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SERIES X: DATA NETWORKS, OPEN SYSTEM COMMUNICATIONS AND SECURITY

Public data networks – Transmission, signalling and switching

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Internet protocol aspects – Transport

Multiple services ring based on RPR

ITU-T Recommendation X.87/Y.1324

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ITU-T Recommendation X.87/Y.1324

Multiple services ring based on RPR

Summary

This Recommendation specifies Multiple Services Ring (MSR) based on Resilient Packet Ring (RPR) and a way of multi-service provision over RPR. MSR is defined to work at the client of RPR MAC layer and uses Fairness Algorithm (FA) of RPR MAC to support services of Class A, Class B and Class C. MSR is used in configurations where a tributary service is managed from provisioning. Architecturally, the link and broadcast topologies are also supported. The features of tributary (Service, just like Ethernet, Frame Relay and G.702, etc.) based 1+1, 1:1 and 1:N standby within 50 ms, tributary (Service) based BW management with symmetry and asymmetry, tributary based multicast and Frame Sequence Number for Performance Monitoring of tributary are highlighted in this Recommendation.

Source

ITU-T Recommendation X.87/Y.1324 was approved on 29 October 2003 by ITU-T Study Group 17 (2001-2004) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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

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

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

Introduction

The expansion of business and metro use of data network services are driving the need to deploy data services infrastructure facilities with pre-plan method in the way of tributary or service. The dynamic bandwidth allocation and differentiated services over an aggregate pipe, tributary based bandwidth management, security function, standby, multicast, performance monitoring and their applications in the different topologies are the basic requirements of carrier class. Therefore, the development of multiple services ring based on RPR in this Recommendation needs to provide the following capabilities:

1) The protocol encapsulation and transport of Ethernet, Frame Relay, G.702 PDH circuit – Synchronous and asynchronous circuit transport, Video signal, voiceband signal, Digital channel supported by 64 kbit/s-based ISDN, etc. over a two-fibre ring, a link-type and broadcast topology of fibres.
2) Service (or tributary) based standby of 1+1, 1:1, and 1:N models within 50 ms.
3) Service (or tributary) based multicast and station-based multicast and broadcast.
4) Bandwidth limitation of service (or tributary) based with symmetry and asymmetry.
5) Tributary merging with symmetry and asymmetry.
6) Line-speed filtering of tributary based.
7) Tributary based performance monitoring in 15 minutes and 24 hours.
8) Mirroring of tributary.
9) Frame based transparent PPPoE and PPPoA transport from access to backbone along a MSR ring or other topologies, in order to simplify accounting mechanism (e.g., Radius), reduce maintenance work, and improve latency variation (compared to Layer 2 and Layer 3 switch) in access network application.

This Recommendation provides a packet-based transport model to multiple services and multiple topologies for continuation and extension of ITU-T Recs X.85/Y.1321 and X.86/Y.1323. Continued compatibility with all existing requirements and standards from ITU-T and other organizations is required.

ITU-T Recommendation X.87/Y.1324

Multiple services ring based on RPR

1 Scope

This Recommendation specifies Multiple Services Ring (MSR) based on Resilient Packet Ring (RPR) and a way of multi-service provision over RPR. MSR is defined to work at the client of RPR MAC layer and uses Fairness Algorithm (FA) of RPR MAC to support services of Class A, Class B and Class C. MSR is used in configurations where a tributary service is managed such that over provisioning does not occur. Architecturally, the link and broadcast topologies are also supported. The features of tributary (Service, just like Ethernet, Frame Relay and G.702, etc.) based 1+1, 1:1 and 1:N standby within 50 ms, tributary (Service) based Bandwidth management with symmetry and asymmetry, tributary based multicast and Frame Sequence Number for Performance Monitoring of tributary are highlighted in this Recommendation. MSR provides a packet-based transport model to multiple services and multiple topologies.

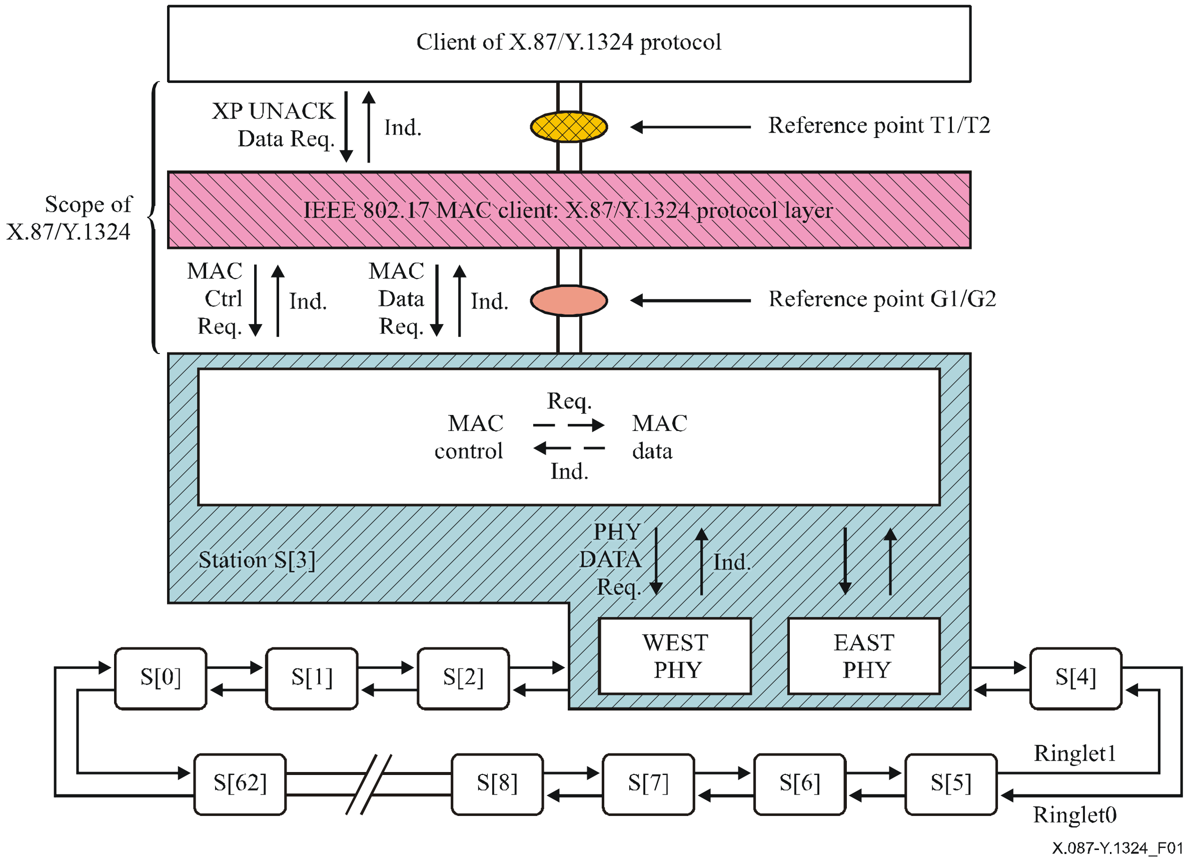


Figure 1/X.87/Y.1324 – Scope of X.87/Y.1324 based on RPR as a MAC client

This Recommendation is based on RPR as a MAC client and is used in configurations where topology and standby is provisioned. What this Recommendation emphasizes is tributary, but not a payload of tributary; standby (1+1, 1:1 and 1:N) and multicast of tributary, but not multicast of MAC; MSR priority, but not MAC priority. The data frame, control frame and network management frame in this Recommendation are all required to map to the payload of RPR data frame. Some control frames RPR defined are also used in X.87/Y.1324, just like topology discovery, protection and FA in RPR. All of these frames specified in this Recommendation have no relations to and are independent of the control frames (just like frames of topology discovery, fairness, protection) of RPR MAC layer. No change is made for all Ethernet-based protocols (including IEEE 802.3 Ethernet), all PDH standards, Frame Relay standards, G.702/ISDN standards and ETSI DVB specifications. This Recommendation is located at a dual-directional symmetric counter-rotating rings based on RPR.

NOTE – It is intended that this Recommendation 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; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

2.1 ITU-T Recommendations

[1] ITU-T Recommendation X.85/Y.1321 (2001), *IP over SDH using LAPS*.

[2] ITU-T Recommendation X.86/Y.1323 (2001), *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 X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic reference model: The basic model*.

[6] ITU-T Recommendation I.363.1 (1996), *B-ISDN ATM Adaptation Layer specification: Type 1 AAL*.

[7] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

2.2 IEEE specifications

[8] IEEE Standard 1802.3-2001, *IEEE Conformance Test Methodology for IEEE Standards for Local and Metropolitan Area Networks – CSMA/CD Access Method and Physical Layer Specifications*.

2.3 Informative Reference

[9] IEEE Standard P802.17/D3.0 (Draft), *Resilient Packet Ring Access Method & Physical Layer Specifications – Media Access Control (MAC) Parameters, Physical Layer Interface, and Management Parameters*.

3 Definitions

This Recommendation defines the following terms:

3.1 aggregate pipe: A physical connection of two adjacent nodes. Aggregate pipe is a channel of RPR based on a span of MSR.

3.2 control signalling frame: A frame used to tributary multicast or standby, etc. in a node.

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

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

3.5 Configuration Table (CT): A mapping table reflecting the actual value of TT and TN in a node and TCCR between nodes on the MSR ring during engineering operation or project installation phase.

3.6 Configuration Table Inquiry (CTI): A function to get CT from a node. CT_Request frame with a CTI parameter reflecting changed (or updating) part of TCCR of a node on MSR ring is sent to other nodes (one of them called Node B) by unicast/multicast/broadcast mode from a node (called Node A, e.g., Central station in the most case) by network management interface during normal engineering operation or project installation phase. All nodes having received CT_Request frame with a CTI parameter will send a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on RPR ring to Node A.

3.7 Configuration Updating Table (CUT): A mapping table reflecting the available value modification of TT and TN in a node and TCCR between nodes on the MSR ring during engineering operation or project installation phase. The incorrect CUT will lead to fault of Tributary on MSR ring. CT_Request frame with a CUT parameter reflecting changed (or updating) part of TCCR of all nodes on MSR ring is sent to other nodes by broadcast mode from a node (e.g., Central station in the most case) by network management interface during normal engineering operation or project installation phase. All nodes having received CT_Request frame will build corresponding mapping relations of TCCR in the local node and send 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 Frame Sequence Number (FSN): A modulo used to performance monitoring based on Tributary service. This 8-bit field is used to identify Frame Sequence Number (FSN) of Ethernet or TCE data frames in numbered modulo N_fsn = 64 (default value, N_fsn is programmable and can be configured to 256 if application needs) from 0 to 63. The field is used to performance monitoring function for packet lost or duplicated of TCE (or Ethernet) based tributary. The FSN field will be set to zero if the signalling control frames or network management frames are used.

3.9 Initial Configuration Table (ICT): A mapping table reflecting the initial and available value of TT and TN in a node and TCCR between nodes on the RPR ring during engineering operation or project installation phase. The ICT must be pre-installed before RPR engineering operation or project installation phase. The incorrect ICT will lead to fault of Tributary services on RPR ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on RPR ring is sent to other nodes by broadcast mode from a node (e.g., Central station in the most case) by network management interface during initial engineering operation or project installation phase. All nodes having received CT_Request frame will build corresponding mapping relations of TCCR in the local node and send 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.

3.10 Multiple Services Ring (MSR): Bidirectional symmetric counter-rotating fibre rings, each node could add and drop one or more independent tributaries.

3.11 multiple services ring over RPR: Bidirectional symmetric counter-rotating fibre rings based on RPR and located at RPR MAC client (refer to Figure 1), each node could add and drop one or more independent tributaries or services of Class A, Class B and Class C, provisioned topology and standby, RPR [9] frame format, tributary service based operation.

3.12 Resilient Packet Ring (RPR): It is defined by RPR [9], a high-speed network technology optimized for frame transmission over a redundant ring topology.

3.13 RPR Rx framer: A RPR MAC framer in Rx side, it terminates a frame of RPR [9] through a station via the ringlet.

3.14 RPR Tx framer: A RPR MAC framer in Tx side, it sources or passes a frame of RPR [9] through a station via the ringlet.

3.15 XP data node: A MSR node that has an eastward Rx, an eastward Tx, a westward Rx and a westward Tx Aggregate Pipe connections along MSR ring, 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. The different connection configuration is applied for the different topologies. A dual-ring structure with a pair of unidirectional counter-rotating ringlets is default and major application form.

3.16 X.87/Y.1324 Protocol (XP): A data link protocol between reference point G1/G2 and reference point T1/T2, used to communicate between different MSR nodes. The XP does operate by sending/receiving both data frame and the associated network management/signalling frames to/from an aggregate pipe of a node.

3.17 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 phase. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmission of 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 also programmable). N_ct is also used by ICT operation.

3.18 Network management frame: A frame used to performance and fault monitoring, node configuration management, etc. along a MSR ring or other different topologies.

3.19 Node Address (NA): An address that identifies a particular station on a network. NA is a OUI MAC address along the RPR ring or other different topologies. IEEE RAC assigns a value of 24 bits, manufacturer assigns the remaining 22 – local indicates a locally administered address. It is the responsibility of the administrator to ensure uniqueness.

3.20 reference point G1: A reference point between RPR MAC and its client. It stands for processing sink of RPR MAC framer in RPR MAC client side.

3.21 reference point G2: A reference point between RPR MAC and its client. It stands for processing source of RPR MAC framer in RPR MAC client side.

3.22 reference point T1: A reference point between Tributary Rx Framer and XP processor. It stands for processing sink of XP before Tributary Rx framer of TCE or Ethernet, etc.

3.23 reference point T2: A reference point between Tributary Tx Framer and XP processor. It stands for processing source of XP after Tributary Tx framer of TCE or Ethernet, etc.

3.24 Source Tributary (ST): A Tributary used as multicast/broadcast source in a membership group within a node.

3.25 Timer_ct A Timer of retransmission used to Configuration Table Operation. A node after first power-on or during the phase needed to change configuration table on a ring will wait to be assigned ICT during configuration modification or project installation phase. After issuing CT_Request frame, Node A will automatically send CT_Request frame again after retransmission of 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_ct times of retransmission (N_ct is also programmable). N_ct is also used by CUT operation.

3.26 transit: A passing of a frame through a station via the ringlet.

3.27 tributary: An independent adding/dropping tributary (or service) channel to/from a data nodes, just like a series "Private Line or Private Circuit for Renting from Carrier". Tributary can be multi-service with a constant bandwidth of symmetry and asymmetry. The different tributaries can be assigned to different priorities.

3.28 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. A Sink corresponds to reference point T1, a source to reference point T2. This adaptation function can include the signal and rate transform, synchronous function between two sides of peer.

3.29 Tributary Cross-Connection Relationship (TCCR): A table reflecting Tributary cross-connection relationship of all nodes on a ring or other topologies. It is global table of a dual-ring structure or other topologies, that is, source and sink connection relationship of all available tributaries.

3.30 tributary membership copy: A duplicate function implementation from Source Tributary (ST) to every Tributary in the corresponding membership group within a node.

3.31 tributary multicast/broadcast: A discriminator of distinguishing unicast or Multicast/Broadcast packets while a packet is coming up from a RPR Rx Framer via the ringlet, so as to provide TBM function. The TBM Function Unit built in a node is defined to support one or more independent hierarchies of multicast which could involve the same or different TT at the same time. TBM Function Unit implements a duplication function within a node (station) from a Tributary getting a payload of a frame from the related topologies to other multiple Tributaries with the same TT value set to having a relation of membership group. A group of TN with the same TT value within a node can be set to become a membership group of multicast/broadcast. It is required that a designated Tributary in the membership group should receive data frames at the reference point G1 from the related topologies (A designated Tributary in the membership group is only allowed to get packets from ST, and is not permitted to receive all other packets). This Recommendation defines this designated Tributary as a Source Tributary (ST). Once getting data frames, the ST duplicates those frames to every Tributary in the corresponding membership group within a node. The ST should be set and designated to a given value of TT and TN by network management entity during the project installation phase or on-line operation phase. The one or more STs can be designated or changed dynamically within a node according to the customer requirements.

3.32 tributary Rx framer: An abstract of physical framer of Tributary at Rx side, it stands for a framer of TCE or Ethernet framer.

3.33 tributary Tx framer: An abstract of physical framer of Tributary at Tx side, it stands for a framer of TCE or Ethernet framer.

3.34 Tributary Number (TN): A number of same types of Tributary Port on a node. This number is 7 if the 7th ISDN is provided in a node.

3.35 Tributary Type (TT): A type of an independent adding/dropping tributary channel to/from the RPR data nodes. This type can be TCE service.

3.36 Tx schedule: A control function for transmitted frames in a node according to the priority level of:

a) forwarded frames from upstream node;

b) multicast/broadcast frames; and

c) transmitted frames from the local station.

If there are several frames to be sent in a node at the same time, the schedule unit will check priority of frame and decide which frame will go first to the downstream along the ringlet.

3.37 XP Rx processor: A set of logical functions used to XP processing in Rx direction. It includes Rx entity from RPR MAC between reference point G1/G2 and T1/T2, discrimination of multicast/broadcast based on Tributary, TT/CS/NM value, TN value, FSN value and other associated XP protocol processing.

3.38 XP Tx processor: A set of logical functions used to XP processing in Tx direction. It includes Tx entity outgoing to RPR MAC, Tx schedule unit, functions of determination of NA, TTL, TT, TN and FSN, multicast/broadcast from the view of RPR MAC layer. The other associated XP protocol processing is also included.

3.39 1+1 standby (tributary based, unidirectional): A 1+1 standby architecture has one normal traffic signal (packet), one working tributary, one standby tributary and a logical bridge. At the source side, the normal traffic signal (packet) is logically bridged to both the working and standby tributary. At the sink side, the normal traffic signal (packet) is selected from the better of the two tributaries. Due to the logical bridging, the 1+1 architecture does not allow an extra unprotected traffic signal (packet) to be provided.

3.40 1:N standby (tributary based, unidirectional): A 1:N standby architecture has N normal traffic signals (packet), N working tributaries and 1 standby tributary which may have an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the N working tributaries. The signals (packet) on the working tributaries are the normal traffic signals (packet). The signal (packet) on the standby tributary may be either one of the normal traffic signals (packet), an extra traffic signal (packet), or the null signal (packet) (e.g., an all-ONEs signal, a test signal (packet), one of the normal traffic signals (packet)). At the source side, one of these signals (packet) is connected to the standby tributary. At the sink side, the signals (packet) from the working tributaries are selected as the normal signals (packet). When a defect condition or a fault indication is detected on a working tributary or under the influence of certain external commands, the transported signal (packet) is bridged to the standby tributary. At the sink side, the signal from this standby tributary is then selected.

3.41 automatic standby switching (tributary based) within 50 ms: Autonomous switching of a signal (packet) from a failed working tributary to a standby tributary when a defect condition or a fault indication is detected on a working tributary or under the influence of certain external commands and subsequent restoration using control signals carried by the corresponding control signalling packet.

