00001010 00000001 00000000”
Normal_State	Binary “00000001 00001001 00000001 00000000”

7.9.2.5 Parameters of WTR_Request Frame

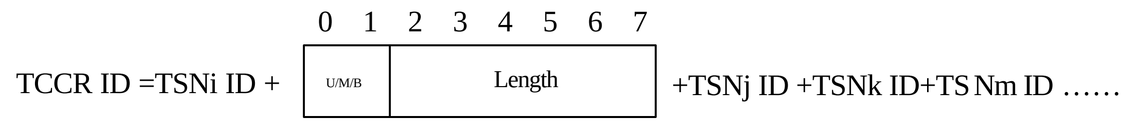
The corresponding operation can be got in 5.7.3 and parameter is shown in Table 13.

Table 13/X.msr – Parameter Type of WTR_Request Frame

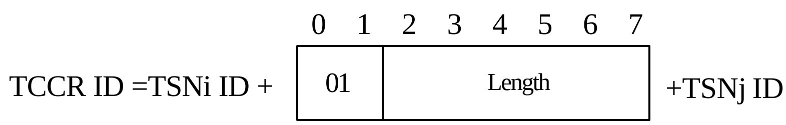
Parameter type	Value of Parameter Field
Successful_WTR	Binary “00000001 00001011 00000001 00000000”

7.9.2.6 CT_Request Frame

The major portion of CT is TCCR ID. A TCCR ID consists of TSNi ID, 2-bit U/M/B field, 6-bit length field and one or more TSNj ID. ID is value of identifier, TSNi, TSNj, TSNk and TSNm are the ith Tributary Sequence Number of same TT of Node n, the jth Tributary Sequence Number of same TT of Node o, the kth Tributary Sequence Number of same TT of Node p and the mth Tributary Sequence Number of same TT of Node q.



Multicasting/Broadcasting Mode



Unicasting Mode

TSNi ID=NA+TT+TSN

Figure 16/X.msr

Expressions of TSN ID and TCCR ID

The ICT, CUT and Null parameters indicate three different operations: ICT, CUT and CTI. Its type and field are described below in Table 14.

Table 14/X.msr –Parameter Type of CT_Request Frame

Parameter type	Parameter Field
ICT	Binary “00000001 00100000 +” octet number of parameter”+”value of TCCR ID shown in Figure 16”
CUT	Binary “00000001 00100001 +” octet number of parameter”+”value of TCCR ID shown in Figure 16”
Null	Binary “00000001 00100011 00000001 00000000”

7.9. 2.7 CT_Response Frame
Null parameter is used by ICT and CUT operation. CTI parameter is followed by CTI operation.

Table 15/X.msr –Parameter Type of CT_Request Frame

Parameter type	Parameter Field
CTI	Binary “00000001 00100100 +” octet number of parameter”+”value of TCCR ID shown in Figure 16”
Null	Binary “00000001 00100011 00000001 00000000”

The corresponding operation can be got in 5.8 and parameter is shown in Table 15.

7.9. 2.8 Fault_Report Frame

Table 16/X.msr –Parameter Type of Fault_Report Frame

Parameter type	Parameter Field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 16.

7.9. 2.9 Parameter of Fault_Inquiry_Request Frame

Table 17/X.msr –Parameter Type of Fault_Inquiry_Request Frame

Parameter type	Parameter Field
Null	Binary "00000001 00100011 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 17.

7.9. 2.10 Parameter of Fault_Inquiry_Response Frame

Table 18/X.msr –Parameter Type of Fault_Inquiry_Request Frame

Parameter type	Parameter Field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"

The corresponding operation can be got in 5.9 and parameter is shown in Table 18.

