INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.1412

(11/2003)

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

Internet protocol aspects – Interworking

ATM-MPLS network interworking – Frame mode user plane interworking

ITU-T Recommendation Y.1412

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ITU-T Recommendation Y.1412

ATM-MPLS network interworking – Frame mode user plane interworking

Summary

This Recommendation addresses the required functions for network interworking between ATM networks and MPLS networks, specifically the user plane interworking mechanisms and procedures. One of the key aspects of network interworking is to provide network support for ATM services during the evolution of networks. Details of the interworking model and required interworking functions are described.

Source

ITU-T Recommendation Y.1412 was approved by ITU-T Study Group 13 (2001-2004) under the ITU-T Recommendation A.8 procedure on 6 November 2003.

FOREWORD

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Introduction

There is a need to focus on the functions required for network interworking between ATM networks and MPLS networks, specifically the user plane interworking mechanisms and procedures. One of the key aspects of network interworking is to provide network support for ATM services during the evolution of networks.

ITU-T Recommendation Y.1412

ATM-MPLS network interworking – Frame mode user plane interworking

1 Scope

This Recommendation focuses on the functions required for network interworking between ATM and MPLS, specifically the user plane interworking mechanisms and procedures for the AAL type 5 protocol data unit (PDU) and service data unit (SDU) transport modes. In particular, it specifies a list of requirements, interworking scenarios and interworking encapsulation formats and semantics for ATM-MPLS AAL type 5 PDU and SDU mode network interworking.

This Recommendation enables transport of ATM PVC or SVC connections over an MPLS network. The encapsulation allows one AAL type 5 CPCS PDU or SDU to be carried within a single MPLS label switched path (LSP).

The scope includes support of AAL type 5, transport of OAM and RM cells.

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.

[1] IETF RFC 3031 (2001), *Multiprotocol Label Switching Architecture*.

[2] ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

[3] ITU-T Recommendation I.610 (1999)/Corrigendum 1 (2000), *B-ISDN operation and maintenance principles and functions*.

[4] ITU-T Recommendation I.610 (1999)/Amendment 1 (2000), *B-ISDN operation and maintenance principles and functions*.

[5] ITU-T Recommendation Y.1710 (2002), *Requirements for Operation and Maintenance functionality in MPLS networks*.

[6] ITU-T Recommendation Y.1711 (2002), *Operation and Maintenance mechanism for MPLS networks*.

[7] ITU-T Recommendation I.371 (2000), *Traffic control and congestion control in B-ISDN*.

[8] ITU-T Recommendation I.371.1 (2000), *Guaranteed frame rate ATM transfer capability*.

[9] ITU-T Recommendation I.356 (2000), *B-ISDN ATM layer cell transfer performance*.

[10] IETF RFC 3270 (2002), *Multi-Protocol Label Switching (MPLS) Support of Differentiated Services*.

[11] IETF RFC 3032 (2001), *MPLS Label Stack Encoding*.

[12] ITU-T Recommendation I.732 (2000), *Functional characteristics of ATM equipment*.

[13] ATM Forum af-sec-0100.002 (2001), *ATM Security Specification Version 1.1*.

[14] ITU-T Recommendation I.363.5 (1996), *B-ISDN ATM Adaptation Layer specification: Type 5 AAL*.

[15] ITU-T Recommendation Y.1411 (2003), *ATM-MPLS network interworking – Cell mode user plane interworking*.

[17] FR Forum Implementation Agreement FRF.8.1 (2000), *Frame Relay/ATM PVC service interworking implementation agreement*.

[18] ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification*.

[19] ITU-T Recommendation I.510 (1993), *Definitions and general principles for ISDN interworking*.

3 Definitions

This Recommendation defines the following terms:

3.1 interworking: The term interworking is used to express interactions between networks, between end systems, or between parts thereof, with the aim of providing a functional entity capable of supporting an end-to-end communication. The interactions required to provide a functional entity rely on functions and on the means to select these functions [19].

3.2 interworking function (IWF): These functions are referred to in the interworking definition, which include the conversion between protocols and the mapping of one protocol to another. The functionality required between networks can be separated from the functionality, if any, required in end systems. The IWFs needed as a result of a service requirement for interworking are categorized as connection-dependent IWFs (i.e., those functions needed in order to interconnect two networks) or communication-dependent IWFs (i.e., those functions in addition to connection-dependent IWFs needed in order to establish a specific end-to-end communication and which may differ from application to application) [19]. The IWF includes interworking between U-plane, C-plane and M-plane functions.

