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Public data networks – Maintenance

Frame Relay operations and maintenance – Principles and functions

ITU-T Recommendation X.151

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Frame Relay operations and maintenance: Principles and functions

Summary

This Recommendation defines the basic Frame Relay Operations and Maintenance Principles and Functions. The quality of Frame Relay services can be tested, measured and diagnosed using OAM frames. FR OAM frames can be used to measure the primary performance parameters of frame relay networks. OAM frames provide the ability to do in-service monitoring on both SVC and PVC connections.

This Recommendation includes a network reference model, an overview of the OAM frame structure, and OAM measurement procedures. The contents of this Recommendation are based on the reference model, the OAM protocol formats, the OAM procedures and descriptions of message flows as defined in FRF.19 – Frame Relay Operations, Administration, and Maintenance Implementation Agreement. Additionally procedures for measurement of frame delay jitter, frame loss ratio and use of loopback for fault detection are defined.

Source

ITU-T Recommendation X.151 was approved by ITU-T Study Group 17 (2001-2004) under the ITU-T Recommendation A.8 procedure on 29 October 2003.

FOREWORD

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

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Frame Relay operations and maintenance: Principles and functions

1 Scope

This Recommendation specifies OAM frame formats and procedures for measuring the performance of frame relay networks. OAM provides a means to test, diagnose and measure the quality of frame relay services. The protocol and procedures may be used by public frame relay networks and by service providers and/or end-users. The procedures are applicable to PVCs, as well as to the data transfer phase of SVCs.

The following clauses of this Recommendation are based on the text of FRF.19:

- Clause 6. A reference model for different networks and domains over which FR OAM measurements can be made.
- Clause 7. OAM protocol formats – Detailed structure (message formats) of FR OAM frames.
- Clause 8. OAM procedures – use of FR OAM frames to measure the primary performance parameters of frame relay services.

Appendices I, II and III – Informative text describing general receive procedures, message flows and delivery ratio calculation to aid interpretation and interoperability.

The following clauses of this Recommendation are additional to the text of FRF.19:

- Clause 8.4.3.6: Procedures for the estimation of frame delay jitter.
- Clause 8.4.4.5: Frame loss ratio calculation.
- Clause 8.8: Network applications of loopback.

NOTE – Interoperability with ATM OAM as defined by ITU-T Rec. I.610 and other OAM protocols is beyond the scope of this Recommendation.

2 References

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

- ITU-T Recommendation E.164 (1997), *The international public telecommunication numbering plan*.
- ITU-T Recommendation I.370 (1991), *Congestion management for the ISDN frame relaying bearer service*.
- ITU-T Recommendation I.555 (1997), *Frame Relaying Bearer Service interworking*.
- ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.
- ITU-T Recommendation X.36 (2003), *Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for public data networks providing frame relay data transmission service by dedicated circuit*.

- ITU-T Recommendation X.76 (2003), *Network-to-network interface between public data networks providing PVC and/or SVC frame relay data transmission service.*
- ITU-T Recommendation X.121 (2000), *International numbering plan for public data networks.*
- ITU-T Recommendation X.144 (2003), *User information transfer performance parameters for public frame relay data networks.*
- ITU-T Recommendation X.145 (2003), *Connection establishment and disengagement performance parameters for public Frame Relay data networks providing SVC services.*
- ITU-T Recommendation X.146 (2000), *Performance objectives and quality of service classes applicable to frame relay.*
- ITU-T Recommendation X.147 (2003), *Frame Relay network availability.*
- ITU-T Recommendation X.148 (2003), *Procedures for the measurement of the performance of public data networks providing the international frame relay service.*
- Frame Relay Forum Implementation Agreement 19, FRF.19 (2001), *Frame relay operations, administration, and maintenance implementation agreement.*

3 Definitions

The following terms, when used in this Recommendation, are used as defined in ITU-T Recs X.144, X.145, X.146, X.147 and X.148.