7.9. 2.11 Parameter of Performance_Report Frame

Table 19/X.msr –Parameter Type of Performance_Report Frame

Parameter type	Parameter Field
A set of TSNi in a node (designated)	Binary "00000001 01000000 +" octet number of parameter "+"value of TSNi shown in Figure 16"
TNFCS_15m (Total Number of FCS in 15 minutes, 4octets, 4octets length)	Binary "00000001 01000001 00000100 "value of TNFCS-15m shown in Figure 16"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNPL-15m shown in Figure 16"
TNFCS_24h (Total Number of FCS in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNFCS-24h shown in Figure 16"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNPL-24h shown in Figure 16"

The corresponding operation can be got in 5.10 and parameter is shown in Table 19.

7.9. 2.12 Parameter of Performance_Inquiry_Request Frame

Table 20/X.msr –Parameter Type of Performance _Inquiry_Request Frame

Parameter type	Parameter Field
A set of TSNi in a node (designated)	Binary "00000001 01000000 +"octet number of parameter "+"value of TSNi shown in Figure 16"

The corresponding operation can be got in 5.10 and parameter is shown in Table 20.

7.9. 2.13 Parameter of Performance_Inquiry_Response Frame

Table 21/X.msr –Parameter Type of Performance _Inquiry_Response Frame

Parameter type	Parameter Field
A set of TSNi in a node (designated)	Binary "00000001 01000000 +" octet number of parameter"+"value of TSNi shown in Figure 16"
TNFCS_15m (Total Number of FCS in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNFCS-15m shown in Figure 16"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4octets length)	Binary "00000001 01000001 00000100 "value of TNPL-15m shown in Figure 16"
TNFCS_24h (Total Number of FCS in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNFCS-24h shown in Figure 16"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5octets length)	Binary "00000001 01000001 00000101 "value of TNPL-24h shown in Figure 16"

The corresponding operation can be got in 5.10 and parameter is shown in Table 21.

7.10 FCS

The Frame Check Sequence field defines as 32 bits (four octets). The FCS is transmitted least significant octet first, which contains the coefficient of the highest term. The FCS field is calculated over all bits of the Destination Node Address, Time to Live, U/M/B, Priority, TT, TSN, CS & NM, Payload (or associated parameters for CS & NM frames), not including any bits (synchronous) or octets (asynchronous or synchronous) inserted for transparency and rate adaptation. This also does not include the Flag Sequences and the FCS field itself. The end of payload or parameter(s) fields are found by locating the closing Flag Sequence and removing the Frame Check Sequence fields. Please refer to RFC 1662 for the calculation of FCS.

7.11 Security Considerations for SDH/SONET aggregate pipe

Due to the malicious users possibly to pass frames of some bit patterns that may lead to

SONET/SDH-layer low-transition-density synchronization problems, SDH/SONET payload scrambling is needed, when the MSRP frames is inserted into the SONET/SDH Higher Order VC or its contiguous/virtual concatenation.

The operation diagram of (x^{43} + 1) self-synchronous scrambler transmitter and receiver (see Figure 17a and Figure 17b are as follows. XOR is an exclusive-OR gate function. The output bits are exclusive-ored with the raw input data bit to produce the transmitted bits. The order of bit transmission within an octet is the most significant bit first. The performing scrambler and descrambler shall be required for higher order VC-n. The C2 octet coding of the high order path signal label is specified (see ITU-T Recommendation G.707) to indicate the contents of synchronous payload envelope. It is recommended that "25" (19 hex) is used to indicate MSRP with (x^{43} + 1) scrambling.