4 Abbreviations

4.1 Abbreviations specified in RPR [9]

This Recommendation makes use of the following abbreviations specified in RPR [9]:

DA Destination Address

FCS Frame Check Sequence

HEC Header Error Check

IEEE Institute of Electrical and Electronics Engineers

LAN Local Area Network

MAC Medium Access Control

MAN Metropolitan Area Network

MIB Management Information Base

MTU Maximum Transfer Unit

PDU Protocol Data Unit

PHY	Physical Layer
POS	Packet Over SONET
RI	Ringlet Identifier
SA	Source Address
SDU	Service Data Unit
SNMP	Simple Network Management Protocol
SPI	System Packet Interface
TTL	Time-To-Live
WAN	Wide Area Network
WTR	Wait To Restore

4.2 Abbreviations specified in ITU-T Rec. I.321

This Recommendation makes use of the following abbreviation specified in ITU-T Rec. I.321:

ATM Asynchronous Transfer Mode

4.3 Abbreviations specified in ETSI

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

DVB Digital Video Broadcast

4.4 Abbreviations specified in this Recommendation

This Recommendation uses the following abbreviations:

AP	Access Point
CP	Connection Point
CS	Control Signalling
CT	Configuration Table
CTI	Configuration Table Inquiry
CUT	Configuration Updating Table
ETBS	Ethernet Tributary Based Standby
FE	Fairness Eligible
ICT	Initial Configuration Table
LMXP	Layer Management of X.87/Y.1324 Protocol
LSFFU	Line-Speed Filtering Function Unit
MAC	Media Access Control
MDCT	MDL Trail Multipoint Connection Point
MDL	MAC Data Link Layer
MDLLC	MDL Link Connection
MDLLF	MDL Link Flow
MDLNC	MDL Network Connection
MDLNF	MDL Network Flow

MDLSC	MDL Subnetwork Connection
MDLSF	MDL Subnetwork Flow
MPCP	Multipoint Connection Point
MSR	Multiple Services Ring
MSR-RPR	Multiple Services Ring over RPR
NA	Node Address of Resilient Packet Ring
NM	Network Management
NRV	Node Reachability Verification
OAM	Operation, Administration and Maintenance
OUI	Organizationally Unique Identifier
PFI	Payload FCS Indicator
PLAS	Pure Local Address Structure (32-bit)
PT	Payload Type
RPR	Resilient Packet Ring
Rx	Receive data
ST	Source Tributary
TBM	Tributary Based Multicast
TBS	Tributary Based Standby
TCCR	Tributary Cross-Connection Relationship
TCE	TDM Circuit Emulation
TCP	Termination Connection Point
TDM	Time Division Multiplex
TFP	Termination Flow Point
TMG	Tributary Merging Group
TN	Tributary Number
TRL	Tributary Loopback
TT	Tributary Type
TTBS	TCE Tributary Based Standby
Tx	Transmission data
U/M/B	Unicast/Multicast/Broadcast
XP	X.87/Y.1324 Protocol entity as a RPR MAC client
XPLC	XP Link Connection
XPNC	XP Network Connection
XP-PDU	XP – Protocol Data Unit
XP-SAP	XP – Service Access Point
XPSC	XP Subnetwork Connection
XP-SDU	XP – Service Data Unit

XPT XP Trail

5 Network framework of multiple services ring based on RPR

5.1 Elements of ring over RPR MAC

MSR based on RPR employs a dual-ring structure consisting of a pair of unidirectional counter-rotating ringlets, more than one node of each with RPR MAC, RPR MAC Client and at least one Tributary. "MSR-RPR" uses OUI MAC addresses and the multicast address in support of tributary services and uses RPR frame format that allows X.87/Y.1324 to define payload within an Ethertype. MSR uses Fairness Algorithm (FA) to support services of Class A, Class B and Class C. X.87/Y.1324 is used in configurations where tributary service is managed by provisioning. Architecturally, the link, broadcast topologies are also supported. Each node could add and drop one or more independent tributaries (e.g., DVB port) and control signalling frames and network management frames. X.87/Y.1324 supports multicast and broadcast of these Tributary services and forwarding data packets.

RPR is defined in [9] and supersedes any descriptive text in X.87/Y.1324. As a result, any descriptive text on RPR functionality in this Recommendation should be considered informative.

5.2 Frame types on a ring and multiple services in tributary

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

Table 1/X.87/Y.1324 – Types of multi-service in Tributary

Tributary types	Capabilities		
TCEs	Full duplex point-to-point	Multicast of node based	Broadcast of node based
Ethernet	Full duplex point-to-point	Multicast of node based	Broadcast of node based
NOTE 1 – The bandwidth of aggregate pipe depends on deployment service requirements, the aggregate Tributary bandwidth be half of the aggregate pipe bandwidth to provide standby bandwidth availability where needed. Where services requirements allow, the aggregate of Tributary bandwidth can exceed the aggregate bandwidth. NOTE 2 – Multicast is half duplex point-to-multipoint of node based. Broadcast is half duplex point of node based to all other points on a ring.			

Transmitted and received frames on a ring have:

1) frames of multi-service station by station;
2) control signalling frame; and
3) network management frame specified in Table 2, to show full capabilities of point-to-point, multicast and broadcast along a ring.

Table 2/X.87/Y.1324 – Frame types

Frame types	Capabilities		
Frames of multi-service station by station	Point-to-point	Multicast	Broadcast
Control Signalling Frame	Point-to-point	Multicast	Broadcast
Network Management Frame	Point-to-point	Multicast	Broadcast

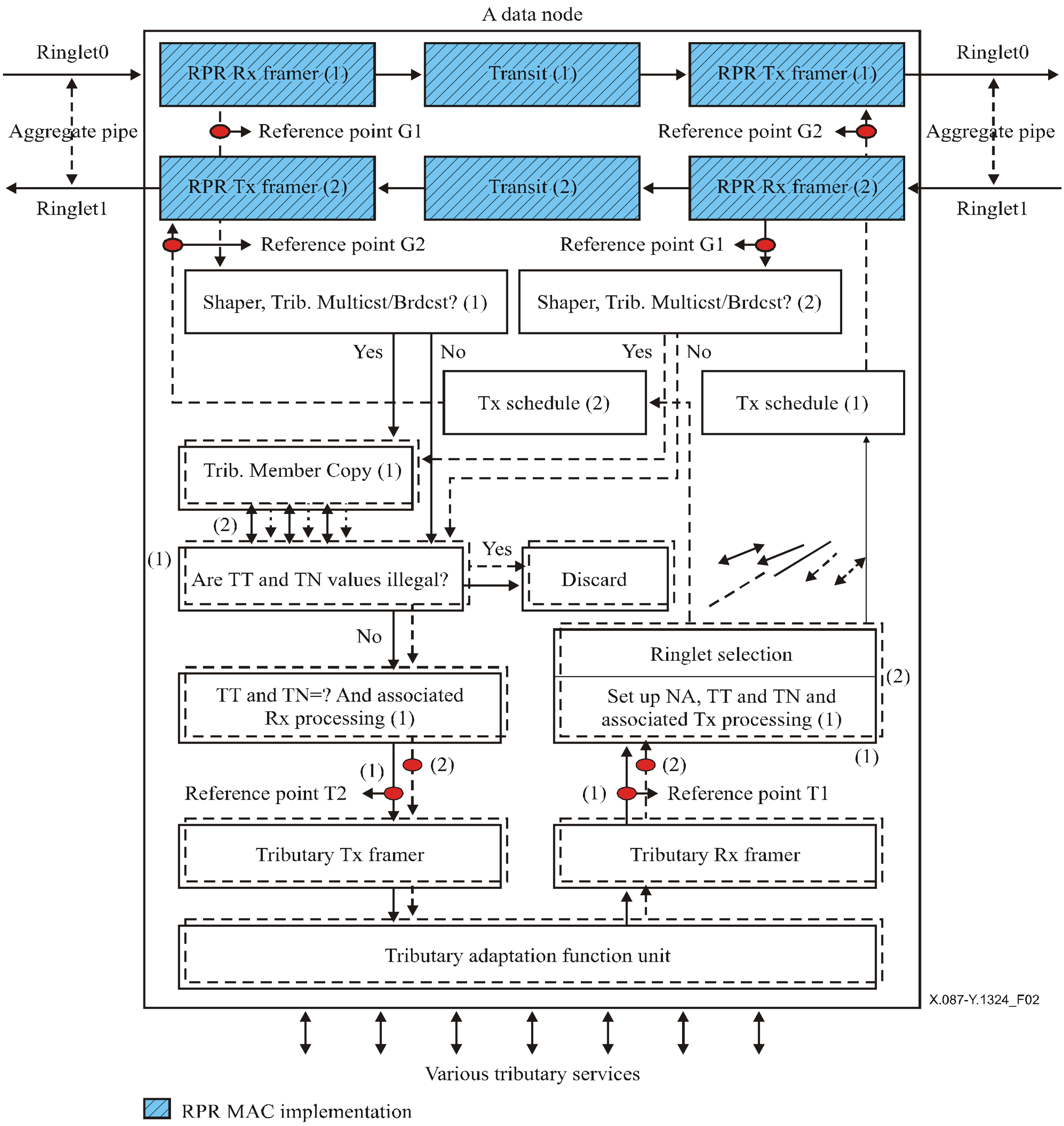


Figure 2/X.87/Y.1324 – Tx and Rx diagram of a data node

5.3 Components of a data node in MAC client

A MSR data node is the 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 over RPR MAC. X.87/Y.1324 node also has functions of receiving, transmitting and forwarding of network management frame, control signalling and data frame within a node. The corresponding change should be made as the different connection configuration is applied for the different topologies. The basic components and elements of a node are as follows.

5.3.1 Aggregate Pipe: A physical connection of two adjacent MSR nodes.

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 Carrier". Tributary can be a G.702 port. The different tributaries can be assigned different priorities.

5.3.3 Ringlet1: An inner single ring of RPR.

5.3.4 Ringlet0: An outer single ring of RPR.

5.3.5 MAC Client: The layer entity of XP that invokes the MAC service interface.

5.3.6 Transit: A passing of a frame through a station via the ringlet.

5.3.7 Schedule Unit: A control function for transmitted frames within a node according to the priority level of forwarded frames from upstream station, multicast/broadcast frames and transmitted frames from the local station. If there are several frames to be sent within a node at the same time, the schedule unit will decide which frame will be delivered first to the downstream along the ring.

5.3.8 RPR Rx framer: A RPR MAC framer in Rx side, it terminates a frame of RPR [9] through a station via the ringlet.

5.3.9 RPR Tx framer: A RPR MAC framer in Tx side, it sources or passes a frame of RPR [9] through a station via the ringlet.

5.3.10 Tributary Rx framer: An abstract of physical framer of Tributary at Rx side, it stands for a framer of TCE, Frame Relay or Ethernet framer.

5.3.11 Tributary Tx framer: An abstract of physical framer of Tributary at Tx side, it stands for a framer of TCE, Frame Relay or Ethernet framer.

5.3.12 XP Rx processor: A set of logical functions (of RPR MAC client) used to XP processing in Rx direction. It includes Rx entity to get packets from RPR MAC, discrimination of multicast/broadcast based on tributary, TT/CS/NM value, TN value, FSN value and other associated XP protocol processing.

5.3.13 XP Tx processor: A set of logical functions (of RPR MAC client) used to XP processing in Tx direction. It includes Tx entity outgoing to RPR MAC, Tx schedule unit, functions of determination of NA, TTL, TT, TN and FSN, multicast/broadcast from the view of RPR MAC layer. The other associated XP protocol processing is also included.

5.3.14 Addressing (48-bit OUI): The IEEE 48-bit OUI is generally used as MAC addresses. It contains: Individual/Group bit – identifies unicast and multicast/broadcast frames, Universal/Local bit – indicates that the address was assigned by IEEE RAC and the manufacturer and should be unique, IEEE RAC assigns a value of 24 bits, manufacturer assigns the remaining 22 – local indicates a locally administered address. It is the responsibility of the administrator to ensure uniqueness. X.87/Y.1324 will use universal address and the broadcast address in support of tributary services.

5.4 Reference point in MAC client of a data node

The four different Reference Points are defined in a node.

5.4.1 Reference Point G1: A reference point between RPR MAC and its client. It stands for processing sink of RPR MAC framer in RPR MAC client side.

5.4.2 Reference Point G2: A reference point between RPR MAC and its client. It stands for processing source of RPR MAC framer in RPR MAC client side.

5.4.3 Reference Point T1: A reference point between Tributary Rx Framer and XP processor. It stands for processing sink of XP before Tributary Rx framer of TCE or Ethernet, etc.

5.4.4 Reference Point T2: A reference point between Tributary Tx Framer and XP processor. It stands for processing source of XP after Tributary Tx framer of TCE or Ethernet, etc.

5.5 Transport functional architecture of MSR networks

5.5.1 General

The functional architecture of MSR transport networks is described using the generic rules defined in ITU-T Rec. G.805. The specific aspects regarding the characteristic information, client/server associations, the topology, the connection supervision and multipoint capabilities of MSR transport networks are provided in this Recommendation.

In a MSR network two levels of multiplexing are used. A node-level multiplexing is used to aggregate multiple packet flows in a single network element. A unique tag (*tributary number*) is used to distinguish between client flows/connections. A ring level MAC layer is used to multiplex aggregates from multiple nodes on a shared ring.

MSR is defined in a modular way; hence a variety of MAC protocols can serve the XP layer. RPR could be one realization of the MAC layer. In that case the Destination MAC address field is used, plus TT/CS/NM and TN to perform the multiplexing function.

5.5.2 MSR layer networks

Two layer networks are defined in the MSR transport network architecture:

- XP Layer Network.
- MAC/Data-Link Layer (MDL) Network. The MDL layer could be either connection-oriented or connectionless.

The XP layer network is a packet based path layer network. The MDL layer network is a section layer network.

A MSR packet consists of payload, XP header and MDL header.

5.5.2.1 XP layer network

The XP layer network provides the transport of adapted information through a XP trail between XP access points. The adapted information is a non-continuous flow client frames (the minimum and maximum frame size is protocol dependent). The XP layer network characteristic information is a non-continuous flow of adapted information extended with XP header, and CS or NM packets. The XP layer network contains the following transport processing functions and transport entities (see Figure 3a):

- XP trail.
- XP trail termination source (XPT source): generates CS or NM packets.
- XP trail termination sink (XPT sink): terminates CS or NM packets.
- XP network connection (XPNC).
- XP link connection (XPLC).
- XP subnetwork connection (XPSC).

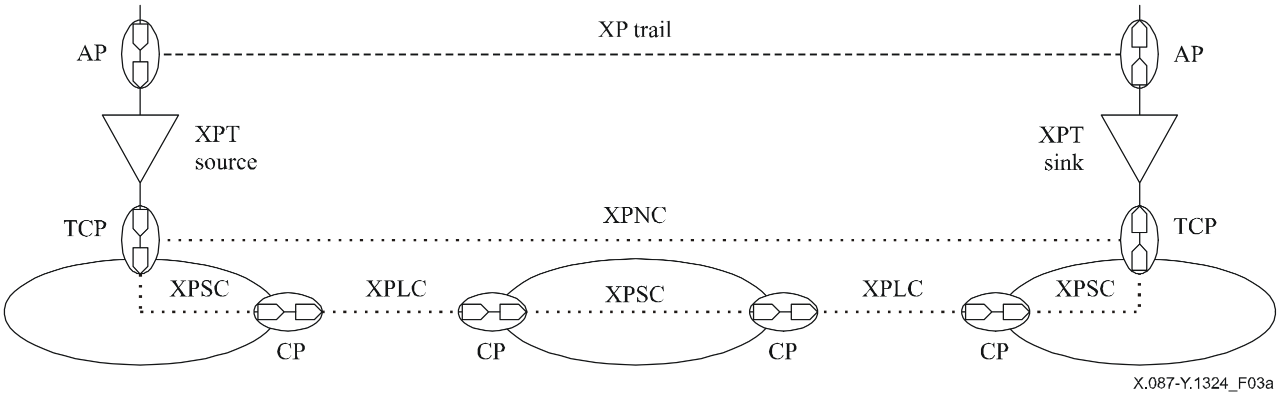


Figure 3a/X.87/Y.1324 – XP layer network example

5.5.2.1.1 XP trail termination

The XP trail termination source sends adapted information at its output, adds the *tributary traffic*, inserts CS or NM packets and generates the characteristic information of the XP layer network at its output. The XP trail termination source can be used without binding its input to an adaptation function, e.g., for testing purposes.

The XP trail termination sink accepts the characteristic information of the XP layer network at its input, terminates the *tributary traffic*, extracts the CS or NM packets and presents the adapted information at its input.

The XP trail termination (XPT) consists of a co-located XP trail termination source and sink pair.

5.5.2.1.2 XP header format

Please refer to clause 7.

5.5.2.2 MDL layer network

The MDL layer network provides the transport of adapted information through an MDL trail between access points. The adapted information is a non-continuous flow of XP layer network characteristic information plus the *tributary number*. The MDL layer network characteristic information is a non-continuous flow of adapted information and OAM information. The MDL layer network contains the following transport processing functions and transport entities (see Figure 3b):

- MDL trail.
- MDL trail termination source (MDLT source): generates CS or NM packets.
- MDL trail termination sink (MDLT sink): terminates CS or NM packets.
- MDL network connection/flow (MDLNC/MDLNF).
- MDL link connection/flow (MDLLC/MDLLF).
- MDL subnetwork connection/flow (MDLSC/MDLSF).

