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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Packet-based Networks

Operation, administration and maintenance functions and mechanisms for the public packet telecommunication data network (PTDN)

Recommendation ITU-T Y.2619

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Recommendation ITU-T Y.2619

Operation, administration and maintenance functions and mechanisms for the public packet telecommunication data network (PTDN)

Summary

As one type of hierarchical packet data networks to meet requirements of future packet-based networks, the public packet telecommunication data network (PTDN) should provide operation, administration, and maintenance (OAM) functions as specified in Recommendation ITU-T Y.2613. Recommendation ITU-T Y.2619 specifies maintenance entities (MTEs), OAM functions, and common OAM mechanisms in PTDN. Recommendation ITU-T Y.2619 also defines OAM mechanisms, functions, and encapsulation specific to connectionless mode and connection-oriented mode. Some examples of encapsulation for OAM messages in different planes are given in an annex.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2619	2018-05-29	13	11.1002/1000/13608

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Event indication, loopback, OAM, public packet telecommunication data network (PTDN), trace.

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Operation, administration and maintenance functions and mechanisms for the public packet telecommunication data network (PTDN)

1 Scope

This Recommendation specifies maintenance entities (MTEs), operation, administration and maintenance (OAM) functions, and common OAM mechanisms in the public packet telecommunication data network (PTDN). It also describes OAM mechanisms specific to connectionless mode and connection-oriented mode (specified in [ITU-T Y.2613]).

2 References

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

[ITU-T Y.2613] Recommendation ITU-T Y.2613 (2010), *General technical architecture for public packet telecommunication data network (PTDN)*.

[ITU-T Y.2616] Recommendation ITU-T Y.2616 (2014), *Interworking mechanisms in public packet telecom data networks*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 defect [b-ITU-T I.113]: Limited interruption of the ability of an item to perform a required function. It may or may not lead to maintenance actions depending on the results of additional analysis.

3.1.2 failure [b-ITU-T G.806]: The fault cause persisted long enough to consider the ability of an item to perform a required function to be terminated. The item may be considered as failed; a fault has now been detected.

3.1.3 public packet telecommunication data network (PTDN) [ITU-T Y.2613]: A packet data network designed for the NGN transport stratum, which should be secure, trustworthy, controllable, and manageable, can meet all the requirements described in [b-ITU-T Y.2601]. PTDN is a hierarchical network, which can be subdivided into several network layers.

3.1.4 link [b-ITU-T G.805]: A "topological component" which describes a fixed relationship between a "subnetwork" or "access group" and another "subnetwork" or "access group".

3.1.5 maintenance entity [b-ITU-T G.8001]: The entity between two of the flow/connection points in a maintenance entity group.

3.1.6 connection oriented [b-ITU-T E.417]: Connection-oriented refers to the transfer of information between two entities by first establishing a path (or connection) for the information transfer. The communication proceeds through three well-defined phases: connection establishment, information transfer, and connection release. The most common example of connection-oriented

information transfer is a telephone call over a circuit-switched network. other examples of connection-oriented information exchange are networks based on [b-ITU-T X.25], frame relay (FR), transmission control protocol (TCP) and asynchronous transfer mode (ATM).

3.1.7 connectionless [b-ITU-T E.417]: Connectionless refers to the transfer of information between two entities without first establishing a path (or connection) for the information transfer. Examples of connectionless transport include the Internet protocol (IP) and user datagram protocol (UDP).

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 maintenance end point (MTEP): End point of a public packet telecommunication data network (PTDN) operation, administration and maintenance (OAM) exercise that is capable of initiating and terminating OAM messages for fault management and performance monitoring.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ATM	Asynchronous Transfer Mode
FR	Frame Relay
ID	Identifier
IP	Internet Protocol
MTE	Maintenance Entity
MTEP	Maintenance End Point
NNI	Network-Network Interface
OAM	Operation, Administration and Maintenance
OAM-c	Operation, Administration and Maintenance-common
PTDN	Public packet Telecommunication Data Network
RTD	Round Trip Delay
TCP	Transmission Control Protocol
TLV	Type–Length–Value
UDP	User Datagram Protocol
UNI	User-Network Interface
VPN	Virtual Private Network

5 Conventions

None.

6 Background

The PTDN can provide connection-oriented and connectionless transmission services [ITU-T Y.2613]. The MTEs can be links and connections in general. In the PTDN, MTEs are virtual circuits in connection-oriented mode, paths in connectionless mode, and links in both modes.

The PTDN may contain multiple administrative domains. One end-to-end MTE can be segmented into access link MTE(s), intradomain MTE(s) and interdomain MTE(s). Figure 1 illustrates one end-to-end MTE that passes through two PTDN domains. PTDN OAM MTEs are the various MTEs involved between two user-network interfaces (UNIs), i.e., an access link MTE is not included in PTDN OAM MTEs. Usually OAM messages should be confined to an administrative domain. Therefore, a gateway function is needed to terminate and regenerate the OAM message when interworking with other administrative domains or networks [ITU-T Y.2616].