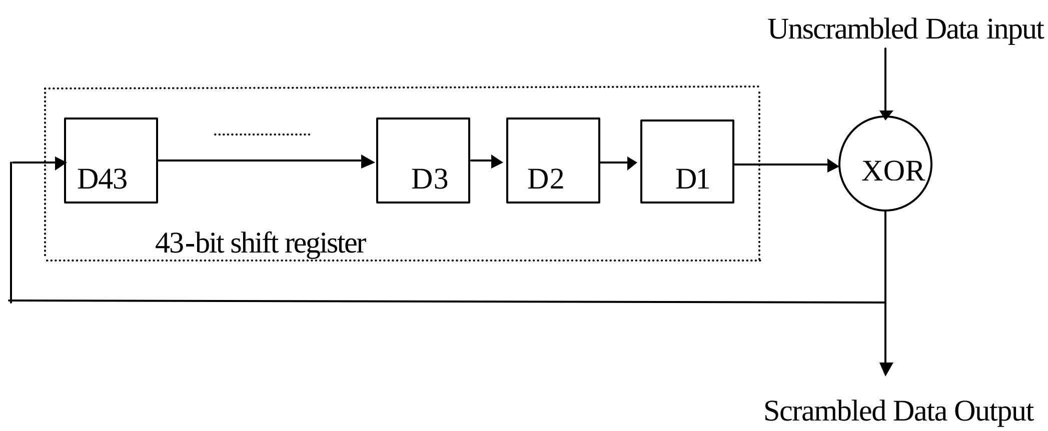


FIGURE 17A/X.MSR

Transmitter diagram

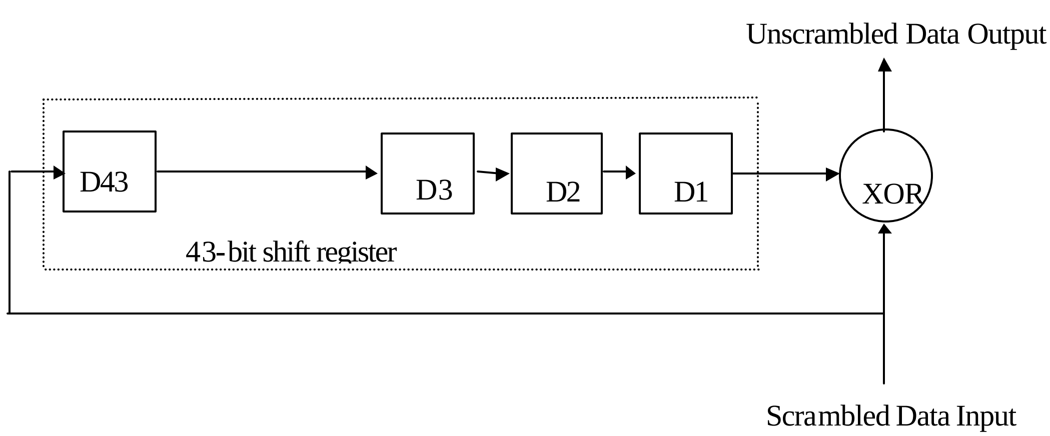


FIGURE 17B/X.MSR

Receiver diagram

The scrambling/descrambling is not required for GE and 10GE aggregate pipe.

8 Filter and schedule Function

MSR filtering function is a filtering and checking facility for frame NA and TTL. All frames reaching to the MSR filter Unit will be sent first to a buffer in the Node. The MSR data node will check frame TTL and NA and perform XOR function with local NA. This frame will be taken away if TTL is zero. If its NA is match, those frames reaching destination will be processed by MSRP processor and not be sent to neighbor (except for multicast and broadcast frames) along the same ring. Otherwise, those mismatched frame will go to neighbor directly by schedule unit without any processing after decrementing TTL field. This is MSR filtering function.

MSR scheduling function is a set of functions used to MSRP protocol processing in Tx direction. It includes Tx Schedule Unit, functions of determination of NA, TTL, TT, TSN, FCS, multicasting/broadcasting according to types and port configuration of Tributary, a route of Layer 3 forwarding packet, requirement of control signalling or requirement of network management. The other associated MSRP protocol processing is also covered.

9 Data Node insertion and Deletion

A data node can be inserted/removed online into/from the ring by using topology discovery (5.7.1) and L2PS (5.7.2 and 5.7.3) functions while other data nodes and services will be operated normally without frame loss and service loss.

10 Tributary Loopback

Once loopback function is set, a node provides local data channel from Tx interface to Rx interface in Tributary.