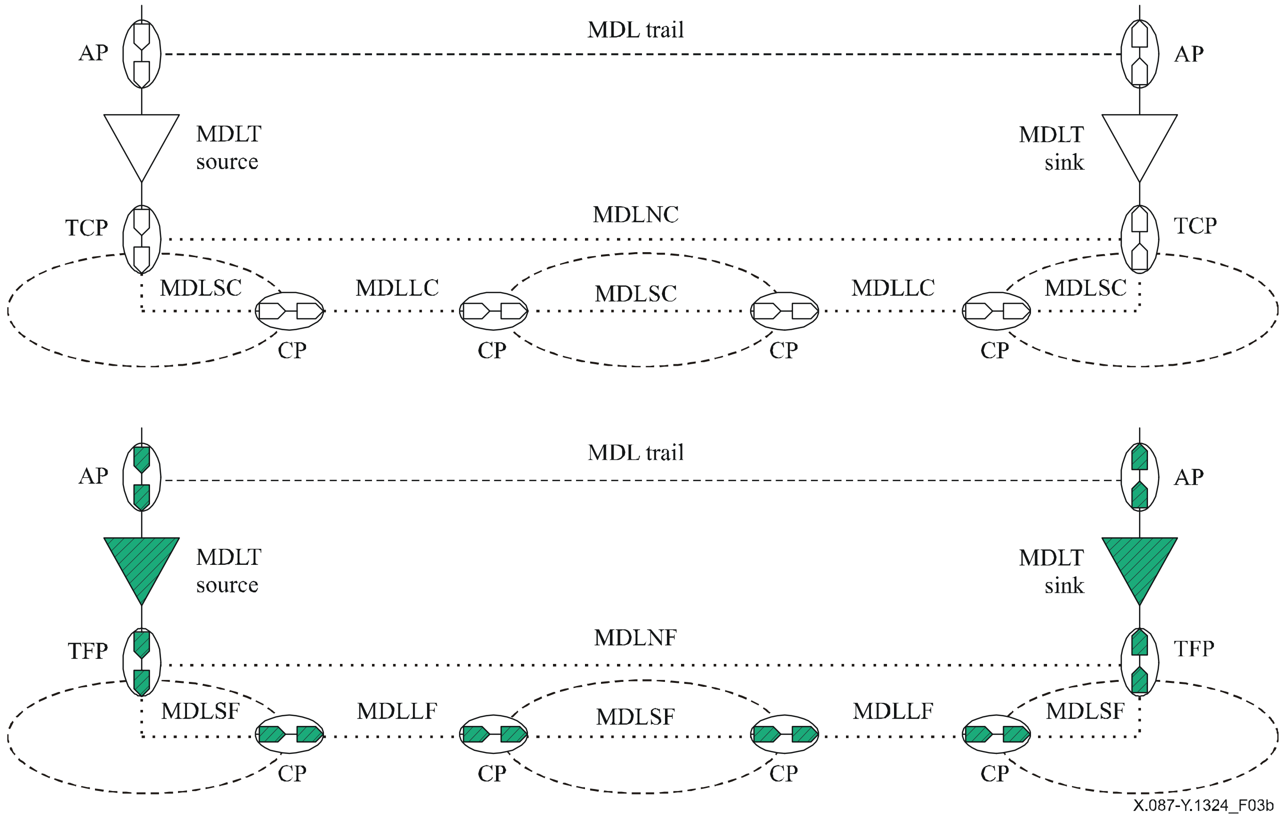


Figure 3b/X.87/Y.1324 – MDL layer network example Connection-oriented (upper)/connectionless (bottom)

5.5.2.2.1 MDL trail termination

The MDL trail termination source generates adapted information at its output, inserts CS or NM packets and generates the characteristic information of the MDL layer network at its output. The MDL trail termination source can be used without binding its input to an adaptation function, e.g., for testing purposes.

The MDL trail termination sink accepts the characteristic information of the MDL layer network at its input, terminates the CS or NM packets and presents the adapted information at its input.

The MDL trail termination (MDLT) consists of a co-located MDL trail termination source and sink pair.

5.5.3 Client/server associations

A key feature of the MSR transport assembly provides the information transfer capability required to support various types of services of different bit rates by various server layers.

In terms of client/server associations, the MSR transport assembly offers a XP trail and uses a trail in a server layer network. This is illustrated in Figure 4.

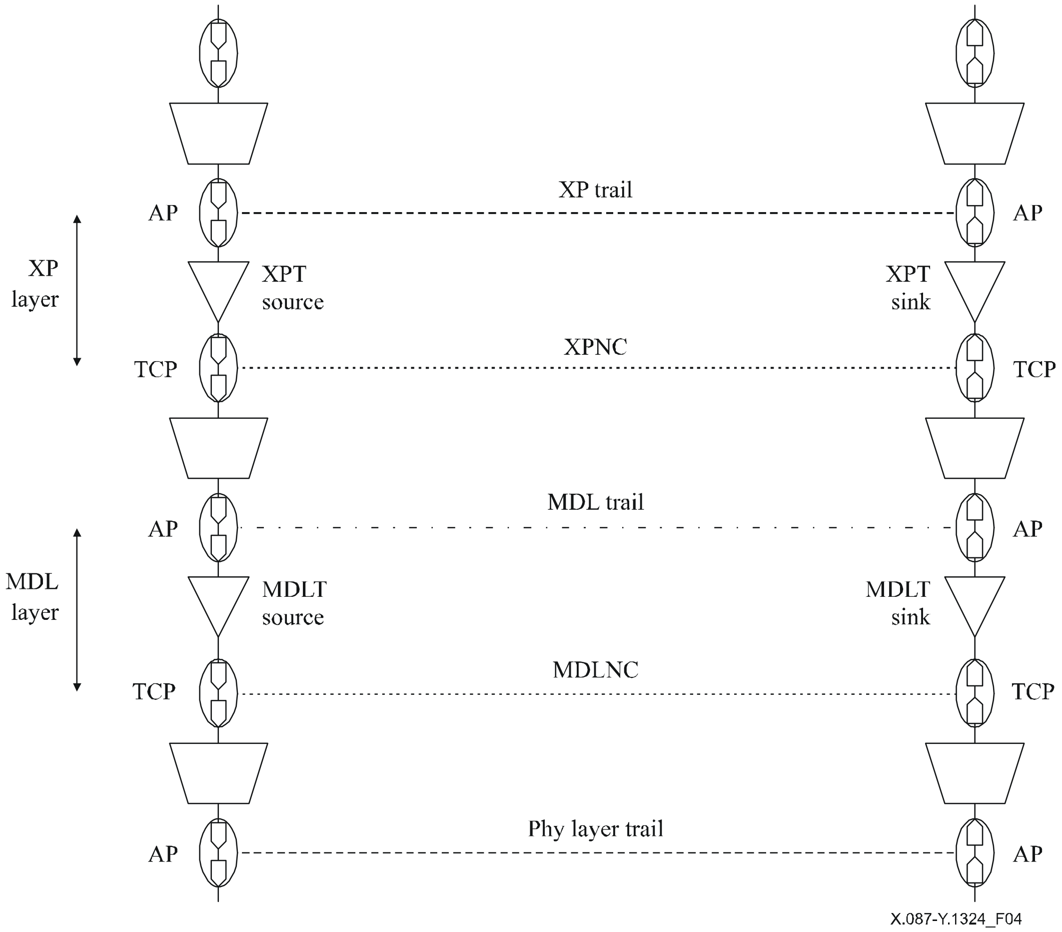


Figure 4/X.87/Y.1324 – Client/server association in a MSR transport ring

5.5.3.1 XP/client adaptation

The XP/Client adaptation is considered to consist of two types of processes: client-specific processes and service-specific processes.

Client-specific processes include:

- Detection of client defects. Two generic types of defects are:
  - Loss of Client Signal;
  - Loss of Client Synchronization.

Service-specific XP/Client adaptation source performs the following functions between its input and its output:

- Adding XP header.
- Inserting CS/NM packets, if needed.

Service-specific XP/Client adaptation sink performs the following functions between its input and its output:

- Remove XP header.
- Terminate CS/NM packets.

The bidirectional XP/Client adaptation function is performed by a co-located pair of source and sink XP/Client adaptation functions.

5.5.3.2 MDL/XP adaptation

The MDL/XP adaptation source performs the following functions between its input and its output:

- Packet multiplexing,
- Adding MDL header.

The MDL/XP adaptation sink performs the following functions between its input and its output:

- Packet demultiplexing according to *tributary number* value.
- MDL header extraction.

The MDL/XP adaptation consists of a co-located MDL/XP adaptation source and sink pair.

5.5.3.3 MDL/physical layer adaptation

Beyond the scope of this Recommendation.

5.5.4 Topology

MSR supports unicast, half-duplex multicast and broadcast connections.

In half-duplex multicast service, traffic from single source port is multicasted to several sink ports.

5.5.4.1 Multipoint connection point (MPCP)

The MPCP is a reference point (Figure 5) that binds CP or a set of CPs.

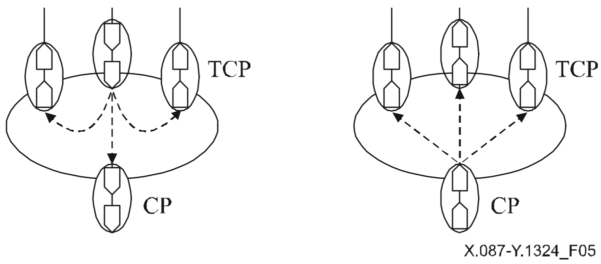


Figure 5/X.87/Y.1324 – XP layer multipoint connection points examples

Other functions are for further study.

5.5.4.2 Point-to-multipoint connections

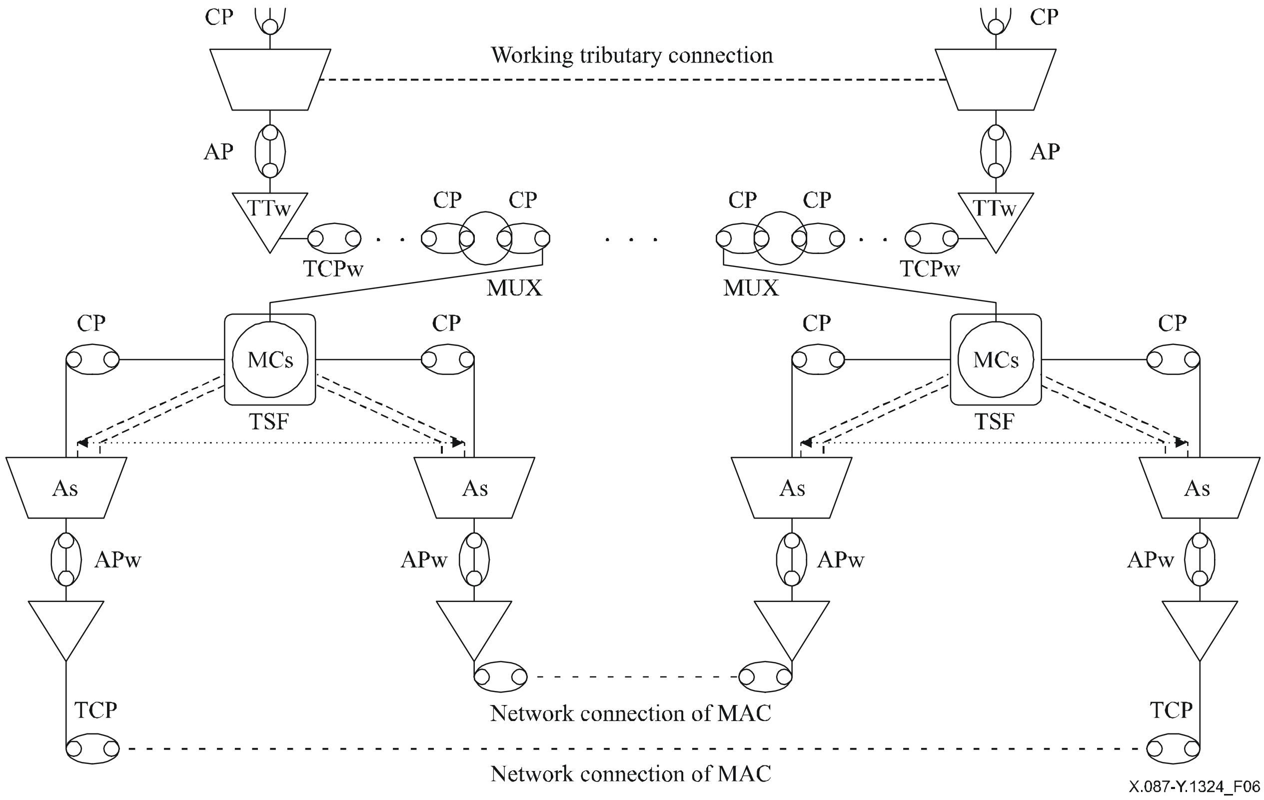
A point-to-multipoint MDL Network Connection/Flow multicasts customer traffic from a single node to a group of nodes. A point-to-multipoint XP Network Connection multicasts customer traffic within a single node, from an MDL/XP adaptation sink to multiple XP/Server adaptation sinks.

5.5.5 Connection supervision

The connection may be directly monitored by use of listen-only (non-intrusive, as defined in ITU-T Rec. G.805) monitoring of the original characteristic information including traffic, CS/NM packets. The information derived from this monitor reflects the status of the connection from the original trail termination source to the connection point at which the monitor is attached. The status of a particular part of a connection may be derived by correlating of receiving data/CS/NM packets, the results obtained from non-intrusive monitors attached to the connection points that delimit the segment. This status may include both the error performance and connectivity of the segment if the original packet was provided with a unique identifier.

5.5.6 Standby

A working trail of tributary connection is replaced by a protecting trail if the working trail fails or if the performance falls below the required level (it is configurable). It is a standby switching method applied in the client layer network. This is modelled by introducing a standby sublayer as shown in Figure 6. The trail termination is expanded, by introducing the standby adaptation function, unprotected trail termination function and protected trail termination function. A standby matrix is used to model the switching between the protecting and working connections. The status of the trails in the standby sublayer is made available to the standby matrix (TSF, Tributary Signal Fail, in Figure 6) by the unprotected trail termination. The communication between the control functions of the standby matrices is not required. The protected trail termination provides the status of the protected trail. Trail standby is a standby method applied in a transport layer network when a defect condition is detected in the same layer network (i.e., switching is activated in the same transport layer network).



Apw	Working access point	MUX	Multiplex of multiple tributary
As	Standby adaptation	TCPw	Working trib connection point
CP	Connection point	TSF	Tributary signal failure
MCs	Switch matrix connection	TTw	Working trib termination

Figure 6/X.87/Y.1324 – Tributary based 1+1 standby

5.6 Operation of network management frames in MAC client

5.6.1 Initial Configuration Table (ICT) operation

ICT is a mapping table reflecting the initial and available value of TT and TN within a node and TCCR between nodes along a ringlet during engineering installation. The ICT must be pre-installed before MSR engineering operation. The incorrect ICT will lead to fault of Tributary services on a ring. CT_Request frame with an ICT parameter reflecting initial TCCR of all nodes on a ring is sent to other nodes by broadcast/multicast 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) having received CT_Request frame will build corresponding mapping relations of TCCR in the local node and send 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_ct times of retransmission (N_ct is also programmable).

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_ct times of retransmission, it is believed that ICT operation for Node B is successful.

5.6.2 Configuration Updating Table (CUT) operation

CUT is a mapping table reflecting the available value modification of TT and TN in a node and TCCR between nodes on the MSR ring during an on-line operation. The incorrect CUT 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 (one of them called Node B) by broadcast/multicast 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 having received CT_Request frame will build corresponding mapping relations of TCCR in the local node and send a point-to-point response by CT_Response frame to Node A.

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_ct times of retransmission (N_ct is also programmable).

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_ct times of retransmission, it is believed that CUT operation for Node B is successful.

5.6.3 Configuration Table Inquiry (CTI) operation

CT_Request frame with a Null parameter is sent to other nodes (one of them called Node B) by unicast/multicast/broadcast 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 having received CT_Request frame with a Null parameter will send a point-to-point response by CT_Response frame with a CTI parameter reflecting actual configuration table of the local node on a ring to Node A.

5.7 Fault management in MAC client

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

5.8 Performance management in MAC client

Once 15 minutes or 24 hours expired, each node in a ring will issue Performance_Report frame with a performance parameter defined in 7.11.1.6 to designated node (connected to network management interface). The network management entity can pass Performance_Request Frame with a performance parameter from designated node to a targeted node if needed anytime. The targeted node responds by Performance_Response Frame with a performance parameter to designated node.

6 The protocol framework

6.1 The protocol framework of aggregate pipe

The protocol framework of XP is shown in Figure 7. This Recommendation treats XP as an upper layer protocol of RPR [9] MAC. The use of control signals is not required. The self-synchronous scrambling/descrambling function is not applied in XP layer during insertion/extraction into/from the MAC payload of RPR. Communication service facilities between XP and RPR MAC layer are accomplished by means of primitives (MA_DATA request and MA_DATA indication, MA_Control request and MA_Control indication shown in Figure 8) with parameters of Ring Control Field, Destination MAC Address, Source MAC Address, Protocol Type field, topology status, TT/CS/NM, TN value, FSN and payload or parameters of XP layer, as shown in clause 7. Specification of primitives specifies the interaction between XP and MAC layer to invoke and provide a service, and presents the elements of primitives.

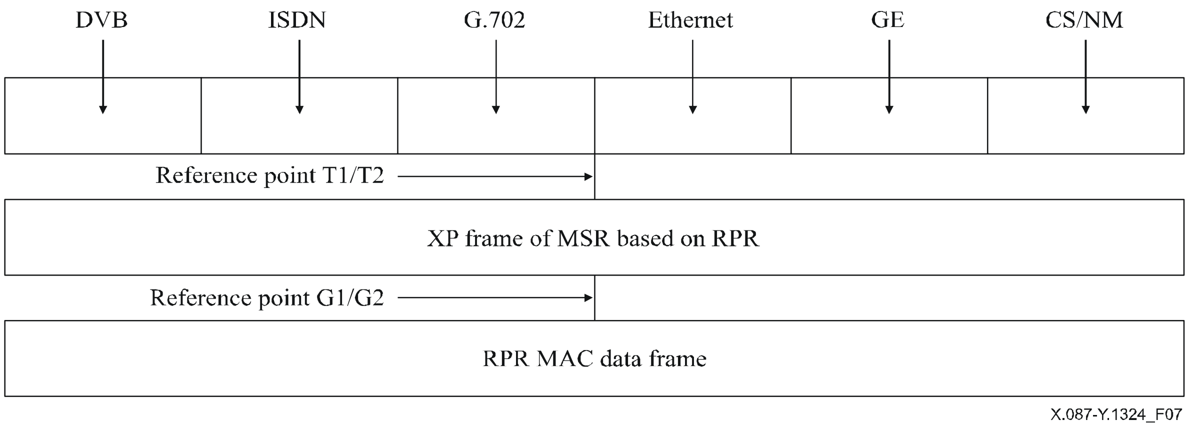


Figure 7/X.87/Y.1324 – Generic protocol stack of MSR based on RPR

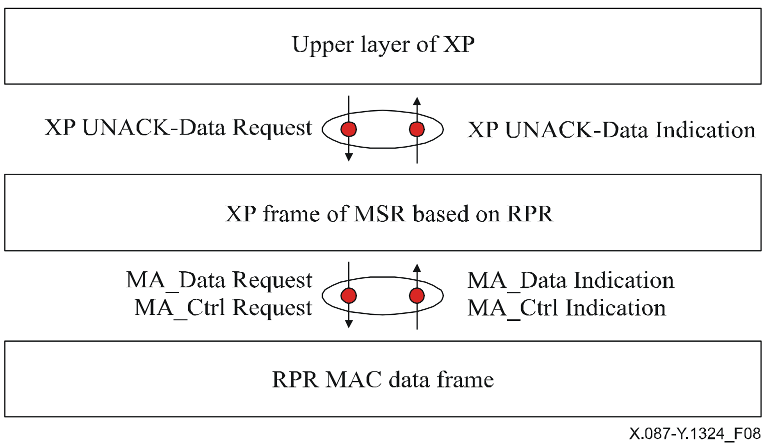


Figure 8/X.87/Y.1324 – Relationship between XP and RPR MAC, upper layer and XP

XP located at RPR MAC client is the data link protocol also, which provides point-to-point transferring over RPR MAC frame. The establishment and disconnection of tributary service are accomplished by the associated control signalling (just like Soft Permanent Virtual Circuit) or network management frames. Communications between data link and the associated upper protocols are accomplished by means of primitives according to the principle of ITU-T Rec. X.212.