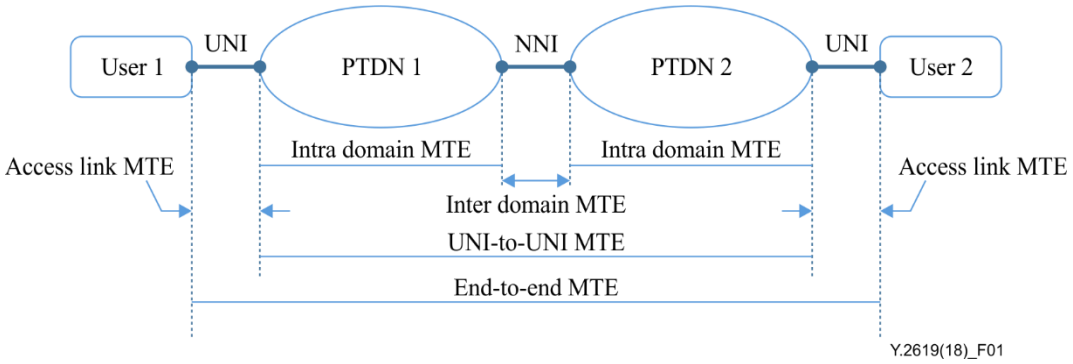


Figure 1 – Illustration of various maintenance entities

When intermediate nodes do not support PTDN OAM functions, they only forward the OAM messages like other packets or frames in the same paths or virtual circuits. If end nodes do not support PTDN OAM functions, they will drop these PTDN OAM messages.

7 OAM functions

The PTDN OAM functions include a continuity check, connectivity verification, event indication and some performance measurement functions. These functions are used to monitor and verify network availability and performance, and to help in the detection, notification, handling and diagnosis of defects and failures.

7.1 Continuity check

A continuity check provides continuous monitoring of the liveliness of links, connections or paths. This function is used for fault management, performance monitoring, and link switching when some defects occur.

7.2 Connectivity verification

A continuity verification provides on-demand or proactive connectivity verification among end points of an MTE. This can be achieved by using loopback and trace mechanisms.

7.3 Event indication

When a defect, failure or monitored event occurs, the detecting node sends indication OAM messages to other related nodes. When receiving these indication messages, the nodes do not send the same indication messages to the sending node. They take necessary actions, such as activating a backup path or link, to overcome the effect of the defect, failure or event.

7.4 Performance measurement

Based on a loopback mechanism, PTDN OAM functions provide simple performance measurements, such as frame/packet loss rate, latency and jitter.

8 OAM mechanisms

This clause describes some common OAM mechanisms used in both connection-oriented and connectionless modes. These mechanisms are loopback, trace and event indication.

8.1 Loopback mechanism

The loopback mechanism provides several capabilities, such as continuity check, connectivity verification, fault localization, round trip delay (RTD) measurement and delay variation measurements.

The loopback mechanism uses loopback OAM messages. These messages can be initiated and inserted at an MTEP, transferred through an MTE and returned (or looped back) to the sending MTEP without taking the MTE out of service.

For unidirectional paths in the PTDN, i.e., multicast paths, an extra return path is required to transfer looped back OAM messages (see clause 10.2).

A loopback OAM message includes the following fields:

- OAM message type, which indicates this is a loopback OAM message;
- sender's handle information, which is used by the sender to process the response OAM message, e.g., the sequence number used to correlate a loopback response against request;
- loopback indication, which indicates whether this message is looped back;
- loopback location information, which indicates which node should loopback this OAM message;
- return information, which is used to tell the sender about return result and return node information;
- additional type–length–value combinations (TLVs), which are used to provide more capabilities – the most often used TLV is timestamp TLV, which is used to calculate RTD by subtracting sending timestamp from receiving timestamp.

8.2 Trace mechanism

The trace mechanism is used to identify and retrieve information about MTEPs on a path and to locate a fault when the path is unavailable.

In the PTDN, the trace mechanism is similar to the loopback mechanism by sending trace OAM message with loopback location information specifying the destination MTEP. However, each intermediate node adds its node information to the OAM message, then forwards this OAM message. The destination MTEP adds its node information and sets a loopback indication field, then returns this OAM message to the source MTEP. When this OAM message returns to the source MTEP, it contains information about all nodes it has passed.

For unidirectional paths in the PTDN i.e., multicast paths, extra return paths are required to return trace messages (see clause 10.2).