3.3 ingress IWF/network element: The point where the AAL type 5 PDUs or SDUs are encapsulated into an MPLS packet (ATM-to-MPLS direction).

3.4 egress IWF/network element: The point where the AAL type 5 PDUs or SDUs are de-encapsulated from an MPLS packet (MPLS-to-ATM direction).

3.5 MPLS packet payload: The MPLS packet payload is comprised of the common interworking indicators, the ATM-MPLS interworking specific header and the payload. The length of the MPLS packet payload is expressed in number of octets.

4 Abbreviations

This Recommendation uses the following abbreviations.

AAL	ATM Adaptation Layer
AINI	ATM Inter-Network Interface
ATC	ATM Transfer Capability
ATM	Asynchronous Transfer Mode
ATM-F	ATM Forum
AUU	ATM User-to-User indication
CES	Circuit Emulation Service
CLP	Cell Loss Priority

CPCS	Common Part Convergence Sub-layer
CPCS-UU	CPCS User-to-User indication
CPI	Common Part Indicator
CRC	Cyclic Redundancy Check
DSS2	Digital Subscriber Signalling System No. 2
E-LSP	EXP-inferred-PSC LSP
EFCI	Explicit Forward Congestion Indication
EXP	Experimental Bit
FIFO	First-In First-Out
ILMI	Integrated Local Management Interface
IP	Internet Protocol
ISH	Interworking Specific Header
IWF	InterWorking Function
L-LSP	Label-only-inferred-PSC LSP
LSP	Label Switched Path
LSR	Label Switching Router
MPLS	Multi-Protocol Label Switching
MTU	Maximum Transport Unit
OAM	Operation and Maintenance
PDU	Protocol Data Unit
PHB	Per Hop Behaviour
PM	Performance Monitoring
PNNI	Private Network-to-Network Interface
PSC	PHB Scheduling Class
PTI	Payload Type Identifier
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RFC	Request For Comments
RM	Resource Management
S-bit	Stack bit
SAP	Service Access Point
SDU	Service Data Unit
SPVC	Soft PVC
SVC	Switched Virtual Circuit
TTL	Time To Live
UNI	User-Network Interface
UU	User-to-User

VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

5 ATM-MPLS interworking

The multi-protocol label switching (MPLS) technology [1] allows services to be supported over a single networking infrastructure. Services in this context are traditional data services such as ATM, Frame Relay, IP and circuit emulation services (CES). Figure 5.1 provides the reference network architecture for ATM-MPLS network interworking where ATM network(s) are interconnected through an MPLS network. For the ATM-to-MPLS direction, an AAL type 5 PDU, AAL type 5 PDU fragment or an AAL type 5 SDU are encapsulated in an MPLS packet by the interworking function. For the MPLS-to-ATM direction, reconstruction of the ATM cells is performed.

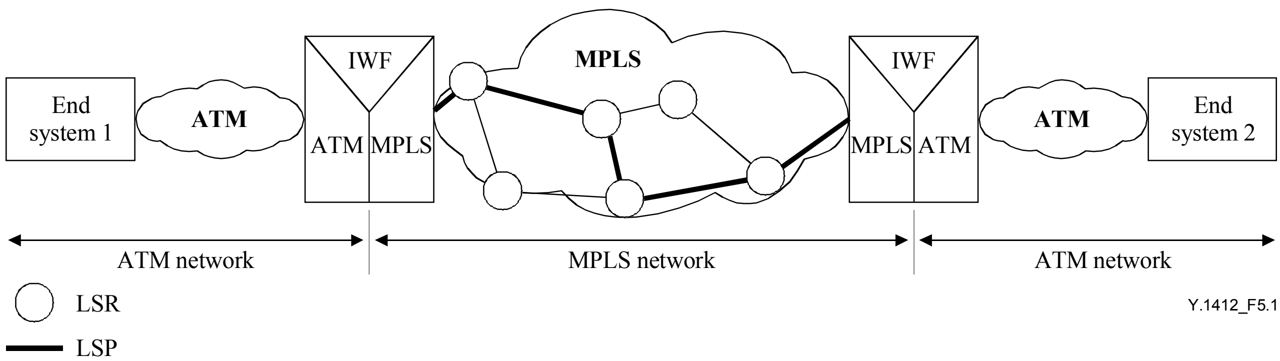


Figure 5.1/Y.1412 – Reference network architecture for ATM-MPLS network interworking