- Frame Transfer Delay
- Frame Delivery Ratio
- Data Delivery Ratio
- Frames_offered
- Frames_received
- Data_offered
- Data_received
- Availability

4 Abbreviations

This Recommendation uses the following abbreviations:

AESA	ATM End System Address
ATM	Asynchronous Transfer Mode
BECN	Backward Explicit Congestion Notification
CIR	Committed Information Rate
DCE	Data Circuit-terminating Equipment
DDR	Data Delivery Ratio
DE	Discard Eligibility
DLCI	Data Link Connection Identifier
DTE	Data Terminal Equipment
FDR	Frame Delivery Ratio
FECN	Forward Explicit Congestion Notification

FR	Frame Relay
FROMP	Frame Relay OAM Maintenance Point
FTD	Frame Transfer Delay
IA	Implementation Agreement
IEEE	Institute of Electrical and Electronics Engineers
IF	Information Field
IPv4	Internet Protocol Version 4
ITU	International Telecommunication Union
MTU	Maximum Transmission Unit
NLPID	Network Layer Protocol Identification
NNI	Network-to-Network Interface
OAM	Operations, Administration and Maintenance
OUI	Organizationally Unique Identifier
PHY	Physical Interface
PVC	Permanent Virtual Circuit
SLA	Service Level Agreement
SVC	Switched Virtual Circuit
UNI	User-to-Network Interface
VC	Virtual Circuit

5 Conventions

For the purposes of ensuring interoperability of OAM systems, the following terms, when used in this Recommendation and highlighted in **bold**, are used as defined in this clause:

Must, Shall, or Mandatory – the item is an absolute requirement of this Recommendation.

Should – the item is highly desirable.

May or Optional – the item is not compulsory, and may be followed or ignored according to the needs of the Recommendation.

Not Applicable – the item is outside the scope of this Recommendation.

NOTE – The abbreviation OAM is used throughout this Recommendation and has the same meaning as the abbreviation OA&M which is used throughout FRF.19.

6 Reference model

Figures 1 and 2 define generic network reference models illustrating typical locations of FR OAM Maintenance Points (FROMPs). The four types of administrative domains used for FR OAM operations are also defined.

Figure 1 illustrates a reference frame relay network that is interworking with an ATM network. A number of example monitoring points are indicated. In this reference network, the following examples of circuit connections are shown:

- A VC that spans a single FR access network section.
- A VC that spans two FR access network sections connected by an NNI.

- A VC that spans two FR access network sections connected by a FR transit network.
- A VC that spans two FR access network sections connected by an ATM transit network section using network interworking.