A trace OAM message includes the following fields:

- OAM message type, which indicates this is a trace OAM message;
- the sender's handle information;
- a loopback indication, which indicates whether this packet/frame is looped back;
- loopback location information, which indicates which node should loopback these OAM packets/frames;
- return information, which is used to tell the sender about the return result and return node information;

- node information TLVs, which contain node information, such as identifier (ID) or address.

8.3 Event indication

The PTDN nodes use event indication to notify the peer MTEP(s) that some events have happened at the sender. For bidirectional paths or virtual circuits, event indication can be transmitted in the forward or backward direction. For unidirectional paths in the PTDN i.e., multicast paths, when an MTEP detects a defect and plans to notify an upstream MTEP, an extra return path is required (see clause 10.2).

An event indication OAM message includes:

- OAM message type, which indicates it is an event indication OAM message;
- an event field, which indicates the information of the defect or event;
- a location field, which indicates its occurrence location.

9 OAM in connection-oriented mode

In the connection-oriented mode, PTDN OAM is used to test and diagnose virtual circuits, and to measure their performance on an end-to-end or segment basis. These virtual circuits may be control/manage circuits or user data circuits. The PTDN OAM in connection-oriented mode includes functions, defined in clause 7, and uses mechanisms defined in clause 8.

The encapsulation of PTDN OAM messages shall follow the link layer frame definitions, specified in clause 6 of [ITU-T Y.2613]. An OAM message is encapsulated in thea frame payload, with the result that MTEPs in OAM messages, i.e., source MTEP and destination MTEP, are specified in the frame payload.

As an OAM frame is inserted and transmitted in the same virtual circuit with other frames, so a field is needed to distinguish it from others. In this case, the OAM field in the frame header, specified in clause 6.3.3.1.1.3 of [ITU-T Y.2613], shall be set to 1 by the OAM frame initiator for identification of OAM frames.

10 OAM in connectionless mode

In connectionless mode, OAM is used to test and diagnose paths in a virtual private network (VPN) or multicast, and to measure their performance. OAM for VPN paths provides the same functions, defined in clause 7, and uses the same mechanisms defined in clause 8. However, paths in multicast are unidirectional, different mechanisms, specified in clause 10.2, will be used.

10.1 OAM message encapsulation

The encapsulation of PTDN OAM messages in connectionless mode shall be as specified in clauses 7.2 and 7.3 of [ITU-T Y.2613].

Similarly, OAM messages can be encapsulated in the packet payload with the result that the MTEP information is in the packet payload. In connectionless mode, when the source MTEP and destination MTEP are the same as the source and destination of the packet, respectively, then source and destination information contained in the packet header can be used as MTEP information instead.

In the control or management plane, the specific value of the message type field in the packet header has to be specified to distinguish OAM messages from other control or management messages. Examples are given in Annex A.

In the data plane, there shall be a 1-bit field in the packet header to distinguish OAM messages from user data packets. This 1-bit field is recommended to occupy 1 bit of reserved fields in the PTDN packet header specified in clause 7.2 of [ITU-T Y.2613]. An example is given in Figure A.3.

10.2 Multicast OAM

The PTDN multicast service is provided only in connectionless mode with point-to-multiple-points unidirectional paths. Multicast OAM is used to test and diagnose those paths, and to measure their performance one-by-one or on a tree basis. A multicast MTE, whose MTEPs are specified by a multicast address, has the following two differences from other MTEs:

– it has more than one destination MTEP for loopback and trace;

– multicast paths are unidirectional; therefore, the extra reverse direction paths are needed to transfer the returned loopback and trace OAM messages, and to transfer event indication OAM messages to notify upstream MTEPs.

These reverse direction paths, referred to as OAM common (OAM-c) paths, are not a part of multicast MTE. The control plane or a specific VPN, more practically, can be used to serve these reverse direction paths and to transmit these OAM messages, referred as OAM-c packets. Along OAM-c paths, intermediate nodes do not intercept and process, but only forward these OAM-c packets.

10.2.1 Loopback

To verify connectivity of a multicast MTE, the source MTEP sends a loopback OAM message to all destination MTEPs specified by a multicast address. When a destination MTEP receives the loopback OAM message, it processes and sends this OAM message as an OAM-c packet on an OAM-c path. The source MTEP may receive more than one response, i.e., returned OAM messages, through OAM-c paths. Based on the received OAM-c packets, the source MTEP can obtain information about the multicast MTE.

To maintain one of the paths in a PTDN multicast, the source MTEP can send a loopback OAM message to a specific destination MTEP by using the destination MTEP node address as destination and loopback MTEP.