6 General requirements

6.1 User plane requirements

For transparent transfer of ATM-related information in the transfer (user) plane, the following are required:

a) The ability to multiplex multiple ATM VCCs into a transport LSP.

b) Support for the traffic contracts and the QoS commitments made to the ATM connections.

c) The ability to transparently carry all OAM cells, including the support for proper operation of OAM PM cells.

d) Transport of resource management (RM) cells.

e) Transport of cell loss priority (CLP) indication and explicit forward congestion indication (EFCI) information from AAL type 5 frame.

f) Maintaining frame sequence integrity for AAL type 5 PDU, AAL type 5 PDU fragment or AAL type 5 SDU.

g) Support of ATM point-to-point and ATM point-to-multipoint connections.

h) Support of bidirectional ATM point-to-point connections with symmetric or asymmetric bandwidth.

i) Support for transparent transport of ATM signalling protocols (e.g., DSS2, B-ISUP, ATM-F UNI, ATM-F PNNI, ATM-F AINI), ATM routing protocols (e.g., ATM-F PNNI) and ATM management protocols (e.g., ATM Forum ILMI), which control the ATM connections across the MPLS network.

j) Support of a mechanism to associate the two transport LSPs, one for each direction, to act as a logical ATM port to ATM signalling and routing, capable of carrying ATM connections between two IWFs.

Figure 6.1 shows the network reference model and protocol layers for ATM-MPLS user plane interworking.

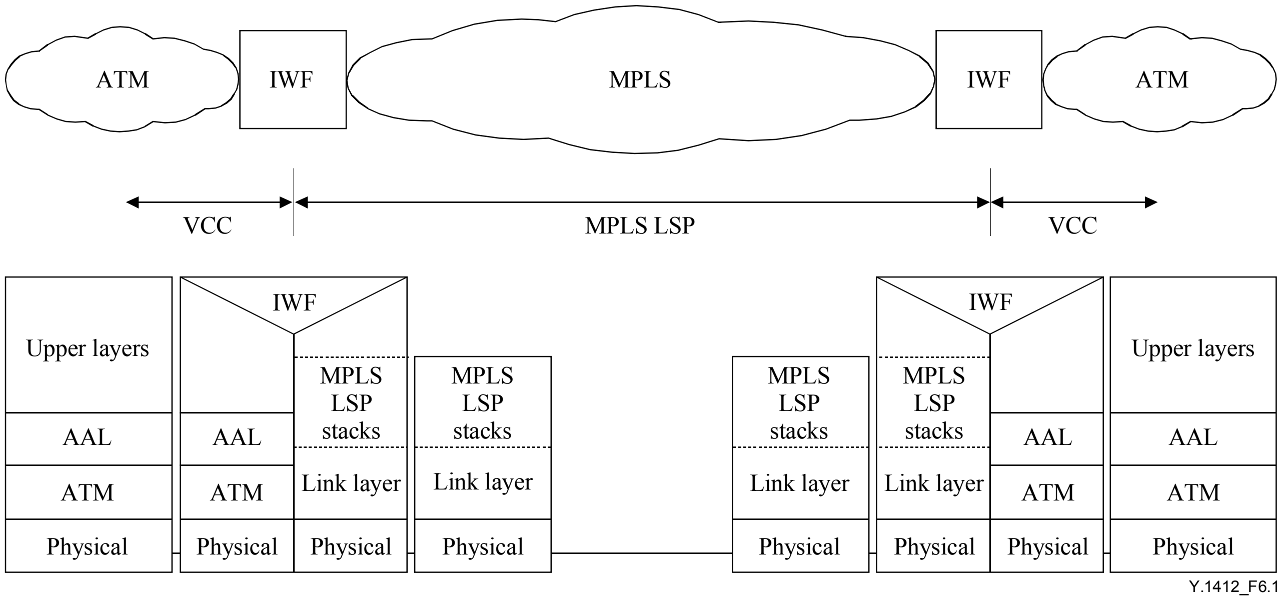


Figure 6.1/Y.1412 – Network reference model and protocol layers for ATM-MPLS user plane interworking