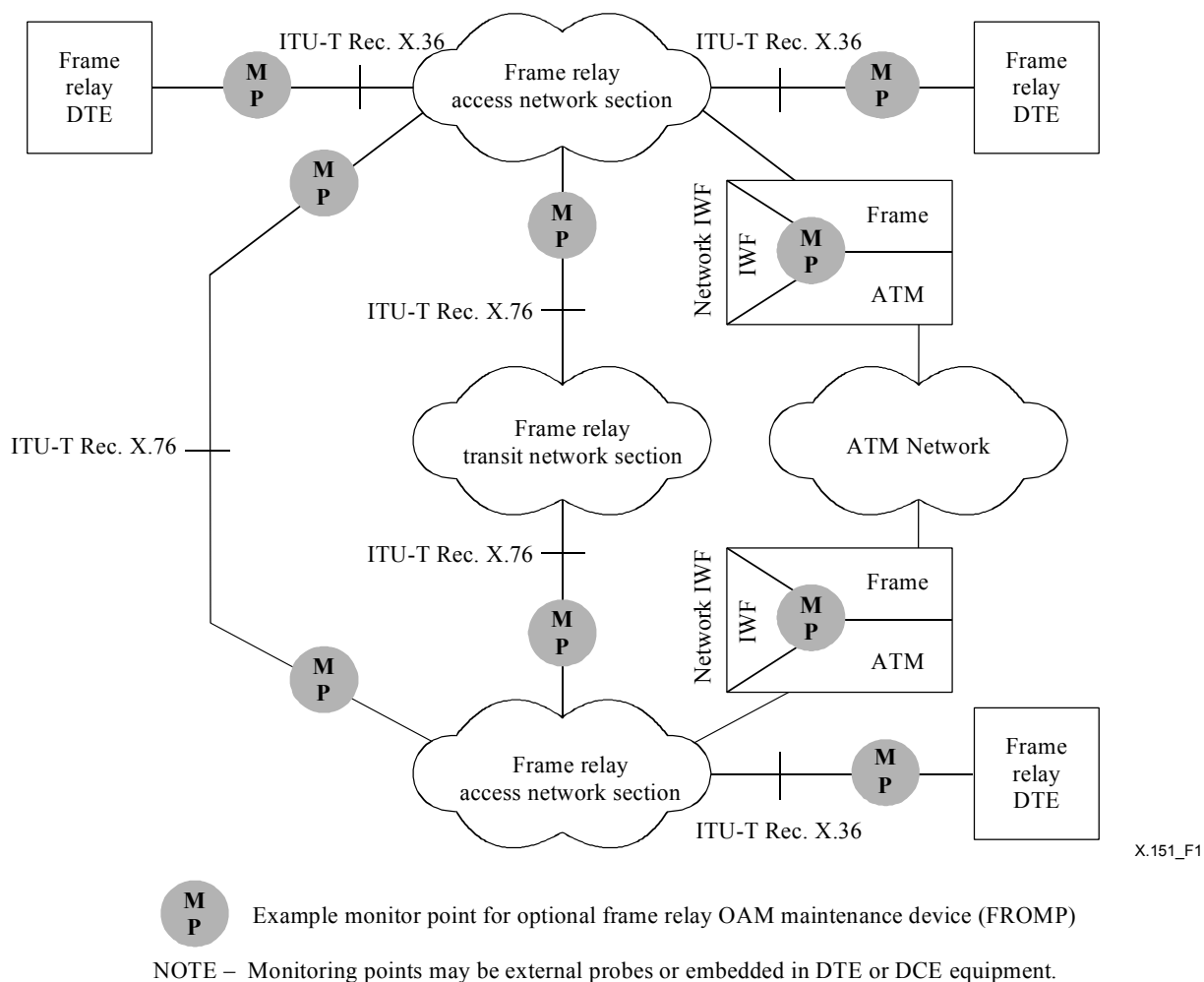


Figure 1/X.151 – Network reference model

Figure 2 shows the location of OAM Maintenance Points (FROMPs) for monitoring performance across various segments of a frame relay virtual connection.