The service facility of XP provided to its upper protocols via SAP (Service Access Point) is the XP-UNACK-DATA request primitive with "User data" (data frame in Tributary and frame of CS/NM) and "Priority" parameters set in a node, and the XP-UNACK-DATA indication primitive with "User data" (data frame in Tributary and frame of CS/NM) and "Priority" parameters from received frame. "User data" is the outgoing/incoming upper layer packet. The default maximum frame size of XP shall be aligned to the size that RPR does after taking into account the overhead of XP frame. The maximum frame size of jumbo payload shall align with clause 8 of RPR [9]. The octet stuffing procedure will not be used in this case.

An invalid frame is a frame which:

a) has fewer than eight octets (includes PT, PFI, 4-bit reserved field, TT/CS/NM, TN, 4-bit reserved field, FSN fields, HEC field) within the RPR MAC payload; or

b) contains a TT or TN that is mismatched or not supported by the receiver.

Invalid frames shall be discarded without notification to the sender. But for the lost or duplicated frames of a tributary, the results of performance monitoring should be reported to layer management entity of RPR MAC client and be operated according to 7.11.1.

The connection management entity is used to monitor the XP link status of receiving the peer link frame. It is a local matter only and does not have 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 XP entity enters the normal way of transmitter and receiver.

– If timer T200 expires before any frames (including MAC data and control frames) are received at the reference point G1, or status report from RPR MAC layer by MA_Control Indication or MA_Data Indication occurs with one or more opcodes, the XP 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 at the reference point G1, or status report from RPR MAC layer by MA_Control Indication or MA_Data Indication occurs with one or more opcodes, the XP entity shall:

  a) indicate this to the local connection management entity by means of the LMXP-ERROR indication primitive;

  b) indicate a notification to the local ETBP/TTBP Function Unit within the node by means of the EVENT_Report primitive with the TT and TN parameters; and

  c) 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.

6.2 MSR (client) interface to RPR MAC

Four service primitives are defined for the non-bridge client interfaces, as shown in clause 5 of RPR [9].

– MA_DATA.request.
– MA_DATA.indication.
– MA_CONTROL.request.
– MA_CONTROL.indication.

Plus MA_UNITDATA.request and MA_UNITDATA.indication primitives.

6.2.1 MA_DATA.request

This primitive defines the transfer of data from a XP entity to a single peer entity, or to multiple peer entities in the case of group addresses. The semantics and parameters of the primitives are defined in clause 5 of RPR [9]. This primitive is invoked by XP entity whenever data is to be transferred to a peer entity or entities. The receipt of this primitive shall cause the MAC entity to insert all MAC specific fields, and any fields that are unique to the particular medium access method, and pass the properly formed frame to the lower protocol layers for transfer to the peer MAC sublayer entity or entities. The MAC does not reflect frames back to the XP. If a client issues a MA_DATA.request primitive with a DA value equal to its local MAC address, the request is rejected.

6.2.2 MA_DATA.indication

This primitive defines the transfer of data from the MAC sublayer entity to XP entity. The semantics and parameters of the primitive are in clause 5 of RPR [9].

The MA_DATA.indication is passed from the MAC sublayer entity (through the MAC control sublayer) to XP entity or entities to indicate the arrival of a frame to the local MAC sublayer entity that is destined for XP. Such frames are reported only if they are validly formed, and their destination address designates the local MAC entity (local station address, broadcast or multicast). A XP may elect to accept or discard frames with FCS errors. The effect of receipt of this primitive by XP is unspecified. The MAC does not reflect frames back to XP. If a MAC receives a frame with a SA value of the local MAC address, it does not cause a MA_DATA.indication primitive to be sent to the originating client (XP). This primitive defines the transfer of control requests from the XP to the MAC control sublayer. Its purpose is to allow the XP to control the local MAC. This primitive does not provide a direct means for a XP to transmit a control frame from the local MAC onto any ringlet, although control frames (for example echo or flush) may be indirectly generated as a result of this request.

6.2.3 MA_Control.request

This primitive defines the transfer of control requests from the XP layer to the MAC control sublayer. Its purpose is to allow the XP to control the local MAC. This primitive does not provide a direct means for a XP to transmit a control frame from the local MAC onto any ringlet; although control frames (for example echo or flush) may be indirectly generated as a result of this request. This primitive defines the transfer of control commands from a XP entity to the local MAC Control sublayer entity. The semantics and parameters of the primitive are in clause 5 of RPR [9]. This primitive is generated by a XP whenever it wishes to use the services of the MAC control sublayer entity. The effect of receipt of this primitive by the MAC control sublayer is opcode-specific.

6.2.4 MA_Control.indication

This primitive defines the transfer of control status indications from the MAC control sublayer to the XP. The semantics and parameters of the primitive are defined in clause 5 of RPR [9]. The MA_CONTROL.indication is generated by the MAC control sublayer under specific conditions to each MAC control operation. The effect of receipt of this primitive by the XP is unspecified. The usage of these indications by the XP is beyond the scope of this Recommendation; however, they are made available to allow a XP to perform more complex actions beyond the capability of the MAC.

6.2.5 RPR MAC interface to the bridge client

RPR MAC internal sublayer service (ISS) is provided by a MAC entity to communicate with the MAC relay entity if tributary services of MSR need to bridge to another MSR. The interface for this sublayer is predefined in IEEE Std 802.1D-1998 and IEEE Std 802.1Q-1998. The MSR will use these specifications. The bridging operation of Tributary traffic depends on the ability to flood frames. The unidirectional flooding via either ringlet0 or ringlet1 is applied to send the frame to all other stations in the ring.

6.2.5.1 Primitives and parameters involved in internal sublayer service

On receipt of a MA_UNITDATA.request primitive from XP layer, the local MAC entity performs data encapsulation to form a MAC frame using the following parameters and default setting. On receipt of a MAC frame from an aggregate pipe, the frame is passed to the reconciliation sublayer which disassembles the MAC frame into parameters, as specified below, that are supplied with the MA_UNITDATA.indication primitive to XP layer.

6.2.6 MAC shapers supplied to the XP

The shapers and indications to the XP operate based on a per-ringlet. The behaviours of all shapers can be characterized by a common algorithm with instance-specific parameters. All shapers' credits are adjusted down or up by decSize and incSize respectively. The decSize and incSize values typically represent sizes of a transmitted frame and of credit increments in each update interval respectively. Crossing below the loLimit threshold will generate a rate-limiting indication, so that offered traffic can stop before reaching zero credits, where excessive transmissions are rejected. The hiLimit threshold limits the positive credits, to avoid overflow. When frames are ready for transmission, credits can accumulate to no more than hiLimit.

Optional idle frames from the MAC rate synchronization are shaped by shaperI (shaper of idles). Frames from the MAC control are usually shaped by shaperM (shaper of MAC). Those control frames directed to the class B or class C add paths are shaped by the shapers for those add paths. All class A add traffic is shaped by shaperA, to avoid having the XP exceed its class A allocated rates. shaperA is logically partitioned into shaperA0, shaperA1, and shaperM. MAC control and XP traffic both flow through shaperA. All class B add traffic is shaped by shaperB and/or by shaperC, to constrain the XP within its class B rates. All class C add traffic is shaped by shaperC, to constrain the XP within its weighted fair-share use of the unused and reclaimable bandwidth.

Each MAC rate shaper can be readily identified by its credit-value name. Some of the transmission paths are affected by only one of these shapers; others are influenced by multiple shapers. The detailed operations and descriptions are referred to as clause 6 of RPR [9].

6.2.7 Choice of strict and relaxed transmissions

Two types of frame transmission are supported, relaxed and strict to XP at the client level. If the strict mode is applied by the RPR MAC, duplication of user data frames and reordering of frames are not permitted. The complexity of supporting strict transmission is particularly burdensome during station or link failures, or ringlet selection. So MSR uses relaxed as a default mode with a minimal amount of reorder and/or duplication. If application is required to provide strict transmission, the mode switch will be made using an opcode of strictOrder carried by the related primitives.

6.2.8 Topology database interface to MSR

MSR uses topology database from RPR MAC in the case of two-fibre ring application and chain. These topology messages contain information about the originating station, and the configuration and capabilities making up the current topology image of that station. These messages are generated on initial start of topology discovery periodically and on detection of a change in station or ring status. The topology image represents:

1) a loop of stations; or

2) a chain of stations resulting from a ring broken at one or more points.

An MLME image of the topology is applied to do this function using the related MIB and primitive.

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 Sink Function. The Sink corresponds to reference point T1, the Source to reference point T2. This adaptation function includes the signal and rate transform, synchronous function between Tributary Rx/Tx Framer and tributary service interface.

7 Generic frame format

A XP frame uses a fixed sized header. The generic frame format is shown in Figure 9. All binary fields in the following descriptions are transmitted in Most Significant Bit (MSB) to Least Significant Bit (LSB) order, from top to bottom. The definitions of Ring Control Field, Destination Address, Source Address, Protocol Type Field, Header Checksum and FCS Field have been specified in RPR. This clause will focus on the PT, PFI, 4-bit reserved field, TT/CS/NM, TN, 4-bit reserved field, FSN field. Protocol type field is 0x88bc assigned by IEEE RAC. The maximum jumbo payload supported for the client PDU is 9100 octets including a frame overhead of MSR as described in clause 8 of RPR [9].

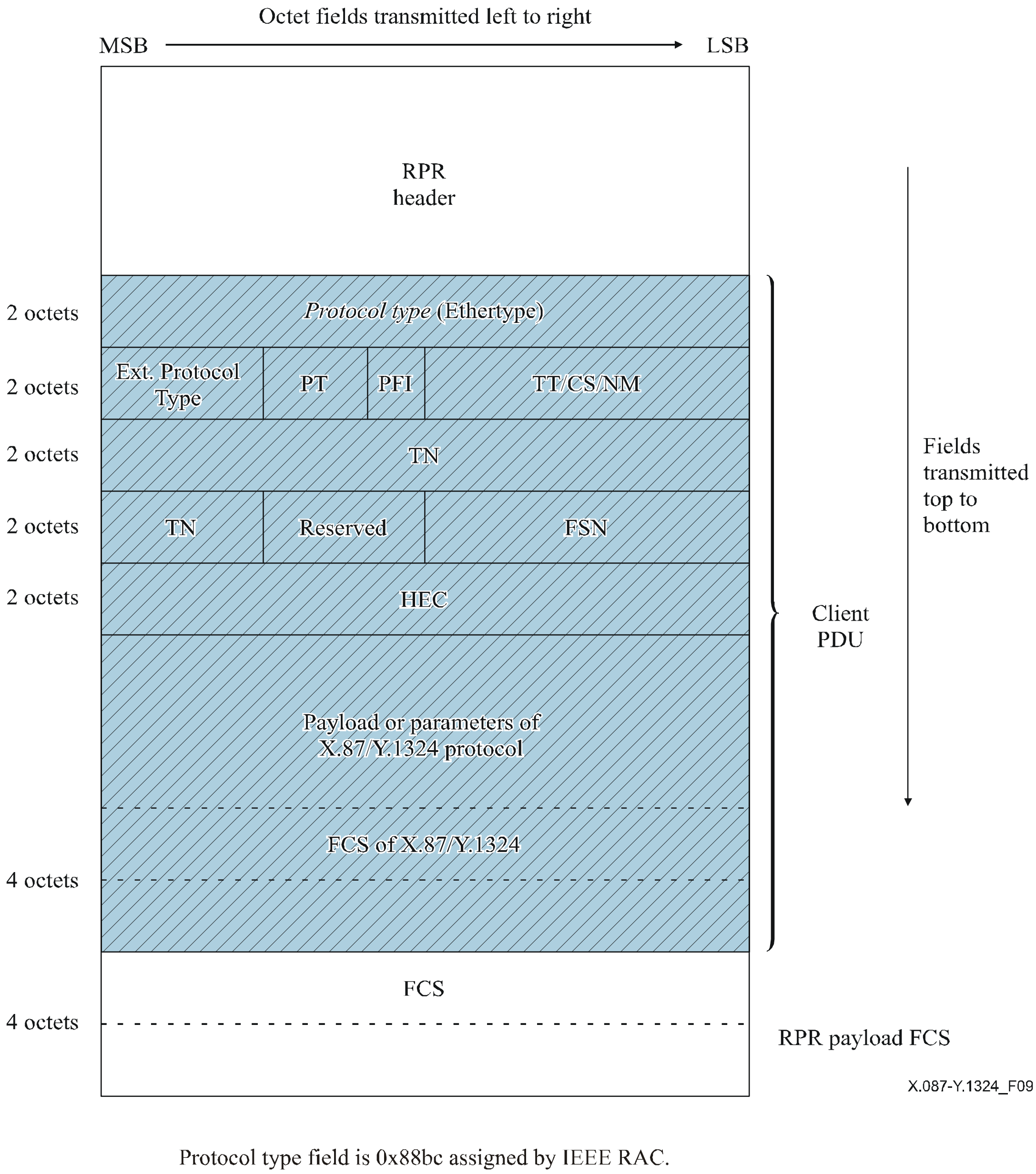


Figure 9/X.87/Y.1324 – Generic frame format of X.87/Y.1324

7.1 Destination address for use of this Recommendation

MSR does support for both local address and OUI MAC address, so this 48-bit field is an OUI MAC address or local address. It is required that all nodes of the same topology use the unified address, either OUI MAC address or local address. The nodes with a local address (including PLAS) shall communicate with each other within the scope of a said topology. The bridging and floodingForm shall not be used. If OUI MAC address is applied, IEEE RAC assigns a value of 24 bits, manufacturer assigns the remaining 22 – local indicates a locally administered address. It is the responsibility of the administrator to insure uniqueness.

The Individual/Group (I/G) address bit (LSB of octet 0) is provided to identify the destination address as an individual address or a group address. If the I/G address bit is "0", it indicates that the address field contains an individual address. If this bit is "1", the address field contains a group address that identifies one or more (or all) stations connected to the ringlet or other topologies. The all-stations broadcast address is a special, predefined group address of all 1's.

The Universally or Locally administered (U/L) address bit is the bit of octet 0 adjacent to the I/G address bit. This bit indicates if the address has been assigned by a local or universal administrator. Universally administered addresses have this bit set to "0". If this bit is set to "1", the entire address (i.e., 48 bits) has been locally administered.

In the case of I/G address bit is used to Individual and U/L address bit is used to Local application, and all other bits of Octet 1 and Octet 0 of 48-bit address field are set to all "0"; this Recommendation defines a 32-bit Pure Local Address Structure (PLAS). The PLAS 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 (Octet 2, 3, 4, 5). Each bit (binary "0" or "1") corresponds to a node. For example, LSB of Octet 2 through MSB of Octet 5, 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 number location of the 7th Node Address may correspond 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 in the case of PLAS. For implementation, people can use Ethernet MAC and Ipv4/Ipv6 address to perform external network management and identify a node from the network management level.

7.2 Extended Ethertype field

This 4-bit field is an extended protocol type field of Ethertype field number 0x88bc from the IEEE RAC within the new specification to handle different aspects of the application and future upgrades over RPR MAC. Binary "0000": Multiple services ring based on RPR, other value: reserved. Ethertype and Extended Ethertype field is a part of client PDU.

7.3 Payload Type (PT) field

This 3-bit field is used to indicate a type of XP frame, 0: User Data of X.87/Y.1324, 1: User Control, 2: Control Signalling (CS), 3: Network Management (NM), 4-7: reserved.

7.4 Payload FCS Indicator (PFI) field

This 1-bit field is used to indicate if the payload FCS of 4 octets is present, 0: not present, 1: present.

7.5 Reserved field

This 4-bit field is reserved for future use.

7.6 TT/CS/NM field

This 8-bit field is used for codes of TT (Tributary Type, or User Data of X.87/Y.1324), CS or NM. Which type is presented will be dependent on PT field indication.

7.6.1 Tributary Type (TT) field

When PT = binary "000", this 8-bit field is used to indicate a type of an independent adding/dropping tributary channel to/from the MSR data nodes. Tributary channel can be Ethernet or various TCEs. Its codes are as follows (see Table 3).

Table 3/X.87/Y.1324 – TT codes

Tributary types	Code
Reserved	00000000-00001000
G.702 PDH circuit – Synchronous circuit transport	00001001
G.702 PDH circuit – Asynchronous circuit 1.544 Mbit/s	00001010
G.702 PDH circuit – Asynchronous circuit 2.048 Mbit/s	00001011
G.702 PDH circuit – Asynchronous circuit 6.312 Mbit/s	00001100
G.702 PDH circuit – Asynchronous circuit 8.448 Mbit/s	00001101
G.702 PDH circuit – Asynchronous circuit 34.368 Mbit/s	00001110
G.702 PDH circuit – Asynchronous circuit 44.736 Mbit/s	00001111
G.702 PDH circuit – Synchronous circuit 1.544 Mbit/s	00010000
G.702 PDH circuit – Synchronous circuit 2.048 Mbit/s	00010001
G.702 PDH circuit – Synchronous circuit 6.312 Mbit/s	00010010
G.702 PDH circuit – Synchronous circuit 8.448 Mbit/s	00010011
G.702 PDH circuit – Synchronous circuit 34.368 Mbit/s	00010100
G.702 PDH circuit – Synchronous circuit 44.736 Mbit/s	00010101
Reserved for other PDH or DSL specification	00010110-00010111
Video signal – Distributive television services	00011000
Video signal – Conversational services of bit rates higher than primary rates	00011001
Video signal – Conversational services of p × 64 kbit/s signals	00011010
Reserved for other Video signals	00011011-00011111
Voiceband signal – 64 kbit/s A-law coded G.711 signals	00100000
Voiceband signal – 64 kbit/s μ-law coded G.711 signals	00100001
Reserved for other voiceband signals	00100010-00100111
Digital channel supported by 64 kbit/s-based ISDN – Transport of 64 kbit/s channel	00101000
Digital channel supported by 64 kbit/s-based ISDN – Transport of 384, 1536 or 1920 kbit/s channel	00101001
Reserved for other TCEs	00101010-00110011
Ethernet (10/100 Mbit/s, specified in IEEE 802.3)	00110100
GE (specified in IEEE 802.3)	00110101
Reserved	00110110-11111111
NOTE – The operation of user data between MAC and client will be implemented by invoking MA_Data Request and return of MA_Data Indication defined in clause 5 of RPR [9].	

7.6.2 CS field

When PT = binary "010", this 8-bit field is used to identify the types of control signalling shown in Table 4. The TN and FSN fields are not used and set to all-zeros value in this case.