6.2 Control plane aspects

For transparent transfer of ATM-related services, the following items are required to be signalled or provisioned:

a) Exchange of interworking label(s) 20-bit label field between IWFs;

b) Correlation of interworking labels for a bidirectional connection for each interworking LSP. Mechanisms are to be defined;

c) Operation in PDU or SDU mode;

d) Support of the connection types switched virtual connection (SVC) and soft permanent virtual connection (SPVC);

e) The ability to control the MPLS interworking LSPs via ATM control protocols by the IWFs for ATM SVCs and ATM Soft PVCs;

f) The control of MPLS transport LSPs or interworking LSPs via MPLS control protocols by the IWFs;

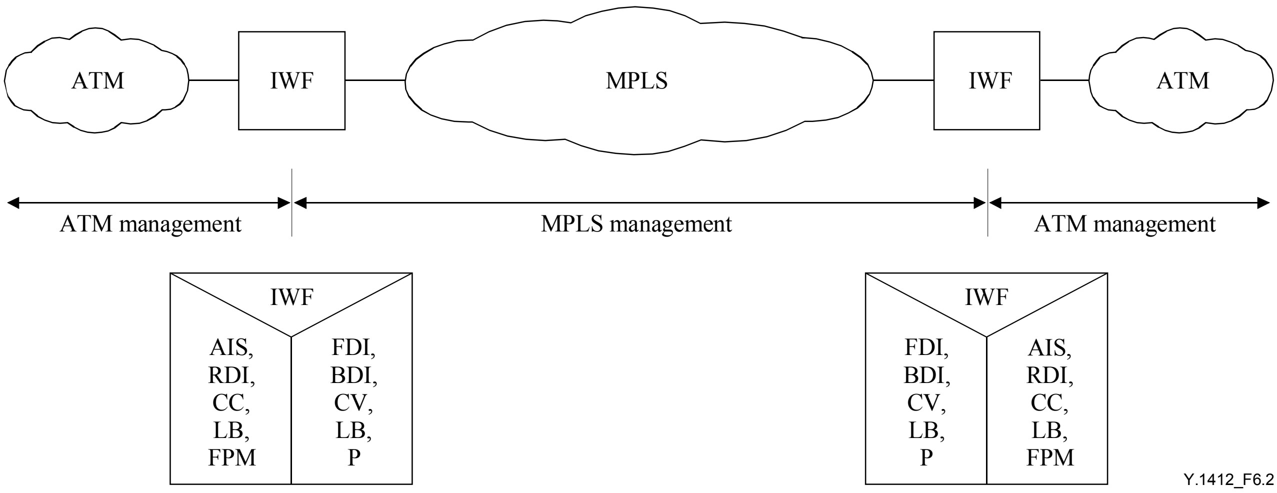
g) The ability to exchange the MTU size which can be supported.

6.3 Management plane aspects

ATM OAM cells carry performance, defect, and protection switching information for VCCs and VPCs on an end-to-end and per segment basis to support the ATM management plane [2], [3] and [4]. OAM functionality in MPLS networks and OAM mechanisms for MPLS networks are specified in ITU-T Recs Y.1710 [5] and Y.1711 [6]. For transparent transfer of ATM-related information in the management plane, the interworking function should support transparent transfer or mapping of performance, defect, and protection switching information between MPLS OAM flows and ATM OAM cells.

As a minimum, the interworking function must transfer ATM OAM information through the MPLS core network by encapsulating OAM cells in MPLS packets. Where end-to-end OAM is required, the interworking function may have to correlate the MPLS OAM information with the ATM OAM. This aspect of OAM interworking with MPLS is outside the scope of this Recommendation.

Figure 6.2 shows functional representation of ATM-MPLS management plane interworking.



AIS	Alarm Indication Signal	FPM	Forward Performance Monitoring
BDI	Backward Defect Indication	LB	Loop Back
CC	Continuity Check	P	P flows
CV	Connectivity Verification	RDI	Remote Defect Indication
FDI	Forward Defect Indicator		

Figure 6.2/Y.1412 – Functional representation of ATM-MPLS management plane interworking

6.4 Traffic management aspects

In ATM, a number of different ATM transfer capabilities (ATC) [7], [8] and quality of service (QoS) classes [9] are defined. A combination of an ATC and an associated QoS class is intended to support an ATM layer service model.