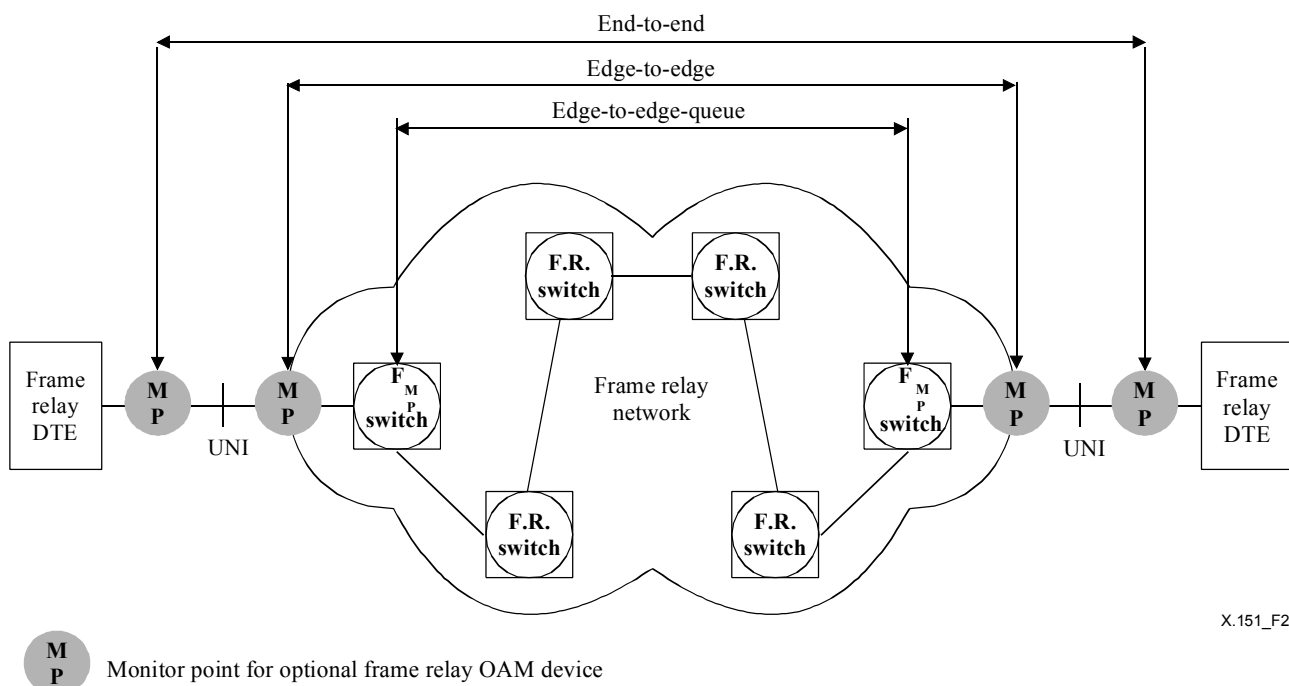


Figure 2/X.151 – Location of OAM Maintenance Points (FROMPs) for monitoring performance

A VC may consist of several sections and components administered by multiple organizations. The portions of a VC that are administered by the same organization(s) create an administrative domain. Figure 3 presents the administrative domain reference model.

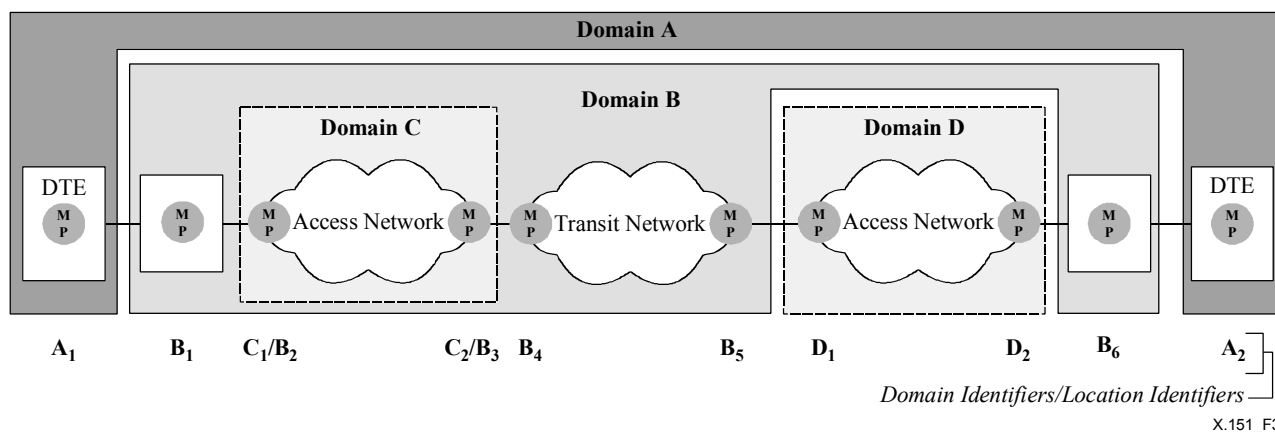


Figure 3/X.151 – Administrative domain reference model

Four different and overlapping types of administrative domains are illustrated in this model. An administrative domain may consist of any arbitrary collection of locations on the virtual circuit.