ANNEX A

MPEG Physical Interface (MPI)

This Annex A is referred to EN 300 429. The following functional blocks are identified:

- The MPEG2-TS (Transport Stream) Physical Interface: the Network Adapter accepts, at its input/output port, an MPEG2-TS consisting of consecutive MPEG2-TS frames. Frames length

of 188 octets and 204 octets can be handled.

- The MPEG / MSRP Adaptation: this corresponds to the adaptation between the MPEG2-TS

and the MSRP. This adaptation, besides format adaptation, provides functions for the MPEG2-TS clock transmission transparency (adaptive clock method) and information transparency using the clock and data recovery mechanism of SDH/SONET. It is expected that under normal transmission conditions the received MPEG2-TS will be quasi error free, corresponding to a Bit Error Rate (BER) of about 10^{-10} to 10^{-11} at the input of an MPEG2 equipment at the receiver site. This requirement is in accordance with the standards for the DVB systems using cable systems (see ETS 300 429).

- It allows the simultaneous transmission of several independent MPEG2-TS on a MSR ring. The order of transmission of information in all diagrams is first from left to right and then from top to bottom. Within each octet or octet the Most Significant Bit (MSB) is transmitted first.

A .1 MPEG Physical Interface (MPI)

The physical characteristics of this interface shall follow the specification given in EN 50083-9. Three different types of interfaces are specified:

- The Synchronous Parallel Interface (SPI);

- The Synchronous Serial Interface (SSI);

- The Asynchronous Serial Interface (ASI).

The interfaces use the MPEG2-TS Frame structure (188 octets). For the SPI and the SSI, the 204-octet format may be used for the transmission of 188-octet MPEG2-TS frames with 16 dummy octets. In order to prevent alarms being raised and failures being reported during set-up procedures or if the input port is not in use (in the case of a multi-port equipment), the MPI function shall have the ability to enable or disable fault case declaration. The MPI shall be either monitored (MON) or not monitored (NMON). The state of MON or NMON is provisioned by the MSR equipment manager to the MPI via the Equipment Management Function.

Signal processing in the transmitter:

A.1.1 Recovery of MPEG2 frames

This function recovers the data octets and their clock from the received signals:

- For the SPI, this recovery is based on the use of the Data (0-7), the DVALID, PSYNC and clock signals, as specified in paragraph 4.1 of EN 50083-9.

- For the SSI interface, the processing includes optical receiver (for fiber-optic-based link) or coupling/impedance matching (for coaxial cable), amplifier/buffer, clock recovery and biphase decoding, serial to parallel conversion, as specified in annex A of EN 50083-9.

- For the ASI interface, the processing includes optical receiver (for fiber-optic-based link) or coupling/impedance matching (for coaxial cable), amplifier/buffer, clock/data recovery and serial-to-parallel conversion, FC comma deletion, 8B/10B decoding, as specified in annex B of EN 50083-9. In the next step, the recovery of the TS clock is performed (cf. annex E of EN 50083-9: implementation guidelines and deriving clocks from the MPEG2 frames for the ASI).

The function also realizes the sync acquisition of the MPEG2-TS frames on the basis of the method proposed in subclause 3.2 of ETR 290 (five consecutive correct sync octets for sync acquisition; two or more consecutive corrupted sync octets should indicate sync loss).

The frame size (188 octets or 204 octets) may be recovered from the received signals on the basis of the PSYNC signal for the parallel interface, or on the basis of periodicity of the synchronization octets for the serial interfaces. For the case of the Synchronous Parallel Interface and the SSI interface, the decision between 204-octet format for MPEG2-TS frames with 16 dummy octets MPEG2-TS frames can be made:

- on the basis of the DVALID signal for the SPI: a high level during the last 16 octets indicate; or

- on the basis of the value of received synchronization octets for the SSI interface: 47H indicates

204-octet format with 16 dummy octets (paragraph A.3.2 of EN 50083-9). Dummy octets are discarded by the MPI function in the case of the 204-octet format with 16 dummy octets. The function passes the recovered MPEG2-TS frames and the timing information.