When a transport LSP is used to carry multiple ATM connections with different combinations of ATC and QoS classes, the transport LSP shall be capable of providing the required QoS for all ATM connections. In an MPLS network that does not support QoS differentiation on a per packet basis, the LSP shall meet the most stringent QoS requirements of the ATM connections transported by the LSP.

6.4.1 Use of differentiated services for ATM-MPLS interworking

Informational RFC 2475 [I-1] and informational RFC 3260 [I-2] describe one way in which an MPLS network may support differentiated services (DiffServ) behaviour aggregates. MPLS packets can be treated with different priorities according to a per hop behaviour (PHB). In this case, two different types of LSPs are defined [10] which can both be used for the transport LSP:

a) Label-only-inferred-PSC LSP(s) (L-LSP);

b) EXP-inferred-PSC LSP(s) (E-LSP).

If an L-LSP is used as a transport LSP, the PHB scheduling class (PSC) of each packet is inferred from the label without any other information (e.g., regardless of the EXP field value). In that case, the LSP shall meet the most stringent QoS requirements of the ATM connections transported by the LSP.

If an E-LSP is used as a transport LSP, the EXP field of the transport label is used to determine the PHB to be applied to each packet, i.e., different packets in one LSP may receive a different QoS. The 3-bit EXP field of the transport label can represent eight different combinations of per hop behaviour (PHB) and drop precedence levels. The mapping of the PHB to EXP fields is either explicitly signalled at label set-up or relies on a preconfigured mapping.

The mapping between ATM QoS classes and MPLS PHBs is for further study.

6.4.2 Connection admission control for the IWF

Virtual connections (VCCs, LSPs) have to be managed on both ATM and MPLS sides of the IWF. The IWF binds an ATM connection with a MPLS connection. The MPLS connection consists of a combination of an interworking LSP and a transport LSP. The IWF connection admission control applies to the bandwidth allocation of the transport LSP.

A connection request shall be accepted only when sufficient resources are available to establish the connection through the whole network (ATM network and MPLS network), to comply with the required QoS and to maintain the agreed QoS of the existing connections.

If there is insufficient capacity to accept a new ATM connection, the network may consider to increase the bandwidth of the transport LSP.

7 Methods for ATM transport over MPLS

For transport of AAL type 5 frames over MPLS interworking LSPs, two encapsulation formats are used, one for AAL type 5 PDU mode and the other for AAL type 5 SDU mode.

7.1 AAL type 5 PDU mode

This mode is used for carrying a whole AAL type 5 PDU in the interworking LSP. The whole AAL type 5 PDU is comprised of its payload, padding, and whole trailer, which include CPCS user-to-user indication (CPCS-UU), common part indicator (CPI), length and cyclic redundancy check (CRC). ATM cells of an AAL type 5 PDU are reassembled and the resulting AAL type 5 PDU is encapsulated in one or more (if fragmentation is performed) MPLS packets. The AAL type 5 PDU encapsulation mechanism supports the ordered delivery of OAM cells in respect to cell flow of that connection.

This mode is only applicable to VCCs.

7.2 AAL type 5 SDU mode

This mode is used for carrying an AAL type 5 service data unit (SDU) in the interworking LSP. No trailer or padding bits are carried.

Since the SDU size may vary between 1 and 65535 octets, it is necessary to make the provision for the application of padding. This is to avoid a problem when the transport path includes an Ethernet link, which requires a minimum packet size of 64 octets. Thus, using this mode requires the presence of a length indicator in the length field of the common interworking indicators.

If the ingress IWF determines that an encapsulated AAL type 5 SDU exceeds the MTU size of the transport LSP, then the AAL type 5 SDU should be discarded.

OAM cells that arrive during the reassembly of an AAL type 5 SDU are sent immediately on the LSP followed by the AAL type 5 SDU payload. In this case, cell sequence integrity is lost.

OAM performance monitoring, as specified in ITU-T Rec I.610 [2], [3] and [4], should not be used in combination with SDU frame mode because the cell sequence integrity is not maintained.