Table 4/X.87/Y.1324 – Type of control signalling

CS Frame Types	Code
Reserved	00000000-00000100
SYNCHRONIZATION Request (Note 1)	00000101
SYNCHRONIZATION Indication (Note 1)	00000110
Topology Discovery Request (implemented by RPR MAC, via MA_Control Request) (Note 2)	00000111
Topology Discovery Indication (implemented by RPR MAC, via MA_Control Indication) (Note 2)	00001000
Reserved	00001001-11111111
NOTE 1 – It is optional timing (sync.) method for TCE tributary, the method (d) is the first option in clause 9.5.2. NOTE 2 – Operation of Control frame between MAC and client will be implemented via MA_Control Request and Indication defined in clause 5 of RPR [9]. NOTE 3 – The other codes of Tributary based standby, multicast, bandwidth policing, security and rate duplication are also shown in clauses 10, 11 and 12.	

7.6.3 NM field

When PT = binary "011", this 8-bit field is used to identify the types of network management frame (OAM) shown in Table 5. The FSN and TN fields are not used and set to binary all-zeros value in this case.

Table 5/X.87/Y.1324 – Type of network management frame (OAM frame)

NM Frame Types	Code
Reserved	00000000-00000110
CT_Request Frame	00000111
CT_Response Frame	00001000
Fault_Report Frame	00001001
Fault_Inquiry_Request Frame	00001010
Fault_Inquiry_Response Frame	00001011
Performance_Report Frame	00001100
Performance_Inquiry_Request frame	00001101
Performance_Inquiry_Response frame	00001110
LMXP_ERROR_Indication frame	00001111
TRL request frame	00010000
TRL response frame	00010001
TRL shortcut request frame	00010010
TRL shortcut response frame	00010011

Table 5/X.87/Y.1324 – Type of network management frame (OAM frame)

NM Frame Types	Code
NRV request frame	00010100
NRV response frame	00010101
NRV shortcut request frame	00010110
NRV shortcut response frame	00010111
Reserved	00011000-11111111

7.7 Tributary Number (TN) field

This 20-bit field is a number of same type of Tributary Ports within a MSR data node.

7.8 Reserved field

This 4-bit field is reserved for future use.

7.9 Frame Sequence Number (FSN) field

This 8-bit field is used to identify Frame Sequence Number (FSN) of Ethernet or TCE data frames or in numbered modulo N_fsn = 64 (default value, N_fsn is programmable and can be configured to 256 if application needs) from 0 to 63. The field is used to performance monitoring function for packet lost or duplicated of TCE based tributary. The related operation is given in 9.3. The FSN field will be set to all-zeros value if the signalling control frames or network management frames are presented.

7.9.1 Processing in the transmit side

The XP provides a sequence count value and a XP indication associated with each frame in the transmit side. The count value applies to FSN field and starts with 0, it is incremented sequentially to 63 and numbered modulo is 64 (default value). When the data link frames carrying Tributary payloads traverse a MSR topology, they may arrive at destination station disorderly, or lost or duplicated in one or more frames. Due to this reason, it is required that frames must be delivered in order.

7.9.2 Processing in the receive side

The Data Link entity in the receive side must detect the lost or duplicated frames modulo by modulo, and track the following status of dynamic data stream:

- frame sequence number and count;
- frame loss (if occur);
- frame duplication (if occur).

There are two ways to solve the real-time processing problem:

1) try to reorder and sort into the correct order; or
2) drop those disordering frames, when disordering case occurred.

In implementation, these two methods should all be supported. If method (1) does not meet reliability transport and performance requirement still, method (2) will be applied. Due to the limitation of native speed and acceptable delay of data link processing, this Recommendation does not support correction method for bit errors and frame losses. If the event of any lost or duplicated frame occurred, data link entity will report to the layer management entity by LMXP-ERROR indication (see clause 9).

7.10 HEC field

The header CRC is a 16-bit checksum. Its generator polynomial is: CRC-16 = $x^{16} + x^{12} + x^5 + 1$.

The checksum is computed over the PT, PFI, 4-bit reserved field, TT/CS/NM field, TN, another 4-bit reserved field and FSN field within the scope of XP, with the bits of the frame presented to the CRC generator in the same order as is described in RPR [9]. The initial value for the HEC CRC calculation is an all-zeros value. Single-bit error correction by the receiver is optional.

7.11 Payload of XP

When Tributary or Ethernet Packet is applied, payload field is used to encapsulate upper layer protocol data or TDM data listed in Table 3. Payload is octet-oriented and its size is variable. The default maximum frame size shall be aligned to the size that RPR does for both IPv4-based and IPv6-based applications (the support of jumbo payload shall align with clause 8 of RPR [9]). Except for Tributary, control signalling frame and network management are described below.

7.11.1 Control signalling and network management part

The XP does work by sending both data frame into a unidirectional ringlet and the associated network management/control frames into a counter-rotating ringlet. Generic format of CS/NM frames is the same as that of Figure 9, just payload field is replaced by the related parameters shown in Figure 9. The difference of the parameter field indicates various control signalling and network management frames as described below. The first octet of parameters field is used to identify how many parameters are used in a CS or NM frame. Each parameter following 1st octet consists of type (or tag), length and value of the parameter. If the total octet number of parameters field is not based on 4- octets, it is optional that the octets padding (Binary 00000000) may be used.

7.11.1.1 CT_Request Frame

The code value of CT_Request Frame is binary "00000111". CT_Request Frame can be applied to point-to-point operation of Tributary based and node based, and also used to node based multicast/broadcast operation. For the Tributary based multicast/broadcast operation, please refer to clause 11. The major portion of CT is TCCR ID. A TCCR ID consists of TNi ID (this is an identifier of Tributary p within node x), 2-bit U/M/B field (6-bit is reserved and set to binary 000000), 8-bit length field (this field is used to indicate the total number of Tributary TNj ID following length field) and one or more TNj ID (this is an identifier of Tributary q within node y). ID is a value of identifier, TNi, TNj, TNk and TNm are the ith Tributary Number of same TT of Node n, the jth Tributary Number of same TT of Node o, the kth Tributary Number of same TT of Node p and the mth Tributary Number of same TT of Node q. The values of n, o, p, q are 0 through 31, and stands for numbering of node. The values of i, j, k, l are 0 through $2^{20} - 1$, and stands for tributary number with the same TT value. In the case of node based broadcast mode, the expressive scheme is very simple and just one TNi ID is used only. It will be sent to reach all stations.

	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5		
TCCR ID = TNi ID +	10	000000B	8-bit length field

+ TNj ID + TNk ID + TNm ID ……

a) Node based multicast mode

	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5		
TCCR ID = TNi ID +	11	000000B	8-bit length field

b) Node based broadcast mode

	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5			
TCCR ID = TNi ID +	01	000000B	8-bit length field	+ TNj ID

c) Node based unicast mode

NOTE – TNi ID = NAx (x = 1, 2, 3, …, 256) + TT + TNp (p = 0, 1, 2, 3, …, $2^{20} - 1$), to identify the pth Tributary with the fixed TT and TN values within ith node. For the case of Multicast/Broadcast Mode, a tributary based outgoing packet within a source node can be multicast or broadcast to a designated or source tributary (ST) of other sink nodes along a MSR ring or other topologies. Each sink node should have only a source tributary to receive this packet from ringlet at a time. If a membership group of multicast or broadcast has been established within a sink node, the said ST will duplicate this packet to other tributaries with the same membership relation.

Figure 10/X.87/Y.1324 – Expressions of TN ID and TCCR ID

What the ICT, CUT and Null parameters indicate are three different operations: ICT, CUT and CTI. Their type and field are described in Table 6.

Table 6/X.87/Y.1324 – 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 10"
CUT	Binary "00000001 00100001" + "octet number of parameter" + "value of TCCR ID shown in Figure 10"
Null	Binary "00000001 00100011 00000001 00000000"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

7.11.1.2 CT_Response Frame

Null parameter in CT_Response Frame is used by ICT and CUT operations. CTI parameter is followed by CTI operation.

Table 7/X.87/Y.1324 – Parameter type of CT_Response Frame

Parameter type	Parameter field
CTI	Binary "00000001 00100100" + "octet number of parameter" + "value of TCCR ID shown in Figure 10"
Null	Binary "00000001 00100011 00000001 00000000"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.6 and the parameters are shown in Table 7.

7.11.1.3 Fault_Report Frame

Table 8/X.87/Y.1324 – Parameter type of Fault_Report Frame

Parameter type	Parameter field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.7 and the parameters are shown in Table 8.

7.11.1.4 Parameter of Fault_Inquiry_Request Frame

Table 9/X.87/Y.1324 – Parameter type of Fault_Inquiry_Request Frame

Parameter type	Parameter field
Null	Binary "00000001 00100011 00000001 00000000"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.7 and the parameters are shown in Table 9.

7.11.1.5 Parameter of Fault_Inquiry_Response Frame

Table 10/X.87/Y.1324 – Parameter type of Fault_Inquiry_Response Frame

Parameter type	Parameter field
PSF	Binary "00000001 00000011 00000001 00000000"
PSD	Binary "00000001 00000010 00000001 00000000"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.7 and the parameters are shown in Table 10.

7.11.1.6 Parameter of Performance_Report Frame

Table 11/X.87/Y.1324 – Parameter type of Performance_Report Frame

Parameter type	Parameter field
A set of TNi in a node (designated)	Binary "00000001 01000000" + "octet number of parameter" + "value of TNi shown in Figure 10"
TNFCS_15m (Total Number of FCS error in 15 minutes, 4 octets length)	Binary "00000001 01000001" + "00000100" + "value of TNFCS_15m shown in Figure 10"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4 octets length)	Binary "00000001 01000001" + "00000100" + "value of TNPL_15m shown in Figure 10"
TNFCS_24h (Total Number of FCS error in 24 hours, 5 octets length)	Binary "00000001 01000001" + "00000101" + "value of "TNFCS_24h shown in Figure 10"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5 octets length)	Binary "00000001 01000001" + "00000101" + "value of "TNPL_24h shown in Figure 10"
NOTE 1 – TNFCS and TNPL represent two different registers reflected values of "Total Number of FCS error" and "Total Number of Frame Loss", respectively. NOTE 2 – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.8 and the parameters are shown in Table 11.

7.11.1.7 Parameter of Performance_Inquiry_Request Frame

Table 12/X.87/Y.1324 – Parameter type of Performance_Inquiry_Request Frame

Parameter type	Parameter field
A set of TNi in a node (designated)	Binary "00000001 01000000" + "octet number of parameter" + "value of TNi shown in Figure 10"
NOTE – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.8 and the parameter is shown in Table 12.

7.11.1.8 Parameter of Performance_Inquiry_Response Frame

Table 13/X.87/Y.1324 – Parameter type of Performance_Inquiry_Response Frame

Parameter type	Parameter field
A set of TNi in a node (designated)	Binary "00000001 01000000" + "octet number of parameter" + "value of TNi shown in Figure 10"
TNFCS_15m (Total Number of FCS error in 15 minutes, 4 octets length)	Binary "00000001 01000001" + "00000100" + "value of TNFCS_15m shown in Figure 10"
TNPL_15m (Total Number of Frame Loss in 15 minutes, 4 octets length)	Binary "00000001 01000001" + "00000100" + "value of TNPL_15m shown in Figure 10"

Table 13/X.87/Y.1324 – Parameter type of Performance_Inquiry_Response Frame

Parameter type	Parameter field
TNFCS_24h (Total Number of FCS error in 24 hours, 5 octets length)	Binary "00000001 01000001" + "00000101" + "value of TNFCS_24h shown in Figure 10"
TNPL_24h (Total Number of Frame Loss in 24 hours, 5 octets length)	Binary "00000001 01000001" + "00000101" + "value of TNPL_24h shown in Figure 10"
NOTE 1 – TNFCS and TNPL represent two different registers reflected values of "Total Number of FCS error" and "Total Number of Frame Loss", respectively. NOTE 2 – The interface interaction between MAC and client are operated via MA_Data Request and Indication primitives.	

The corresponding operation is in 5.8 and the parameters are shown in Table 13.

7.12 XP payload FCS

The Frame Check Sequence (FCS) is a 32-bit cyclic redundancy check (CRC) as used in IEEE 802.3 CSMA/CD. The generator polynomial is:

$$\text{CRC-32} = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x^{1} + 1$$

The FCS CRC is calculated starting from the octets following the HEC field to the end of the frame, with the bits of the frame presented to the CRC generator in the same order as is described in RPR [9]. The initial value for the FCS CRC calculation is an all-ones value. If Ethernet is contained in the payload, or CS/NM parameters are contained in the payload, PFI is set to zero and XP payload FCS will not be used.

8 Tributary Loopback (TRL) and Node Reachability Verification (NRV)

8.1 Tributary Loopback (TRL)

Once TRL function is set, a node provides local or remote data channel shortcut from Tx interface to Rx interface in Tributary. This Recommendation allows the XP entity to get a TRL request (OAM) operation from OAM to a specific destination in order to check the Tributary connectivity of a MSR station. At the interface from OAM to MAC, parallel operation should be made by the corresponding MIB in RPR MAC to invoke an OAM frame specified in clause 11 of RPR [9]. TRL_request used by XP OAM when transferred to both RPR MAC and XP entity from OAM will produce a TRL operation. The MSR TRL request (OAM operation) capability allows for a frame to be inserted in a Tributary at one station in the ring, and a Loopback response (XP operation) returned by a peer Tributary of another station through the same or opposite ringlet, with minimal impact on the data flow between stations. Those frames activated by TRL request/response operation can be assigned any service class. Those frames activated by the TRL request may contain any number of user specific octets up to the maximum permitted frame size, and the userData is copied into the reply frame. The TRL request/response operation can be sent through the default ringlet, ringlet0 or ringlet1 for the dual-fibre ring case.

The operation of a TRL request source station from a XP OAM shall contain:

1) The invocation of network management (OAM) frame of MSR.
2) The related fields of network management frame include:
   a) The DA to the target MAC address.
   b) The SA to its own MAC address.
   c) The values of target TT and TN, service class of payload.
   d) The route of request operation, i.e., ringlet selection.
   e) The desired protectionMode.
   f) The payload of a MSR request frame includes (in order): source TN (20-bit), 12-bit reserved field (set to all "0") and desired userData (an integer of octet).

On receipt of a TRL network management frame from an aggregate pipe, the response frame is passed to the reconciliation sublayer which disassembles the MAC frame into parameters. The response operation of a sink station in the XP entity shall contain:

a) Exchange DA and SA of incoming frame to form outgoing response frame.
b) Exchange the TN values between source and target.
c) The route of response operation, i.e., ringlet selection.
d) The desired protectionMode and userData (payload of a MSR frame).
e) The payload of a MSR response frame includes (in order): the changed TN (20-bit) value, 12-bit reserved field (set to all "0") and copy all received userData from the request frame.

The corresponding type code of network management frame operation is listed in Table 5.

8.2 Tributary Loopback (TRL) shortcut

Once TRL shortcut function is set, a node provides round-trip shortcut along the ringlet from a local station to itself and also including from the local Tx to the local Rx of Tributary. This Recommendation allows the XP OAM to request a TRL shortcut operation to a specific destination in order to check the fibre connectivity of a ringlet. At the interface from OAM to MAC, parallel operation should be made by the corresponding MIB in RPR MAC to invoke a flush operation specified in clause 11 of RPR [9]. A flush has the effect of clearing the selected ringlet of previously sourced Tributary traffic. A flush function will be used when changing the ringlet selection algorithm, when revised ringlet selection protocols are necessary to access all stations (for steer-protection) or to improve bandwidth utilization (for wrap protection). The RPR flush capability may also be used for Tributary controlled misorder prevention when changing the preferred ring direction of a given flow or for Tributary determination of RTT. This is very useful to allocated bandwidth and account management of Tributary based.

The corresponding type code of network management frame operation is listed in Table 5.

8.3 Node Reachability Verification (NRV)

To check Node reachability along a ringlet, this Recommendation allows the XP OAM to request a NRV operation to a specific destination in order to check the node reachability. At the interface from OAM to MAC, parallel operation should be made by the corresponding MIB in RPR MAC to invoke an OAM frame specified in clause 11 of RPR [9]. The NRV request capability allows for a frame to be inserted at one station, and a NRV response (XP operation) returned by another station through the same or opposite ringlet, with minimal impact on the data flow between stations. NRV request/response frames can be assigned any service class. The NRV request frame may contain any number of user specific octets up to the maximum permitted frame size, and the userData is copied into the reply frame. The NRV request/response operation can be sent through the default ringlet, ringlet0 or ringlet1 for the dual-fibre ring case.

The operation of a NRV request source station from a XP OAM shall contain:

1) The invocation of network management (OAM) frame of MSR.
2) The related fields of network management frame include:
   a) The DA to the target MAC address.
   b) The SA to its own MAC address.
   c) The values of target TT and TN and service class of payload are don't care.
   d) The route of request operation, i.e., ringlet selection.
   e) The desired protectionMode.
   f) The payload of a NRV request frame is don't care.

On receipt of an NRV network management (request) frame from an aggregate pipe, the response frame is passed to the reconciliation sublayer which disassembles the MAC frame into parameters. The response operation of a sink station in the XP entity shall contain:

a) Exchange DA and SA of incoming frame to form outgoing response frame.
b) Selection of the desired response route, i.e., ringlet selection.
c) The desired protectionMode and userData (don't care).

The corresponding type code of network management frame operation is listed in Table 5.

8.4 Node Reachability Verification (NRV) shortcut

To check Node reachability along a ringlet, this Recommendation allows the XP OAM to request a NRV shortcut (request) operation to a specific destination in order to check the node reachability from a local station to itself. At the interface from OAM to MAC, parallel operation should be made by the corresponding MIB in RPR MAC to invoke flush operation specified in clause 11 of RPR [9].

The corresponding type code of network management frame operation is listed in Table 5.

9 TDM Circuit Emulation (TCE) over MSR

9.1 Introduction

This clause provides a protocol model along MSR for TDM based bit-stream or octet-stream over MSR. Each station can have one or more TCEs as Tributary. TCE is operated end-to-end and is originated from the source station and terminated at the sink station. TCE can be operated in the way of half-duplex point-to-point, full-duplex point-to-point or half-duplex point-to-multipoint.

9.2 Protocol framework of TDM Circuit Emulation (TCE)

The protocol framework of TCE is involved in the underlying RPR MAC aggregate pipe shown in Figure 11. The functions of encapsulation, real-time transport of order, detection of disorder and duplication, sorting, error report, primitives and related parameters, and timing synchronous processing, etc. are performed within the XP.