The function shall meet the electrical/optical characteristics, return loss and jitter requirements specified in EN 50083-9. This function shall also detect:

- the absence of valid input signals;

- the absence of clock;

- a DVALID signal constantly low in the case of the Synchronous Parallel Interface (SPI).

If any of these defects is detected, a Loss Of Signal (LOS) is reported at the Element Management Function if the function is in MON state.

If a loss of synchronization of MPEG2-TS frames is detected according to the procedure proposed in the subclause 3.2 of ETR 290 (i.e. two or more consecutive corrupted sync octets are found), a TS-sync_loss error on the input signal (TSLE_I) is reported at the Element Management Function if the function is in MON state.

Performance monitoring (end to end)

Errored blocks are detected on the basis of the transport_error_indicator present in the headers of the incoming MPEG2-TS frames, in accordance to ETR 290. A second filters perform a simple integration of errored blocks by counting during one second interval. The function generates the following performance parameters concerning the input MPEG2-TS signal received on the interface:

- N_EBC_I: every second, the number of errored blocks within that second is counted as the

Near-End Error Block Count (N_EBC_I).

- N_DS_I: every second with at least one occurrence of TSLE_I or LOS (corresponding to the notion of Severely Disturbed Period introduced in ETR 290 [12]) shall be indicated as Near-End Defect Second (N_DS_I). If the function is in the MON state, at the end of each second interval, the contents of the N_EBC_I counter and of the N_DS_I indicator are reported to the EMF. Furthermore, on request of the EMF block, the MPI block evaluates and reports to the EMF the number of received MPEG2-TS frames within one second (BC_I).

A.1.2 Signal processing in the receiver

a) Generation of the signals at the MPEG Physical interface

This function receives the data bytes provided at the reference point b of figure 1 by the MAA block and recovers the synchronization of the MPEG2-TS frames on the basis of the method proposed in subclause 3.2 of ETR 290 (five consecutive correct sync bytes for sync acquisition; two or more consecutive corrupted sync bytes should indicate sync loss). The type of frame (MPEG2-

TS frame) is determined on the basis of the periodicity of the synchronization bytes. After the recovery of the frame structure and only in the case of a MPEG2-TS frame structure, the function shall use the transport_error_indicator of the MPEG2-TS frames. The function determines the transmission format to be used at the output interface according to the following table A.1:

Table A.1: Transmission format of the output interface

Type of frames received by the MPEG 2 Physical Interface block	**Transmission format on the physical interface**	
MPEG2-TS frames (188 octets)	SPI, SSI	188-octet frames or 204-octet frames with 16 dummy octets, according to the parameter FORMAT provided by the Element Management Function block.
	ASI	188-octet frames

The function generates the appropriate signals at the output interface, according to the type of physical interface and to the transmission format selected:

- For the Synchronous Parallel Interface (SPI), the function generates the Data (0-7), the DVALID, PSYNC and clock signals, as specified in paragraph 4.1 of EN 50083-9.

- For the SSI interface, the processing includes parallel to serial conversion, biphase coding, amplifier/buffer and optical emitter (for fiber-optic-based link) or coupling/impedance matching (for coaxial cable), as specified in annex A of EN 50083-9.

- For the ASI interface, the processing includes 8B/10B coding, FC comma symbols insertion, parallel-to-serial conversion, amplifier buffer and optical emitter (for fiber-optic-based link) or coupling/impedance matching (for coaxial cable), as specified in annex B of EN 50083-9. The function shall meet the electrical/optical characteristics, return loss and jitter requirements specified in EN 50083-9.

If a loss of synchronization of MPEG2-TS frames is detected according to the procedure proposed in the subclause 3.2 of ETR 290 (i.e. two or more consecutive corrupted sync octets are found), a TS-sync_loss error for the output signal (TSLE_O) is reported at the Element Management Function if the function is in MON state.