Domain A – Set of interfaces and devices administered by the end-user (locations A₁ and A₂).

Domain B – Set of interfaces and devices administered by a global service provider working with local partners in each region (locations B₁, B₂, B₃, B₄, B₅ and B₆).

Domain C – Set of interfaces and devices administered by a local partner of the global service provider (locations C_1 and C_2). A network partner has granted the global service provider permission to interrogate OAM devices operated by the local partner. This permission is reflected in multiple domain memberships (C_1/B_2 and C_2/B_3).

Domain D – Set of interfaces and devices controlled by a local partner of the global service provider (locations D_1 and D_2). The partner has refused to grant the global service provider permission to interrogate OAM devices operated by the local partner.

Administrative domains provide well-defined zones for OAM messaging. At the outermost points of an administrative domain on a given VC (see Figure 3 points B_1 and B_6 for Domain B), an administrative boundary exists to delineate the domain. All OAM messages include a domain identification, which is used to identify the intended administrative domain.

A FROMP at a domain boundary of a VC's administrative domain prevents messages intended for the domain from being forwarded beyond the domain boundary. As an example, location D_2 does not send an OAM message with a domain identification for Domain D towards B_6 .

Further, these boundary devices detect and discard counterfeit messages originating outside the administrative domain. Thus, if a rogue application at location B_5 creates a message claiming to have domain identification D and sends the message to D_1 , D_1 will discard the message to prevent an illegal OAM request from entering the domain.

Messages for other domains **must** be passed through the domain boundary in either direction without interpretation or discard. As an example, location A_1 transmits a message towards location A_2 . Location B_1 , a boundary device for Domain B, checks the administrative domain identification and verifies that the message does not claim to originate from within Domain B. The message is then forwarded onward to locations C_1 and D_1 where the same boundary checks are made. The message is then forwarded onward to location A_2 , the target of the message.

Messages received from within a domain are trusted. As an example, location B_1 in Domain B trusts messages from direction C_1 with the domain identification for Domain B because they share a common administrative domain.

The Administration/organization that controls the insertion of OAM frames in a FR management domain must ensure that those frames are extracted before they leave the span of control of that Administration/organization with the exception of those management domains that have been extended by bilateral agreements.

7 OAM protocol formats

Frame relay OAM messages are carried in standard frame relay frames. Two encapsulation formats for the data portion of these frame relay frames are defined to allow for interoperability with other traffic. The messages consist of a header portion, and one or more information fields.

The remainder of this clause describes the format of frame relay OAM protocol messages, and consists of three portions:

- An encapsulation format (see 7.1);
- An OAM message (see 7.2) containing one or more;
- OAM Information Fields (see 7.3).

NOTE – See 8.1 for rules on encoding and decoding these formats. Figures throughout this Recommendation illustrate 2-octet DLCI encoding. Both 2- and 4-octet addresses are supported in all cases.

7.1 Encapsulation formats

The frame relay OAM protocol supports two encapsulation formats. These formats allow for implementation in a variety of network elements and for compatibility with U-plane traffic formats.

Implementations **must** support the multiprotocol encapsulation format to be compliant with this Recommendation. Implementations **may** optionally support the non-UI encapsulations.

7.1.1 Multiprotocol encapsulation

The multiprotocol encapsulation format is compatible with frame relay equipment and applications. The format uses a NLPID (0xB2) to distinguish OAM traffic from U-plane traffic conforming to ITU-T Rec. X.36. Figure 4 depicts the multiprotocol encapsulation format when an X.36 2-octet header is used.

Bits								Octet
8	7	6	5	4	3	2	1	
DLCI (msb)						C/R	EA	1
x	x	x	x	x	x	0	0	
DLCI (lsb)				FECN	BECN	DE	EA	2
x	x	x	x	x	x	x	1	
Control								3
0	0	0	0	0	0	1	1	(Note)
NLPID								4
1	0	1	1	0	0	1	0	
FR_OAM Message								5

NOTE – Control is at octet 5 when 4-octet addressing of X.36 is used.