10.2.2 Trace

The trace mechanism is similar to the loopback mechanism specified in clause 10.2.1 except that:

– along the MTE paths, each intermediate node adds its node information, such as node ID and address, into the OAM message, then forwards the OAM message;

– the destination nodes add their node information to the OAM messages, then encapsulate the messages into OAM-c packets, and transmit the messages along the OAM-c paths;

– the returned OAM-c packets contain information about nodes lying in the forwarding direction of the paths only.

10.2.3 Event indication

The event indication mechanism is similar to the mechanism specified in clause 8.3, except that the backward indication OAM messages are encapsulated as OAM-c packets and transmitted along OAM-c paths.

11 Security considerations

OAM functions can enhance the security of the PTDN. For example, connectivity verification function or path detection function can detect misconfigured connections or wrongly delivered flows, therefore prevent user traffic from being exposed to unintended recipients.

OAM functions of service providers or network operators do not allow messages originated from one network to get transmitted to other networks without going through the gateway function. Gateway function may contain additional security functions.

Annex A

Examples of encapsulation of OAM packets in connectionless mode

(This annex forms an integral part of this Recommendation.)

Figure A.1 illustrates encapsulation of an OAM message in the management plane. In this example, the management message with type value 0x8F is an OAM message.

8	7	6	5	4	3	2	1	Octets
Version(4)			Packet type(2) 1 0		Address length(2)			1
Message Type(8) 1 0 0 0 1 1 1 1								2
Upper Payload length(8)								3
Lower Payload length(8)								4
Source address*								
Destination address*								
Payload (OAM message)								

*Note: address has variable length.

Figure A.1 – An example of encapsulation for an OAM message in the management plane

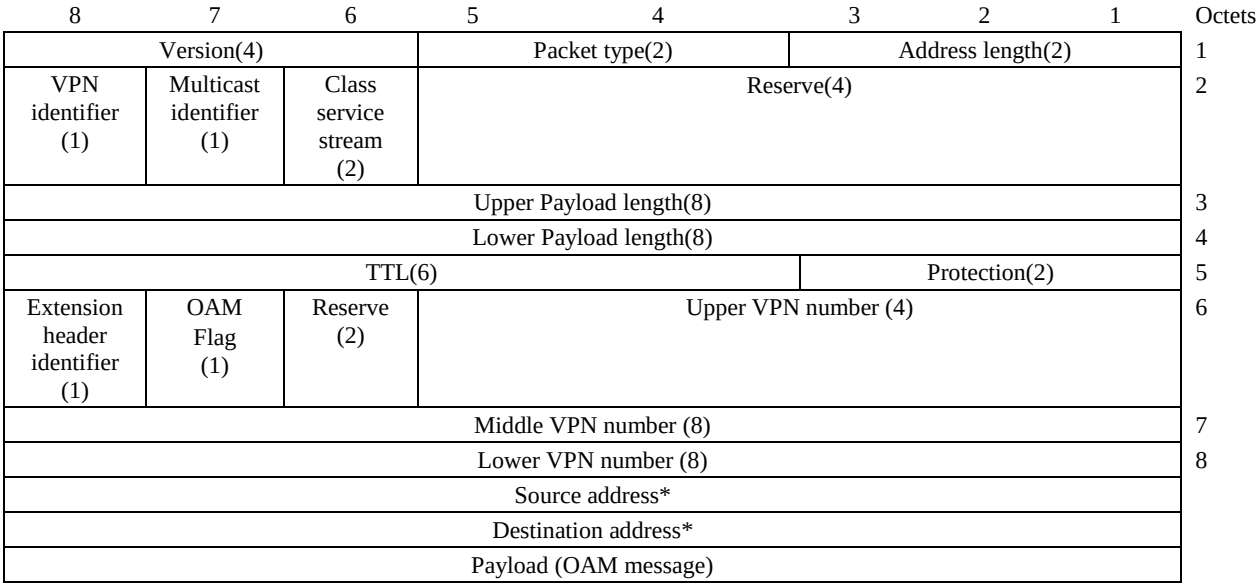
Figure A.2 illustrates encapsulation of an OAM message in the control plane. In this example, the control message with type value 0xCF is an OAM message.

8	7	6	5	4	3	2	1	Octets
Version(4)			Packet type(2) 0 1		Address length(2)			1
Message Type(8) 1 1 0 0 1 1 1 1								2
Upper Payload length(8)								3
Lower Payload length(8)								4
Source address*								
Destination address*								
Payload (OAM message)								

*Note: address has variable length.

Figure A.2 – An example of encapsulation for an OAM message in the control plane

Figure A.3 illustrates encapsulation of an OAM messages in the user data plane. In this example, the first bit of Reserve(3) (specified in Figure 7.2 of [ITU-T Y.2613]) has been used as an OAM Flag and is set to 1.



*Note: address has variable length.

Figure A.3 – An example of encapsulation of an OAM message in the data plane

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