Performance monitoring (end to end)

Errored blocks are detected on the basis of the transport_error_indicator present in the headers of the MPEG2-TS frames regenerated in the MPI block, in accordance to ETR 290. One second filters perform a simple integration of errored blocks by counting during one second interval. The function generates the following performance parameters concerning the output MPEG2-TS signal delivered by the interface:

- N_EBC_O: every second, the number of errored blocks within that second is counted as the Near-End Error Block Count (N_EBC_O).

- N_DS_O: every second with at least one occurrence of TSLE_O or LOS (corresponding to the notion of Severely Disturbed Period introduced in ETR 290) shall be indicated as Near-End Defect Second (N_DS_O). If the function is in the MON state, at the end of each second interval, the contents of the N_EBC_O counter and of the N_DS_O indicator are reported to the Element Management Function. Furthermore, on request of the Element Management Function block, the MPI block evaluates and reports at the Element Management Function the number of received MPEG2-TS frames within one second (BC_O).

For the detailed description, please refer to EN 50083-9 and ETR 290.

ANNEX B

Ethernet data processing in the case of SDH/SONET based Aggregate Pipe

The MSRP processing is divided into transmit and receive processing as follows:

B.1 The MSRP Transmit Processing

1) Receive MAC frame through MII or GMII from MAC and detect the SPD (Start Frame Delimiter);
2) Synchronize it to the SDH clock;
3) Add start flag (0x7e) of MSRP frame;
4) Add destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT and TSN fields to the MSRP frame;
5) FCS generation over destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT, TSN and payload fields to the MSRP frame, it does not include the Flag, Inter-frame gap and Abort sequence (0x7d7e, option) octets;
6) Transparency processing or octet stuffing within the MSRP frame:
   - 0x7e $\geq$ 0x7d, 0x5e;
   - 0x7d $\geq$ 0x7d, 0x5d;

   Octet stuffing does not occur during the transfer of Rate Adaptation sequence, Abort sequence, Flag;
7) Add end flag (0x7e) of MSRP frame;
8) Add IPG (Inter-Frame-Gap) fill octet(s) (0x7e), if needed;
9) Scramble all octets before send to SDH payload.

B.2 The MSRP Receive Processing

1) De-scramble all octets before processing;
2) Remove IPG (Inter-Frame-Gap) fill octet(s) (0x7e) if needed;
3) Detect start flag (0x7e) of MSRP Frame;
4) Perform octet removal (transparency processing), within the MSRP Frame:
   - 0x7d, 0x5e > 0x7e;
   - 0x7d, 0x5d $\geq$ 0x7d;
5) Check for validation of the destination NA, Time-to-Live, U/M/B, FWR/SWR, Priority, TT and TSN fields;
6) Perform the FCS generation and checking;
7) Detect closing flag (0x7e);
8) Synchronize the MAC frame to MII RX_CLK;
9) Add preamble and SPD (Start Frame Delimiter) and send it to MAC through MII or GMII.

B.3 Erroneous Frame Handling

The MII or GMII Interface provides a method by which the MAC device could indicate to the MSRP entity by TX_ERR when a particular frame contains errors and should be aborted or discarded.

The Ethernet over SDH/SONET using MSRP supports two options for aborting an erroneous frame.

The first option is to abort a frame by inserting the abort sequence, 0x7d7e. Reception of this code at the far end will cause the receiver to discard this frame (the Abort sequence octets are also scrambled).

For the second option, the MSRP entity can also abort an erroneous frame by simply inverting the FCS octets to generate an FCS error. The selection of abort mode is controlled via the management interface.

An invalid frame is a frame which:

a) is not properly bounded by two flags; or

b) has fewer than sixteen octets between flags of frames; or

c) contains a FCS error; or

d) contains a NA, U/M/B, TT or TSN which are mismatched or not supported by the receiver.

e) has an invalid control sequence, i.e. {0x7d, ZZ} where ZZ octet is not 5d, 5e, 7e.

Invalid frames shall be discarded without notification to the sender. No action is taken as the result of that frame.