Figure 4/X.151 – Multiprotocol encapsulation format

7.1.2 Non-UI encapsulation

The non-UI encapsulation format is designed for use with frame relay traffic that is not distinguishable from the OAM multiprotocol encapsulation format. The prime example of this is clause 5/I.555 (X.25 encapsulated) traffic. Figure 5 depicts the non-UI encapsulation format when an X.36 2-octet header is used.

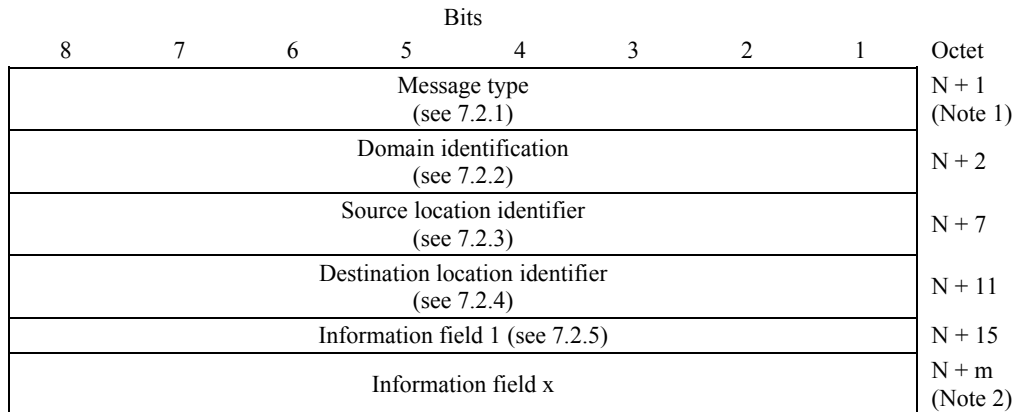
Bits								Octet
8	7	6	5	4	3	2	1	
DLCI (msb)						C/R	EA	1
x	x	x	x	x	x	0	0	
DLCI (lsb)				FECN	BECN	DE	EA	2
x	x	x	x	x	x	x	1	
Control								3
0	0	0	0	0	0	1	0	(Note)
NLPID								4
1	0	1	1	0	0	1	0	
FR_OAM Message								5

NOTE – Control is at octet 5 when 4-octet addressing of X.36 is used.

Figure 5/X.151 – Non-UI encapsulation format

7.2 OAM message format

Figure 6 depicts the format of OAM messages.



NOTE 1 – Offset N is 4, 6, or 10, depending upon encapsulation and address size used.

NOTE 2 – Information fields are populated as needed.

Figure 6/X.151 – OAM message format

7.2.1 Message type field

The purpose of the message type field is to identify the message being sent. Values for this field are shown in Table 1.

Table 1/X.151 – OAM message type values

Message type value	Usage
0x1	Hello (see 8.3 for usage)
0x2	Service verification (see 8.4 for usage)
0x3	Non-latching loopback (see 8.5)
0x4	Latching loopback (see 8.6)
0x5	Diagnostic indication (see 8.7)

7.2.2 Domain identification

The purpose of the domain identification field is to uniquely identify the Administrative Domain to which this message belongs. This field consists of two parts, a 1-octet descriptor for the type of plan, shown in Table 2 below, followed by a 4-octet domain identifier.

Table 2/X.151 – Domain identification plan

Domain identification plan value	Usage
0x00	Reserved for future use
0x01	User defined identifier
0x02	OUI identifier
0x03	IPv4 network identifier
0x31	X.121 identifier
0x33	E.164 identifier
0xFF	Private domain identifier
NOTE 1 – User defined identifiers are for use by end-user administered equipment. NOTE 2 – OUI, IPv4, X.121 and E.164 identifiers are for use by service providers. NOTE 3 – Private domain identifiers are for use via multilateral agreement.	

The domain identification field (the combined values of the type of plan and domain identifier) **must** be unique for each administration along the path of a VC.