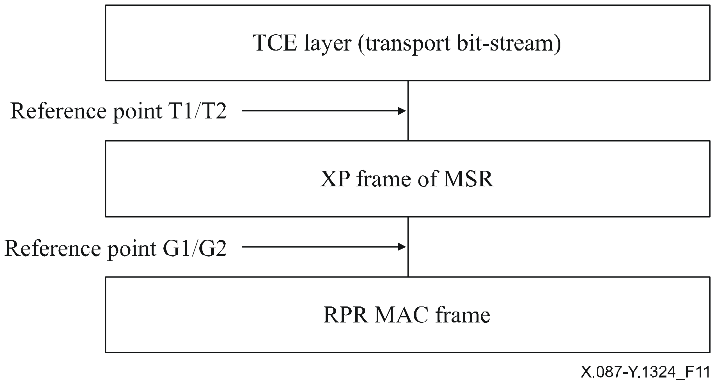


Figure 11/X.87/Y.1324 – TDM service channel over MSR

9.3 Services provided by MSR Data link

9.3.1 Definitions

The layer services provided by MSR Data link to TCE layer are:

- transfer of service data units with a constant source bit rate from TCE layer and the delivery of them with the same bit rate in MSR data link layer; and/or
- transfer of timing information between source and destination; and/or
- transfer of structure information between source and destination; and/or
- indication of lost, duplicated or errored information that is not recovered by RPR data link if needed.

9.3.2 Primitives between XP and the XP user

9.3.2.1 General

At the Service Access Point (SAP) of XP layer, the following primitives are used between the XP and the TCE layer:

- From a TCE layer to the XP,
  XP-UNACK-DATA Request.
- From the XP to the TCE layer,
  XP-UNACK-DATA Indication.
- From the XP to the management entity,
  LMXP-ERROR Indication.

A XP-UNACK-DATA Request primitive at the local XP-SAP will result in a XP-UNACK-DATA indication primitive at its peer XP-SAP.

9.3.2.2 Definition of XP primitives

9.3.2.2.1 XP-UNACK-DATA request (be not used to signalling frames)

XP-UNACK-DATA request (USERDATA [Necessary],
STRUCTURE [optional])

The XP-UNACK-DATA request primitive requests the transfer of the XP-SDU, i.e., contents of the USERDATA parameter, from the local XP entity to its peer entity. The length of the XP-SDU and the time interval between two consecutive primitives are constant. These two constants are a function of the XP service provided to the TCE layer.

9.3.2.2.2 XP-UNACK-DATA indication (be not used to signalling frames)

XP-UNACK-DATA indication (USERDATA [Necessary],
STRUCTURE [optional],
ERROR [optional])

A XP user is notified by the XP that the XP-SDU, i.e., contents of the USERDATA parameter, from its peer is available. The length of the XP-SDU and the time interval between two consecutive primitives should be constant. These two constants are a function of the XP service provided to the TCE layer.

9.3.2.2.3 LMXP-ERROR indication

LMXP-ERROR indication (T_error [Necessary],
REG_lost [optional],
REG_duplicated [optional])

REG_lost and REG_duplicated parameters are used to identify how many sequence frames are lost and duplicated by FSN detection from the transmit side to receive side in the specific period (T_error). Once sequence lost or duplicated is occurred, LMXP-ERROR indication will be applied.

9.3.2.3 Definition of primitive parameters

9.3.2.3.1 USERDATA parameter

The USERDATA parameter carries the XP-SDU to be sent or delivered. The size of each block to be delivered depends on the specific XP layer service used. For the same type of TCE payload, i.e., G.702 PDH circuit, the payload length of XP-PDU is constant and default is set to 512 octets. For the supported TCE payloads, the payload length of XP-PDUs is defined in Table 14.

Table 14/X.87/Y.1324 – Selection of default payload length of XP-PDU

Types of TCE payload	Default payload length of XP-PDU (octets)
G.702 PDH circuit – Synchronous circuit transport	512
G.702 PDH circuit – Asynchronous circuit transport	512
Video signal – Distributive television services	188
Video signal – Conversational services of bit rates higher than primary rates	188
Video signal – Conversational services of p × 64 kbit/s signals	188
Voiceband signal – 64 kbit/s A-law or μ-law coded G.711 signals	512
Digital channel supported by 64 kbit/s-based ISDN – Transport of 64 kbit/s channel	512
Digital channel supported by 64 kbit/s-based ISDN – Transport of 384, 1536 or 1920 kbit/s channel	512

9.3.2.3.2 STRUCTURE parameter (option of XP-UNACK-DATA primitive)

The STRUCTURE parameter can be used when the data stream of TCE layer to be transferred to the peer XP entity is organized into groups of bits. The length of the structured block is fixed for each instance of the XP service. The length is an integer multiple of 32 bits. An example of the use of this parameter is to support circuit mode bearer services of the 64 kbit/s-based ISDN. The two values of the STRUCTURE parameter are:

– BOUND; and

– DATA-STREAM.

The value BOUND is used when the USERDATA is the first part of a structured block which can be composed of consecutive USERDATA. In other cases, the STRUCTURE parameter is set to DATA-STREAM. The use of the STRUCTURE parameter depends on the type of XP service provided. The use of this parameter is agreed prior to or at the connection establishment by network management between the TCE layer and the Data Link layer. In most applications, the function of "STRUCTURE parameter" has been covered by the transform and adaptation function of Tributary at the Tributary interface within a node since XP uses pre-plan and connection-oriented policy, and TCCR is made (e.g., ISDN 64 kbit/s Tributary source in a node to ISDN 64 kbit/s Tributary sink, E12 (2048 kbit/s) Tributary source in a node to E12 (2048 kbit/s) Tributary sink) by network management entity or control signalling before Tributary service is operated online.

9.3.2.3.3 ERROR parameter (option of XP-UNACK-DATA primitive)

The ERROR parameter is involved to identify that the USERDATA is errored or non-errored. The ERROR parameter has two values:

– NO; and

– YES.

The "YES" value does imply that the USERDATA covers a dummy value within this frame. The "NO" value implies that the no error is found from transmit to receive side. The use of the ERROR parameter and the choice of dummy value depend on the type of XP service provided. The use of this parameter is agreed prior to or at the connection establishment of TCCR between the TCE layer and the XP layer.

9.3.2.3.4 T_error, REG_lost and REG_duplicated parameters

The connection management entity is used to monitor the error status of receiving the peer link frame at peer-to-peer level. It is a local matter only and does not have any associated frame to be used between the two sides.

REG_lost and REG_duplicated parameters are attached to LMXP-ERROR indication primitive to identify how many sequence frames are lost and/or duplicated from the transmit side to receive side in the specific period (T_error). Their accumulation values are stored and transformed to the two specific registers in the receive side. The parameter T_error in the unit of second is an initial value (15 minutes and 24 hours are two default values) and configurable by the network management entity according to the rate of specific service over XP. Each Tributary has the corresponding REG_lost and REG_duplicated, and is separately operating from the other Tributary. At the beginning of RPR Data Node start-up, the REG_lost and REG_duplicated of each Tributary are clear and set to zero.

– If the timer T_error expires before no lost or duplicated frames are received, the link entity shall restart timer T_error. The XP entity shall not indicate this to the local connection management entity.

– Once the timer T_error expires if any lost or duplicated frame is received, the XP entity shall indicate this to the local connection management entity by means of the LMXP-ERROR indication primitive, and restart timer T_error.

9.4 Supported functions of XP for TCE case

The following functions can be performed in the XP in order to meet the requirements of TDM (Time Division Multiplex) timing, structure, jitter and wander:

a) source clock frequency recovery at the receiver;

b) recovery of the source data structure at the receiver;

c) blocking and deblocking of XP user information;

d) control of frame latency variation;

e) processing of lost or duplicated frames.

NOTE – For some XP users, it could be necessary to provide end-to-end QoS monitoring. This function can be achieved by calculating a CRC, reporting lost or duplicated frames in the default period (e.g., 15 minutes and 24 hours) for the XP-PDU. A corresponding periodic count of CRC computation, values of REG_lost and REG_duplicated are sent to network management entity.

9.4.1 TCE processing mode

9.4.1.1 Processing mode of G.702 PDH

For this subclause, it is necessary to identify TCE data structure and the clock operation mode at the XP service boundary, i.e., framing or non-framing, types of clock (synchronous or asynchronous) where needed to make comparison to a network clock. Asynchronous and synchronous TCE transport provides transport of signals from TCE sources whose clocks are non-frequency-locked and frequency-locked to a network clock respectively. The judgement of synchronous or asynchronous will depend on the service provided by the specific network, i.e., PDH, SDH, or ISDN. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along RPR during the project installation phase.

1) *Asynchronous G.702 circuit*

   a) Circuit rate at XP service boundary: 1.544, 2.048, 6.312, 8.448, 44.736 and 34.368 Mbit/s as specified in ITU-T Rec. G.702.

   b) Payload size to be encapsulated: See Table 14.

   c) Source clock frequency recovery: Asynchronous frequency.

   d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

2) *Synchronous G.702 circuit*

   a) Circuit rate at XP service boundary: 1.544, 2.048, 6.312, 8.448, 44.736 and 34.368 Mbit/s as specified in ITU-T Rec. G.702.

   b) Payload size to be encapsulated: See Table 14.

   c) Source clock frequency recovery: Synchronous timing.

   d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

9.4.1.2 Processing mode of Video signal transport

This subclause presents the processing mode of Video signal transport. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along RPR during the project installation phase.

1) *Mode of Conversational services of p × 64 kbit/s signals*

This subclause gives the processing mode of interactive video signals of the p × 64 videotelephony and videoconference applications as specified in ITU-T Rec. H.320.

a) Circuit rate at XP service boundary: 384, 1536 or 1920 kbit/s in the 64 kbit/s-based ISDN by using H0, H11, H12, respectively.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Synchronous timing.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

2) *Mode of Distributive television services*

This subclause illustrates transport of distributive television signals encoded by using MPEG-2 with a constant bit rate specified in ITU-T Rec. J.82.

a) Circuit rate at XP service boundary: Depending on MPEG-2 parameters.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Asynchronous frequency.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

3) *Mode of Conversational services of bit rates higher than primary rates*

This subclause illustrates transport of interactive video signals for, i.e., videotelephony and conference applications specified in ITU-T Rec. H.310.

a) Circuit rate at XP service boundary: Depending on H.310 parameters.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Synchronous/Asynchronous per ITU-T Rec. H.310.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive. ITU-T Rec. H.310 should be taken into account.

9.4.1.3 Processing mode of digital channel supported by 64 kbit/s-based ISDN

This subclause presents the processing mode of digital channel supported by 64 kbit/s-based ISDN. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along RPR during the project installation phase.

1) *Mode of 64 kbit/s channel*

a) Circuit rate at XP service boundary: 64 kbit/s.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Synchronous timing.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

2) *Mode of 384, 1536 or 1920 kbit/s channel*

a) Circuit rate at XP service boundary: 384, 1536 or 1920 kbit/s.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Synchronous timing.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

9.4.1.4 Processing mode of Voiceband signal

This subclause presents the processing mode of 64 kbit/s A-law or μ-law coded G.711 signals. Care should be taken to select the shortest transport path, control priority of delivery and transient, and reduce transport latency and latency variation along RPR during the project installation phase.

a) Circuit rate at XP service boundary: 64 kbit/s.

b) Payload size to be encapsulated: See Table 14.

c) Source clock frequency recovery: Synchronous timing.

d) Error status indication at the receiver: Count report of lost or duplicated frames by LMXP-ERROR Indication primitive.

9.4.2 TCE function of MSR data link

9.4.2.1 TCE functions for circuit

The following subclauses provide both asynchronous and synchronous TCE transport function along RPR or other topologies. Asynchronous and synchronous TCE supports transport of signals from constant bit rate sources whose clocks are non-frequency-locked and frequency-locked respectively to a network clock. Asynchronous examples are G.702 signals at 1.544, 2.048, 6.312, 8.448, 32.064, 44.736 and 34.368 Mbit/s, Synchronous examples are at 64, 384, 1536 and 1920 kbit/s as specified in the series of ITU-T Recs I.231.x.

1) *Consideration of XP user information*

   The length of the XP-SDU is 64 octets. A XP-SDU constitutes one XP PDU payload.

   For those XP users, it requires a peer-to-peer presetting of structured data, i.e., 8 kHz structured data for circuit mode bearer services of the 64 kbit/s-based ISDN.

2) *Processing strategy of frame delay variation*

   A buffer mechanism is used to support this function. In the event of buffer underflow, it can be necessary for the XP to maintain bit count integrity by inserting the appropriate number of dummy bits. In the event of buffer overflow, it may be necessary for the XP to maintain bit count integrity by dropping the appropriate number of bits.

   When G.702 1.544-Mbit/s and 2.048-Mbit/s signals are being transported, the inserted dummy bits shall be all "1"s.

3) *Processing strategy of lost and duplicated frames*

   A destination XP can determine whether the frames have been lost by tracking the Frame Sequence Number (FSN) or sequence count values of the received XP PDUs. Detected duplicated frames are discarded.

   In order to maintain the bit count integrity of the XP user information, it may be necessary to compensate for lost frames detected by buffer underflow and sequence count processing by inserting the appropriate number of dummy payloads. The content of this dummy payload depends on the XP service being provided. For example, this dummy payload is all "1"s for G.702 1.544-Mbit/s and 2.048-Mbit/s signals.

4) *Guaranty of jitter and wander*

   This function is required for delivery of XP-SDUs to a XP user at a constant bit rate. Recovered source clock should meet the requirements of jitter and wander performance of the related Recommendation defined. For example, the jitter and wander performance for G.702 signals is specified in ITU-T Recs G.823 and G.824, for which the XP procedure is to be used.

9.4.2.2 TCE functions of video signal

The following clauses present processing of video signals for interactive and distributive services:

1) *Consideration of XP user information*

   The length of the XP-SDU is 188 octets. A XP-SDU constitutes one XP PDU payload.

   For those XP users, it requires a peer-to-peer presetting of structured data. Depending on the type of XP service provided (i.e., the interface to the XP user), the ERROR parameter will be passed to the XP user to facilitate further picture processing.

2) *Processing strategy of frame delay variation*

   A buffer mechanism is used to support this function. The size of this buffer is dependent upon the specifications of video signal. In the event of buffer underflow, it may be necessary for the XP to maintain bit count integrity by inserting the appropriate number of dummy bits. In the event of buffer overflow, it may be necessary for the XP to maintain bit count integrity by dropping the appropriate number of bits.

3) *Processing strategy of lost and duplicated frames*

   A destination XP can determine whether the frames have been lost by tracking the Frame Sequence Number (FSN) or sequence count values of the received XP PDUs. Detected duplicated frames are discarded.

   In order to maintain the bit count integrity of the XP user information, it may be necessary to compensate for lost frames detected by buffer underflow and sequence count processing by inserting the appropriate number of dummy payloads. The content of this dummy payload depends on the XP service being provided.

   Information in lost frames may be recovered by the mechanism described in 9.5.1.

4) *Guaranty of jitter and wander*

   This function is required for delivery of XP-SDUs to a XP user at a constant bit rate.

   Some XP users may require source clock frequency recovery, i.e., recovery in the receive side of camera clock frequency that is not locked to the network clock.

9.4.2.3 TCE functions of voiceband signal

The following clauses support processing of a single voiceband signal, i.e., one 64 kbit/s A-law or µ-law coded G.711 signal.

1) *Consideration of XP user information*

   The length of the XP-SDU is 64 octets. A XP-SDU constitutes one XP PDU payload.

2) *Processing strategy of frame delay variation*

   A buffer mechanism is used to support this function. The size of this buffer depends on the specifications provided in voiceband signal.

3) *Processing strategy of lost and duplicated frames*

   For voiceband signals, there is still a need to detect duplicated and lost frames.

   The receiving XP entity must detect/compensate for lost frame events to maintain bit count integrity and must also minimize the delay, i.e., to alleviate echo performance problems, in conveying the individual voiceband signal octets from the XP-PDU payload to the XP user. The receiving XP entity may take actions based on the received Sequence Number values, but such actions must not increase the conveyance delay across the XP receiving entity to alleviate echo performance problems.

   The XP receiving entity must accommodate a sudden increase or decrease in the nominal frame transfer delay. (A protection switching event in the RPR may result in a change of transfer delay.)

4) *Guaranty of jitter and wander*

The XP provides synchronous circuit transport for the voiceband signal.

NOTE 1 – Example receiver techniques use a timing-based mechanism or a buffer-fill-based mechanism, possibly supplemented by a Sequence Number processing algorithm that does not introduce additional delay.

NOTE 2 – For transporting signals of speech and 3.1 kHz audio bearer services as specified in 64 kbit/s ISDN, the need for A/μ-law conversion is identified. The conversion between A-law and μ-law coded PCM octets are as specified in ITU-T Rec. G.711. This conversion function is outside the scope of this Recommendation.

9.4.2.4 TCE functions of high quality audio signal

The case is the same as above. The TCE functions of high quality audio signals in XP include the following capabilities in principle.

a) consideration of XP user information;

b) processing strategy of frame delay variation;

c) processing strategy of lost and duplicated frames;

d) guaranty of jitter and wander.

9.5 XP protocol involved to support TCE

The following subclauses describe XP procedures to be provided for implementing XP functions involved to support TCE.

9.5.1 Processing strategy of Frame Sequence Number (FSN)

9.5.1.1 Processing in the transmit side

The XP provides a sequence count value and a XP indication associated with each XP-PDU payload in the transmit side. The count value applied to FSN field starts with 0, is incremented sequentially to 63 and is numbered modulo 64 when TT field is set to support TCE function. When the data link frames carrying TCE payloads traverse a RPR or other topologies, they may arrive at destination station disorderly. Due to this reason, it is required that frames must be delivered in order. Ensuring in-order delivery is also an effective approach to out-of-order detection.

9.5.1.2 Processing in the receive side

The XP receives and derives the following information associated with each XP-PDU payload in the receive side:

- sequence number;
- count;
- check error of the frame sequence number and count.

The implementation of sequence count values and number will be specified on a service-specific basis (e.g., REG_lost and REG_duplicated). The XP entity in the receive side identifies lost or duplicated XP-PDU payloads.

XP entity tracks the following status of dynamic data stream:

- XP-PDU payload sequence number and count;
- XP-PDU payload loss (if occur);
- XP-PDU payload duplication (if occur).

There are two ways to solve the real-time processing problem:

1) try to reorder and sort into the correct order; or

2) drop those disordering frames, when disordering case occurred.

In implementation, these two methods should all be supported. If method (1) does not meet reliability transport and performance requirement still, method (2) will be applied. Due to the limitation of native speed and acceptable delay of data link payloads listed in Table 14, this Recommendation does not support correction method for bit errors and frame losses.

9.5.2 Recovery method of timing and structured information

To support TCE services available in Table 14, the requirements of timing and structured information should be based on the native characteristics of these services, and it is necessary for these TCEs to recover these signal characteristics as closely specified in the related standard as possible in the receive side, including the signal jitter, bit-rate, timing characteristics and structured information transfer (if it has) as it was sent. In most applications, STRUCTURE information could be provided by the transform and adaptation function of Tributary at the Tributary interface within a node since XP uses pre-plan and connection-oriented policy, and TCCR is made (e.g., ISDN 64 kbit/s Tributary source in a node to ISDN 64 kbit/s Tributary sink, E12 Tributary source in a node to E12 Tributary sink) by network management entity or control signalling before Tributary service is operated online.