The format of the 4-octet domain identifier is dependent upon the value of the domain identification plan.

7.2.2.1 Domain identifier format for "User Defined" plan

The "User Defined" plan is intended for use by customer administered equipment. When the domain identification plan indicates usage of the user defined identifier, the format of the remaining 4 octets is not subject to standardization. A value of zero **may** be used as the default value to indicate the last OAM capable device on the VC.

7.2.2.2 Domain identifier format for "OUI" plan

The "OUI" plan is one of several plans intended for use by service providers. When the domain identification plan indicates usage of the OUI identifier, the format of the remaining 4 octets is created by using a zero byte followed by a 3-octet OUI. OUI identifiers are assigned and administered by the IEEE.

7.2.2.3 Domain identifier for "IPv4 Network" plan

The "IPv4" plan is also intended for use by service providers. When the domain identification plan indicates usage of the IPv4 identifier, the format of the remaining 4 octets is the network portion of a public IPv4 address block owned by the service provider. Public IPv4 addresses are administered by the IETF.

7.2.2.4 Domain identifier format for "X.121" plan

The "X.121" plan is also intended for use by service providers. When the domain identification plan indicates usage of the X.121 identifier, the value of the remaining 4 octets are created as follows:

- Take X.121 DNIC, as defined in ITU-T Rec. X.121;
- Pad on the left with zeros, as necessary, to 8 octets;
- BCD encode the result into 4 octets.

7.2.2.5 Domain identifier format for "E.164" plan

The "E.164" plan is also intended for use by service providers. When the domain identification plan indicates usage of the E.164 identifier, the value of the remaining 4 octets are created as follows:

- Take E.164 network identification field of the transit network ID, as defined in ITU-T Rec. X.76;
- Pad on the left with zeros, if necessary, to 8 octets;
- BCD encode the result into 4 octets.

7.2.2.6 Domain identifier format for "Private" plan

When the domain identification plan indicates usage of the private domain identifier, the format of the remaining 4 octets is not subject to standardization.

7.2.3 Source location identifier field

The purpose of the source location identifier field is to uniquely identify the source of an OAM message with the indicated administrative domain.

The values used in the source location identifier field **must** be unique for each administration along the path of a VC. The value of all ones is reserved and **may not** be used as a source location identifier.

The format of this 4-octet field is not subject to standardization.

7.2.4 Destination location identifier field

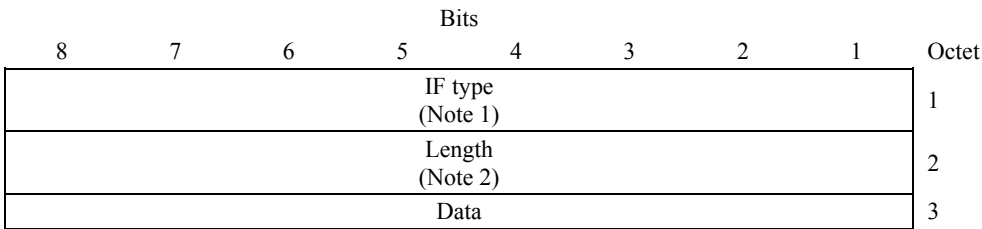
The purpose of the destination location identifier field is to uniquely identify the destination of an OAM message with the indicated administrative domain, or to indicate a broadcast destination.

The values used in the destination location identifier field **must** be unique for each administration along the path of a VC. The value of all ones is used to indicate the global (all destinations) broadcast for the identified administration.

The format of this 4-octet field is not subject to standardization.

7.2.5 OAM information field format

OAM information fields are self identifying type-length-data entities. Figure 7 depicts the general format of an information field. Each type of information field will be defined in subsequent subclauses.



NOTE 1 – Information field type values are defined in 7.2.5.1.

NOTE 2 – Length includes type, length, and data subfields.

Figure 7/X.151 – OAM information field format

7.2.5.1 IF-type field values

The values for the IF-type field of the OAM information field are defined in Table 3.