For the timing issue of MSR, the four methods that could be used to engineering projects are:

a) timing (synchronous) signalling broadcasted periodically from that designated station with an external synchronous source along the MSR or other topologies;

b) timing (synchronous) information received from an external facility for referencing to all stations;

c) timing (synchronous) information received from an external facility for referencing to a said central station, other stations along a ring will get timing information from the line side and reference to the central station;

d) no timing (synchronous) information and referencing to MAC sublayer.

If method (a) is applied, the primitives are defined as follows.

– SYNCHRONIZATION Request (NA, T_sync)

  The signalling frame of SYNCHRONIZATION Request primitive will have the highest priority among all other signalling frames defined in this Recommendation and be operated in a way of broadcast. The broadcasted period is Timer T_sync. Its default value is 8000 frames per second. This value is programmable and can be changed by network management entity.

– SYNCHRONIZATION Confirm (Non parameter)

  After getting the signalling frame of SYNCHRONIZATION Request, each station along a ring will align the phase relations of its oscillator facility (including frequency-locked) and send SYNCHRONIZATION Confirm signalling frame with lower priority to the source station initiating the signalling frame of SYNCHRONIZATION Request. The codes of these two signalling frames are listed in Table 4.

Since the service types and connection relations of TCEs from source to destination, including Node address, TT and TN, are pre-plan before service Tributary is operated, the initial timing (except for phase relations and actual bit-stream) and structured information should be pre-set by configuration function of network management entity before those TCE services are available. The phase relations and actual bit-stream of TCE signals are designed to perform the extraction of output transmission bit timing information from the received frame stream, and require a phase-locking mechanism. It is recommended that method (d) is first choice in this Recommendation.

9.5.3 Services from MAC

The services provided from the MAC sublayer allow:

a) the peer-to-peer Tributary data exchange;

b) the parameters exchange between MAC and XP entity;

c) the data exchange across MSR by the bridge.

The RPR MAC provides **strict** and **relaxed** frame transmission service. The MAC sublayer presents a service interface for the exchange of XP PDUs between XP entities. The MAC service interface supports service classes denoted class A, class B, and class C. For all service classes, the MAC service interface provides per ringlet indications to XP of whether traffic can or cannot currently be accepted. For service class C, the MAC service interface also provides the number of hops to the nearest congested station. Each service class is rate controlled to prevent XP from transmitting more traffic than was allocated or allowed by fairness, as applicable.

9.5.3.1 Class A services

Class A (real-time service) service provides an allocated, guaranteed data rate and a low end-to-end delay and jitter bound. Within this class, there is a mechanism to reserve some or all of the allocated bandwidth. Fairness Eligible (FE) bit in the RPR header must always be set to 0 on class A traffic. Class A traffic moves through the primary transit path in each station as it propagates around the ring.

9.5.3.2 Class B services

Class B (near real-time service, allocated or opportunistic) service provides an allocated, guaranteed data rate, optional additional data rate that is not allocated or guaranteed, and bounded end-to-end delay and jitter for the traffic within the allocated rate. Class B has similarities to the class A service and also has similarities to class C service, in which traffic beyond the allocated rate profile is subject to the fairness algorithm, and is marked by the MAC as such with the fairness eligible (FE) bit in the RPR header prior to transmission on the ring. In a single-queue or a dual-queue implementation, class B traffic moves through the primary transit path or secondary transit path, regardless of whether the frame is marked fairness eligible or not.

9.5.3.3 Class C services

Class C (best-effort service, opportunistic) service provides a best-effort traffic service with no allocated or guaranteed data rate and no bounds on end-to-end delay or jitter. Class C traffic is always subject to the fairness algorithm, and is marked by the MAC as such with the fairness eligible (FE) bit in the RPR header prior to transmission on the ring. In a single-queue implementation, class C traffic moves through the primary transit path. In a dual-queue implementation, class C traffic moves through the secondary transit path.

9.6 Management function involved to support TCE

The following functions are required for the network management entity:

9.6.1 TCE property (including structured information of data stream) mismatch between the source and destination

The related operation is described in details in 5.6.

10 Tributary Based Standby (TBS)

The Tributary of this clause is a logical service channel defined in clause 3, such as Ethernet, TCEs with a fixed value of Tributary Type (TT) and Tributary Number (TN) in the frame format. The application scope of Tributary based standby involved in this clause is located at full-duplex point-to-point application only. The tributary standby operation of half-duplex point-to-point, multicast and broadcast is outside the scope of this clause. A Node of RPR can provide support of multiple ETBP and Multiple TTBP at the same time.

A 1+1 unidirectional standby architecture has one normal traffic signal (packet), one working tributary, one standby tributary and a logical bridge. At the source end, the normal traffic signal (packet) is logically bridged to both the working and standby tributary. At the sink end, the normal traffic signal (packet) is selected from the better of the two tributaries. Due to the logical bridging, the 1+1 architecture does not allow an extra unprotected traffic signal (packet) to be provided.

A 1:N unidirectional standby architecture has N normal traffic signals (packet), N working tributaries and 1 standby tributary which may have an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the N working tributaries. The signals (packet) on the working tributaries are the normal traffic signals (packet). The signal (packet) on the standby tributary may be either one of the normal traffic signals (packet), an extra traffic signal (packet), or the null signal (packet). At the source side, one of these signals (packet) is connected to the standby tributary. At the sink side, the signals (packet) from the working tributaries are selected as the normal signals (packet). When a defect condition or a fault indication is detected on a working tributary or under the influence of certain external commands, the transported signal (packet) is bridged to the standby tributary. At the sink side, the signal from this standby tributary is then selected.

10.1 Ethernet Tributary Based Standby (ETBS)

When needed to support the ETBP Function, ETBP Function Unit embedded in the corresponding Tributary part of XP entity as an attachment in XP entity will be activated by the configuration function of network management entity (this configuration function is performed either in the projection installation phase or MSR on-line operation phase) and the corresponding Tributary is set to a Working Tributary.

For operation of 1+1 ETBP, it is needed to designate a mate standby Tributary with the same service property, source and destination. The payloads of the mate working Tributary and standby Tributary will carry the same traffic.

For 1:1 ETBP, it is also needed to designate a mate standby Tributary with the same service property, source and destination. The payloads of the standby Tributary use an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the working tributary (once ETBP occurred for this working Tributary, the extra traffic transport will be stopped by a bridge function).

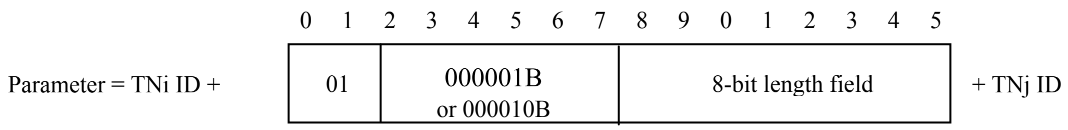
For 1:N ETBP, there are multiple working Tributaries (e.g., number is N), it is also needed to designate a mate standby Tributary with the same service property, source and destination. The payloads of the standby Tributary can carry an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the N working tributaries (once ETBP in one of N working Tributaries occurred, this additional traffic transport will be stopped by a bridge function).

The CS operational codes of ETBP are listed in Table 15.

Table 15/X.87/Y.1324 – Codes of ETBP frame

CS frame types	Codes
1+1 ETBP_Request Frame	00100001
1+1_ETBP_Response Frame	00100010
1:1 ETBP_Request Frame	00100011
1:1 ETBP_Response Frame	00100100
1:N ETBP_Request Frame	00100101
1:N ETBP_Response Frame	00100110
NOTE 1 – 1+1 and 1:1 ETBP_Request Frame is a multicast frame and should be issued to four ends of two targeted Tributaries (including the working and standby tributaries) at the same time. 1:N ETBP_Request Frame is a multicast frame and should be issued to multiple ends of targeted Tributaries (including the N working tributaries and a standby tributary) at the same time. NOTE 2 – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

The parameters of 1+1 ETBP_Request Frame and 1:1 ETBP_Request Frame have the same format as that of the unicast mode of TCCR ID. This parameter consists of TNi ID (this is an identifier of Tributary p within node x), 2-bit U/M/B field (6-bit is reserved and set to binary 000000), 8-bit length field (this field is used to reflect the total number of Tributary TNj ID following length field, its value should be binary 000001 00000001 for 1+1, binary 000010 00000001 for 1:1) and a TNj ID (this is an identifier of Tributary q within node y).



Full duplex point-to-point mode

NOTE – TNi ID = NAx (x = 1, 2, 3, …, 256) + TT + TNp (p = 0, 1, 2, 3, …, 2^{20} – 1), to identify the pth Tributary with the fixed TT and TN values within xth node. TNi ID and TNj ID stand for standby and working tributaries respectively.

Figure 12/X.87/Y.1324 – Expressions of 1+1 and 1:1 tributary standby parameters

The parameters of 1+1 ETBP_Response Frame and 1:1 ETBP_Response Frame are the same as that of 1+1 ETBP_Request Frame and 1:1 ETBP_Request Frame respectively.

The parameters of 1:N ETBP_Request Frame have the same format as that of the multicast/broadcast mode of TCCR ID. This parameter also consists of TNi ID (this is an identifier of Tributary p within node x), 2-bit U/M/B field (6-bit is reserved and set to binary 000000), 8-bit length field (this field is used to reflect the total number of Tributary TNj ID following length field, its value should be binary 000011 00000100 if N = 4) and a TNj ID (this is an identifier of Tributary q within node y).

	0 1	2 3 4 5 6 7	8 9 0 1 2 3 4 5
Parameter = TNi ID +	01	000011B	8-bit Length field

+ TNj ID + TNk ID + TNl ID + TNm ID……

Full duplex point-to-point mode

NOTE – TNi ID = NAx (x = 1, 2, 3, …, 256) + TT + TNp (p = 0, 1 , 2, 3, …, $2^{20} - 1$), to identify the pth Tributary with the fixed TT and TN values within xth node. TNi ID is used to present standby tributary, and TNj ID, TNk ID, TNl ID and TNm ID, etc. represent working tributaries, the total number is N.

Figure 13/X.87/Y.1324 – Expressions of 1:N tributary standby parameter

The parameters of 1+1 ETBP_Response Frame, 1:1 ETBP_Response Frame and 1:N ETBP_Response Frame are specified in Table 16.

Table 16/X.87/Y.1324 – Parameters of ETBP_Response Frame

CS frame types	Codes
ETBP successful	Binary "00000001 00010001 00000001 00000000"
ETBP unsuccessful	Binary "00000001 00010010 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

The ETBP Function Unit is used to monitor the link status of receiving the peer link frames at the reference point T1/T2. It is a local matter only and does not have any associated frame to be used between the two sides.

– After initialization (the defaults of T_etbp and N_etbp are set to 10 milliseconds and 4 respectively), the link entity enters the normal way of transmitter and receiver.

– If the timer T_etbp expires before any MAC frame is received or status report from MAC layer by MA_CONTROL Indication or MA_DATA Indication occurs with one or more opcodes (receptionStatus, serviceClass, topochange, protchange), the link entity shall restart timer T_etbp and decrement the retransmission counter N_etbp.

– If the timer T_etbp expires and retransmission counter N_etbp has been decremented to zero before any MAC frame from the aggregate is received or status report from MAC layer by MA_CONTROL Indication or MA_DATA Indication is kept still with one or more opcodes (receptionStatus, serviceClass, topochange, protchange), the link entity of the aggregate shall inform the all local Tributary entities (within a node), which are set to have the other standby Tributary, and send a periodic Error-Hello message from entity of the aggregate to those entities of Tributary within that node. After getting Error-Hello, the local Tributary entity will perform an action of ETBP (1+1, 1:1 or 1:N) to the corresponding standby Tributary within the same node, change previous transmission channel of aggregate to the counter-rotating ringlet of pre-setting. After the entity of Tributary enters into the normal transmission operation, the local aggregate entity will restart timer T_etbp and recover the value of N_etbp. Every standby Tributary has its T_etbp and N_etbp of itself.

– For the case of 1:1 and 1:N, after the ETBP Function Unit receives a periodic Error-Hello message, the link entity in the transmit side will perform an action of ETBP (1:1 or 1:N) to the corresponding standby Tributary.

– The value of T_etbp and N_etbp shall be configurable. The minimum unit configured of T_etbp and N_etbp is 1 millisecond and 1 respectively.

Once ETBP Function Unit detects that the failure span is recovered and enters normal status from the ETBP (that is, stop Error-Hello Message), ETBP Function Unit will wait T_etbp_wtr (the default to 10 minutes, its value is also programmable and should be much greater than T_etbp), and then switch to the working Tributary. After switching to the working Tributary, ETBP Function Unit issues an ETBP_RECOVERY_EVENT_Report with parameters of TT and TN to network management entity.

10.2 TCE Tributary Based Standby (TTBS)

When needed to support the TTBP function, TTBP Function Unit embedded in the corresponding Tributary in XP entity will be activated by the configuration of network management (this configuration is performed either in the projection installation phase or on-line operation phase) and the corresponding Tributary is set to a working Tributary.

For operation of 1+1 TTBP, it is needed to designate a mate protection Tributary with the same service property, source and sink. The payloads of the mate working Tributary and protection Tributary carrying the same traffic are required.

For 1:1 TTBP, it is also needed to designate a mate standby Tributary with the same service property, source and sink. The payloads of the protection Tributary can run an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the working tributary (once TTBP occurred for this working Tributary, the extra traffic transport will be stopped by a bridge function).

For 1:N TTBP, there are N working Tributaries; it is also needed to designate a mate standby Tributary with the same service property, source and sink. The payloads of the standby Tributary can run an extra traffic signal (packet) in case of no defect condition (or a fault indication) or external commands for the working Tributary (once TTBP in one of N working Tributaries occurred, this additional traffic transport will be stopped by a bridge function).

The CS operational codes of TTBP are listed in Table 17.

Table 17/X.87/Y.1324 – Codes of TTBP frame

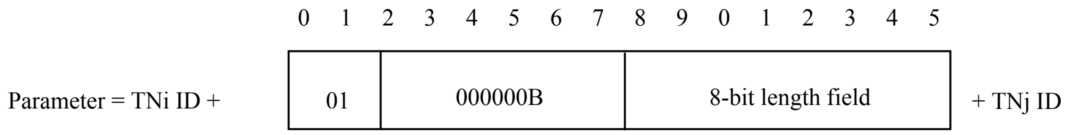
CS frame types	Codes
1+1 TTBP_Request Frame	00100111
1+1 TTBP_Response Frame	00101000
1:1 TTBP_Request Frame	00101001
1:1 TTBP_Response Frame	00101010
1:N TTBP_Request Frame	00101011
1:N TTBP_Response Frame	00101100
TTBP_RECOVERY_EVENT_Report	00101101
NOTE 1 – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives. NOTE 2 – 1+1 and 1:1 TTBP_Request Frame is a multicast frame and should be issued to four ends of two targeted Tributaries (including the working and standby tributaries) at the same time. 1:N TTBP_Request Frame is a multicast frame and should be issued to multiple ends of targeted Tributaries (including the N working tributaries and a standby tributary) at the same time.	

The parameters of the 1+1, 1:1 and 1:N TTBP_Response frame in this clause are specified in Table 18.

Table 18/X.87/Y.1324 – Parameters of TTBP_Response Frame

CS frame types	Codes
TTBP successful	Binary "00000001 00010011 00000001 00000000"
TTBP unsuccessful	Binary "00000001 00010100 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives	

The parameters of 1+1 TTBP_Request Frame and 1:1 TTBP_Request Frame have the same format as that of the unicast mode of TCCR ID. This parameter consists of TNi ID (this is an identifier of Tributary p within node x), 2-bit U/M/B field (6-bit is reserved and set to binary 000000), 8-bit length field (this field is used to reflect the total number of Tributary TNj ID following length field, its value should be binary 000000 00000001) and a TNj ID (this is an identifier of Tributary q within node y).



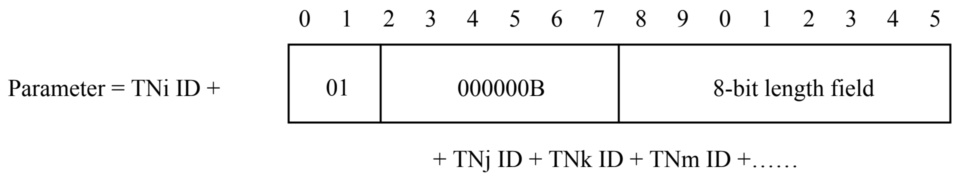
Full duplex point-to-point mode

NOTE – TNi ID = NAx (x = 1, 2, 3, …, 256) + TT + TNp (p = 0, 1, 2, 3,…, 2^{20} – 1), to identify the pth Tributary with the fixed TT and TN values within xth node. TNi ID and TNj ID stand for standby and working tributaries respectively.

Figure 14/X.87/Y.1324 – Expressions of 1+1 and 1:1 tributary standby parameters

The parameters of 1+1 TTBP_Response Frame and 1:1 TTBP_Response Frame are the same as that of Request primitives above.

The parameters of 1:N TTBP_Request Frame have the same format as that of the multicast/broadcast mode of TCCR ID. This parameter also consists of TNi ID (this is an identifier of Tributary p within node x), 2-bit U/M/B field (6-bit is reserved and set to binary 000000), 8-bit length field (this field is used to reflect the total number of Tributary TNj ID following length field, its value should be binary 000000 00000001) and a TNj ID (this is an identifier of Tributary q within node y). Refer to Figure 15.



Full duplex point-to-point mode

NOTE – TNi ID = NAx (x = 1, 2, 3, …, 256) + TT + TNp (p = 0, 1, 2, 3, …, 2^{20} – 1), to identify the pth Tributary with the fixed TT and TN values within xth node. TNi ID is used to present standby tributary, and TNj ID, TNk ID and TNm ID, etc. represent working tributaries, the total number is N.

Figure 15/X.87/Y.1324 – Expressions of 1:N tributary standby parameter

The TTBP Function Unit is used to monitor the link status of Tributary by monitoring the peer link frames of an aggregate. Normally, the entity in the receive side of aggregate does always receive or transit the MAC frame from the upstream node. No link-error occurs and no Error-Hello is also sent to the local Tributary entity within a node. It is a local matter only and does not have any associated frame to be used between the two sides.

– After initialization (the defaults of T_ttbp and N_ttbp are set to 10 milliseconds and 3 respectively), the link entity enters the normal way of transmitter and receiver.
– If the timer T_ttbp expires before any MAC frame from the aggregate is received or status report from MAC layer by MA_CONTROL Indication or MA_DATA Indication occurs with one or more opcodes (receptionStatus, serviceClass, topochange, protchange), the link entity of aggregate shall restart timer T_ttbp and decrement the retransmission counter N_ttbp.
– If the timer T_ttbp expires and retransmission counter N_ttbp has been decremented to zero before any MAC frame from the aggregate is received or status report from MAC layer by MA_CONTROL Indication or MA_DATA Indication occurs with one or more opcodes (receptionStatus, serviceClass, topochange, protchange), the link entity of the aggregate shall inform all local Tributary entities (within a node), which are set to have the related standby switch flag to other standby Tributary, and send an Error-Hello message from the aggregate entity to those entities of Tributary within that node. After getting Error-Hello, the local Tributary entity will perform an action of TTBP (1+1, 1:1 or 1:N) to the corresponding standby Tributary within the same node, change previous transmission channel of aggregate to the counter-rotating ringlet of pre-setting. After the entity of Tributary enters into the normal transmission operation, the local aggregate entity will restart timer T_ttbp and recover the value of N_ttbp. Every standby Tributary has its T_ttbp and N_ttbp of itself.
– The value of T_ttbp and N_ttbp shall be configurable. The minimum unit configured of T_ttbp and N_ttbp is 1 millisecond and 1 respectively.

Once TTBP Function Unit detects that the failure span is recovered and enters normal status from the TTBP, TTBP Function Unit will wait T_ttbp_wtr (the default to 10 minutes, its value is also programmable and should be much greater than T_ttbp), and then switch to the working Tributary. After switching to the working Tributary, TTBP Function Unit issues a TTBP_RECOVERY_EVENT_Report with parameters of TT and TN to network management entity.

11 Tributary Based Multicast (TBM)

The Tributary of this clause is a logical service channel defined in clause 3, such as TCE or Ethernet with a fixed value of Tributary Type (TT) and Tributary Number (TN) in the MSR frame. The application scope of Tributary Based Multicast (TBM) is located at the operation of half-duplex point-to-multipoint only. The full-duplex point-to-point will not be recommended to the scope of this clause.

The TBM Function Unit built in a node is defined to support one or more independent hierarchies of multicast (or broadcast) which could involve the same or different TT at the same time. TBM Function Unit implements a duplication function within a node (station) from a Tributary getting a payload of a frame from the related topologies to other multiple Tributaries with the same TT value set to having a relation of membership group. A group of TN with the same TT value within a node can be set to become a membership group of multicast/broadcast. It is required that a designated Tributary in the membership group should receive data frames at the reference point G1 from the related topologies. A designated Tributary in the membership group is only allowed to get packets from ST, and is not permitted to receive all other data packets. This Recommendation defines the specific designated tributary that gets the node based packet from MSR, as a Source Tributary (ST).

Once getting data frames either from MAC frame or from tributary side, the ST duplicates those frames to every Tributary in the corresponding membership group within a node. The ST should be set and designated to a given value of TT and TN by network management entity during the project installation phase or on-line operation phase. The one or more STs can be designated or changed dynamically within a node according to the customer requirements.

The CS operational codes of TBM are listed in Table 19.

Table 19/X.87/Y.1324 – Codes of TBM frame

CS frame types	Codes
TBM_Request Frame	00101101
TBM_Response Frame	00101110
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

If a TBP is applied to operation of TBM, it is recommended that a ST be designated to a working Tributary, and the ST can also be operated to become the working Tributary of 1+1 and 1:1 application described in 10.1 and 10.2.

The parameters of TBM_Request and TBM_Response frame in this clause are specified in Table 20 if the multicast/broadcast field is changed from "01" to "10" or "11".

Table 20/X.87/Y.1324 – Parameters of TBM_Request and TBM_Response Frame

CS frame types	Codes
TBM successful	Binary "00000001 00010101 00000001 00000000"
TBM unsuccessful	Binary "00000001 00010110 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

12 Bandwidth policing, merging, line-speed filtering, stacking and mirroring of tributary

12.1 Tributary based policing – Bandwidth limitation with symmetry and asymmetry

TCE rate at XP service boundary should be operated and be fully compliant with IEEE 802.3, ITU-T Rec. G.702, ISDN and other related standards in the normal case. But in some application of service level agreement, the policy of operation and maintenance needs a limitation for rate to perform the bandwidth-based accounting. The MSR entity provides a Bandwidth Limitation Function Unit. When this Function Unit is activated to a Tributary, this Tributary provides configuration incremental level with minimum unit granularity (64 kbit/s for TCE) from 0 to the specified value the related standard defined. The corresponding standard values of bandwidth are specified in the related standard and must not be passed over. Once bandwidth is set up for a Tributary during project installation or on-line operation phase, this programmable threshold limit applies to this Tributary and its corresponding port. The setting of bandwidth threshold and monitoring of actual traffic flow are performed by configuration function and management entity.

The CS operational codes of bandwidth limitation are listed in Table 21.

Table 21/X.87/Y.1324 – Codes of bandwidth limitation frame

CS frame types	Codes
Bandwidth Limitation_Request Frame	00101111
Bandwidth Limitation_Response Frame	00110000
NOTE 1 – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives. NOTE 2 – Bandwidth Limitation_Request Frame is a multicast frame and should be issued to two ends of targeted Tributary at the same time.	

The parameter of Bandwidth Limitation_Request Frame includes the following elements:

- Targeted (Tributary) Port A: TNi = NAx + TT + TNp.
- Targeted (Tributary) Port B: TNj = NAy + TT + TNq.
- Bandwidth required to be provided from Port A to Port B: a designated integer value (an octet) between 0 and standard bandwidth, e.g., binary code: 01000100 represents 68×64 kbit/s bandwidth.
- Bandwidth required to be provided from B to A: a designated integer value (an octet) between 0 and standard bandwidth, e.g., binary code: 00100000 represents 32×64 kbit/s bandwidth (this is an example of asymmetrical bandwidth availability), binary code: 00000000 represents no bandwidth available, it is needed that customers use the operation of half duplex point-to-point from port A to port B.
- Standard bandwidth: the related standard (binary code of G.702 E12: 00100000) for TCE.
- Minimum granularity: 64 kbit/s (binary code: 00000001) for TCE.

Bandwidth from port A to port B and from port B to port A is independent of each other. The separated bandwidth can be symmetrical or asymmetrical. All of these elements will be mapped to CS frame in the above order. Bandwidth Limitation_Response Frame uses two parameters: Bandwidth Limitation_successful or Bandwidth Limitation_unsuccessful as shown in Table 22.

Table 22/X.87/Y.1324 – Parameters of Bandwidth Limitation_Response Frame

CS frame types	Codes
Bandwidth Limitation_successful	Binary "00000001 00010111 00000001 00000000"
Bandwidth Limitation_unsuccessful	Binary "00000001 00011000 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

Bandwidth limitation of tributary based can be used to operations of half duplex point-to-point, full duplex point-to-point, multicast and broadcast.

12.2 Tributary merging with symmetry and asymmetry

The MSR entity provides a Merging Function Unit by which up to sixteen Tributaries of the same TT can be merged together to form a Tributary Merging Group (TMG). Up to eight TMGs can be established in a MSR or other topology node. The TMG is similar to one logical link and is very useful when the higher bandwidth of application is required. The member Tributary of a TMG must be of the same TT and configured in full-duplex mode. The benefits of forming a TMG are link redundancy, aggregate throughput, incremental bandwidth and load balancing on the TMGs. Once a TMG is formed, a TMG of TCE must be identified using only a TN value (It is usually the first member Tributary) in the corresponding frames of data, signalling and network management. For the upper layer application over a TMG, a logical channel can only be seen externally.

The CS operational codes of Tributary Merging are listed in Table 23.

Table 23/X.87/Y.1324 – Codes of Tributary Merging frame

CS frame types	Codes
Tributary Merging_Request Frame	00110001
Tributary Merging_Response Frame	00110010
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

The parameter of Tributary Merging_Request Frame includes the following elements:

- First Targeted Tributary: TNi = NAx + TT + TNp.
- Second Targeted Tributary: TNj = NAy + TT + TNq.
- Third Targeted Tributary: TNk = NAz + TT + TNr.
- Fourth Targeted Tributary: ………..

Tributary Merging from A to B and from B to A is independent of each other. The Tributary Merging of two half-duplex channels can be symmetrical or asymmetrical. All of these elements will be mapped to CS control frame in the above order. Tributary Merging_Response Frame uses two parameters: Tributary_Merging_successful or Tributary_Merging_unsuccessful shown in the Table 24.

Table 24/X.87/Y.1324 – Parameters of tributary Merging_Response Frame

CS frame types	Codes
Tributary_Merging_successful	Binary "00000001 00011001 00000001 00000000"
Tributary_Merging_unsuccessful	Binary "00000001 00011010 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

Tributary Merging can be used to point-to-point operations of both half duplex and full duplex.

12.3 Tributary based security – line-speed filtering

The MSR entity provides a Line-Speed Filtering Function Unit (LSFFU) of Tributary based to Content-Aware frame classification, which enables a node processing application to filter and classify frames based on certain protocol fields of upper layer in the payload of frame. Filters can be set on the defined fields from Layer 2 to Layer 4 within a frame. LSFFU of a node can filter individual ingress or egress ports of Tributary. Filtering algorithm uses two constructs:

a) the filter mask, which defines which fields to filter; and

b) the rules table, which defines the filtering options.

Up to 48 filters are available, each containing a 64-octet wide shuttered filter mask value to apply on any protocol field at any offset within the first 96 octets of the incoming frame. The rules table is up to 256 entries deep for TCE Tributary.

Once the classification results and filter match or partial match have been achieved, the following policies can be taken, individually or in their combination:

- modification of the IP Type Of Service (TOS precedence) field;
- delivery of a copy of the related frames to the domain of management;
- discarding the related frames;

- transferring the related frames to other egress port of a Tributary;
- transmission of a copy of the related frames to the "mirrored to" Tributary;
- modification of protocol field.

The LSFFU provides the ability to track and profile up to 1024 data flows. The traffic on these data flows can be monitored or regulated via internal meters and has the ability to assign two independent policies to the profile status of a data flow and execute these actions at line rate.

The CS operational codes of Line-Speed Filtering are listed in Table 25.

Table 25/X.87/Y.1324 – Codes of Line-Speed Filtering frame

CS frame types	Codes
Line-Speed Filtering_Request Frame	00110011
Line-Speed Filtering_Response Frame	00110100
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

The parameter of Line-Speed Filtering_Request Frame includes the following elements:

- Targeted Tributary: TNi = NAx + TT + TNp.
- Modification of the IP Type Of Service (TOS precedence) field, binary code: 10000001, the detailed operation is under study. Otherwise, binary code: 00000000 will be used.
- Delivery of a copy of the related frames to the domain of management, binary code: 10000010 represents that action of "Delivery of a copy of the related frames to the domain of management" will be taken. Otherwise, binary code: 00000000 will be used.
- Discarding the related frames, binary code: 10000011 represents that action of "Discarding the related frames" will be taken. Otherwise, binary code: 00000000 will be used.
- Transferring the related frames to other egress port of a Tributary, binary code: 10000100 represents that action of "Transferring the related frames to other egress port of a Tributary (this Tributary is presented as TNj = NAx + TT + TNq)" will be taken. So the octet "10000100" plus "TNj" will be used for this function. Otherwise, binary code: 00000000 will be used.
- Modification of protocol field, binary code: 10000101, the detailed operation is under study. Otherwise, binary code: 00000000 will be used.

Line-Speed Filtering from A to B and from B to A is independent of each other. The Line-Speed Filtering of two half-duplex channels can be selected to use or not use. All of these elements will be mapped to CS frame in the above order. Line-Speed Filtering_Response Frame uses two parameters: Line-Speed Filtering successful or Line-Speed Filtering unsuccessful as shown in Table 26.

Table 26/X.87/Y.1324 – Parameters of Line-Speed Filtering_Response Frame

CS frame types	Codes
Line-Speed Filtering successful	Binary "00000001 00011011 00000001 00000000"
Line-Speed Filtering unsuccessful	Binary "00000001 00011100 00000001 00000000"
NOTE – Operation of control frame for tributary between MAC and client will be implemented via MA_Data Request and Indication primitives.	

Line-speed filtering can be used to point-to-point operations of both half duplex and full duplex.

13 Topology application of link-type, broadcast network and pseudo-mesh

13.1 Support of a link-type with adding and dropping tributary services

In some applications, it is needed to build a link-type topology shown in Figure 16 in which the connection between Node 2 and Node 4 (it is suppositional) is one or more Tributaries. This Tributary may be a Tributary of other MSR. If the topology is involved in Figure 16, steering and wrapping, data node insertion and deletion, fairness should not be used. Instead, these functions will be switched off via configuration function of the network management. Link-type network bidirectional can be supported by RPR MAC depending on topology/protection mechanisms being disabled. MA_DATA.request is currently specified to allow a packet to be sent with Wrap Disable, Protection Disable, and Steering Disable by explicitly requesting a particular ringlet with no protection. It requires further study to determine if other MAC mechanisms would prevent this request from being fulfilled. The data and control packet will share the same channel and RI (Ringlet Identifier) field is always set to "0".

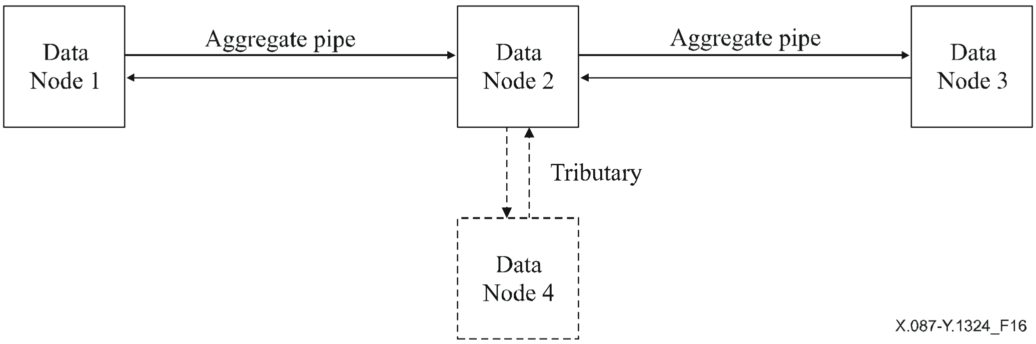


Figure 16/X.87/Y.1324 – A MSR topology, link-type with adding and dropping tributary services

13.2 Support of a broadcast connection to DVB application

In DVB application for example, it is needed to build a broadcast network topology as shown in Figure 17 in which the connections from Node 1 to Nodes 2/3/4 are aggregate pipes of single direction. If the topology is involved in Figure 17, the protection switch of aggregate pipe based, steering and wrapping, data node insertion and deletion, Tributary based Standby and in-band network management should not be used. Instead, these functions will be switched off via configuration function of the network management. Broadcast Network – unidirectional may be supported by RPR MAC depending on topology/protection mechanisms being disabled. MA_DATA.request is currently specified to allow a packet to be sent with Wrap Disable, Protection Disable, and Steering Disable by explicitly requesting a particular ringlet with no protection. It requires further study to determine if other MAC mechanisms would prevent this request from being fulfilled. The data and control packet will share the same channel and RI (Ringlet Identifier) field is always set to "0".

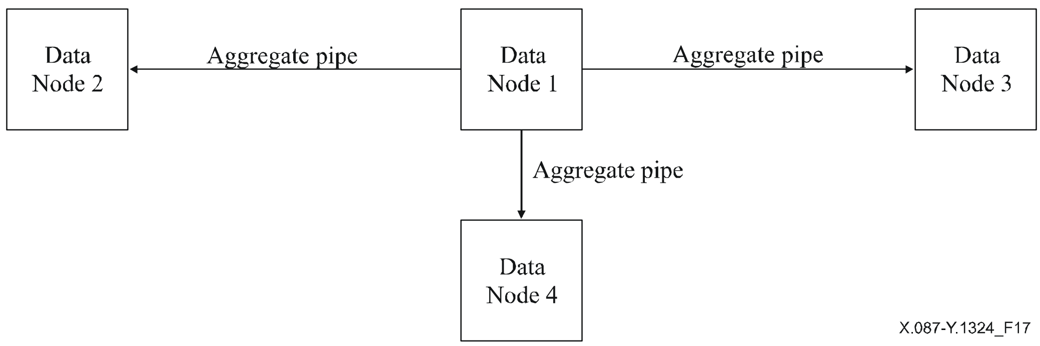


Figure 17/X.87/Y.1324 – A MSR topology, broadcast connection to DVB application

13.3 Support of a pseudo-mesh topology

Pseudo-mesh topology presented in Figure 18 is a particular example of a two-fibre ring. Eight Nodes via aggregate pipes are attached together to form a ring. The Tributaries of Nodes 2, 4, 6 and 8 are connected to Node 9 (it is suppositional) by tributaries. In this application, all functions and specifications defined in this Recommendation can be used effectively. Tributary cross-connection is concentrated and scheduled on Node 9.

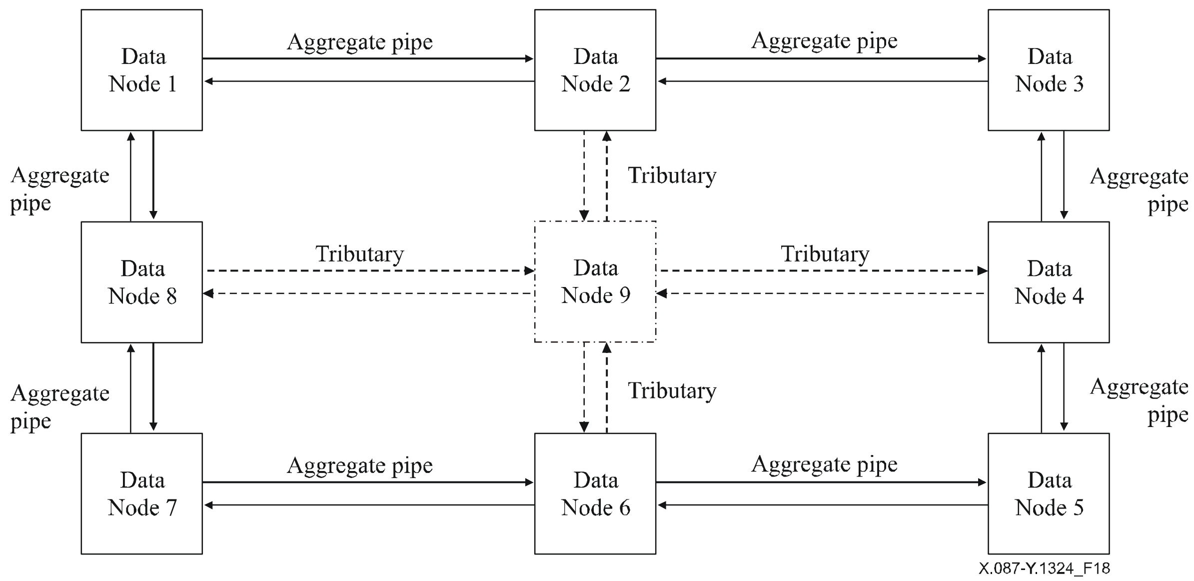


Figure 18/X.87/Y.1324 – A MSR topology, pseudo-mesh connection

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