This mode is only applicable to VCCs.

7.3 Functional group considerations for ATM-MPLS network interworking

Figure 7.1 provides an illustration of functional grouping for ATM-MPLS network interworking.

MPLS transport label
Interworking label
Common interworking indicators
ATM-MPLS interworking specific header
Payload

Figure 7.1/Y.1412 – ATM-MPLS interworking functional groups

7.3.1 MPLS transport label

The 4-octet MPLS transport label identifies a LSP used to transport traffic between two ATM-MPLS IWFs. The MPLS transport label is a standard MPLS shim header [11]. This label is processed at each LSR. Since MPLS LSPs are unidirectional, a pair of MPLS transport LSPs carrying traffic in opposite directions will be required to create a bidirectional transport. The setting of the EXP and TTL fields of the MPLS transport label is outside the scope of this Recommendation. The S bit is set to 0 for this label, indicating that this is not the bottom of the label stack. More than one transport LSP may exist in each direction at any given time between any two ATM-MPLS IWFs.

7.3.2 Interworking label

The 4-octet interworking label uniquely identifies one interworking LSP carried inside a MPLS transport LSP. The interworking label is a standard MPLS shim header [11]. More than one interworking LSP may be supported by one MPLS transport LSP.

Since an MPLS LSP is unidirectional, for the case of bidirectional ATM VCCs, there will be two different interworking LSPs, one for each direction of the connection. These may have different label values.

The interworking function maintains context information that associates ATM connections with the interworking LSP.

In the MPLS-to-ATM direction, the 20-bit interworking label field value is translated to the VPI and VCI. This association is signalled or provisioned between a pair of peer IWFs. MPLS packets received with an invalid or unassigned interworking label are discarded.

The S bit is set to 1 to indicate the bottom of the label stack.

As the interworking label is only significant to the ATM-MPLS interworking functions at either end of the interworking LSP, it appears to the IWFs as though they are directly connected by a link of one hop. Therefore, the TTL value in the interworking label should be set to 2.

The setting of the EXP bits are for further study.

7.3.3 Common interworking indicators

The functions in the common interworking indicators are related to the interworking LSP.

In general, the common interworking indicators functional group is comprised of a control field, a length field and a sequence number field.

7.3.3.1 Control field

The control field is not present when operating in AAL type 5 PDU mode. It only exists when operating in AAL type 5 SDU mode. See 9.3.1.

7.3.3.2 Length field

The length field indicates the length of the payload. When the LSP path includes an Ethernet link, a minimum packet size of 64 octets is required. This may require padding to be applied to the MPLS packet payload in order to reach this minimum MPLS packet size. The padding size can be determined from the length field so that the padding can be extracted at the egress.

This field shall always be present. See 8.3.2 and 9.3.2.

7.3.3.3 Sequence number field

The sequence number field is used to check the sequence integrity of MPLS packets sent from the ingress IWF to the egress IWF. In general, ATM services require that the sequence integrity be maintained. When ATM services are transported over an underlying MPLS-based network, it is required that the MPLS network should attempt to maintain the sequence integrity of the ATM cells encapsulated in the MPLS packets.

Even under the normal "first-in first-out" (FIFO) operation, it is possible that misordering of the packets could occur. As an option, the sequence number field can be set by the IWF in the ATM-to-MPLS direction. The sequence number is a 2-octet field using a 16-bit, unsigned circular space.

This field shall be present, but its use is optional. If the sequence number function is not used, then it is set to all zeros at the ATM-to-MPLS direction IWF.

7.3.3.3.1 Setting the sequence number

If the sequence number field is used, then the following procedures apply in the ATM-to-MPLS direction:

a) The sequence number shall be set to 1 for the first MPLS packet transmitted on the interworking LSP.

b) For each subsequent MPLS packet, the sequence number shall be incremented by 1.

c) If the result of incrementing is a value of 65535 for the current MPLS packet, the sequence number shall be reset to 1 for the next MPLS packet.

If the ingress IWF does not use the sequence number, then the sequence number field shall be set to zero.

7.3.3.3.2 Processing the sequence numbers

If the IWF is capable of monitoring sequence integrity, then the following procedures shall be used:

a) If the sequence number is 0, the sequence integrity of the packets cannot be determined by the IWF. In this case, the received packet is considered to be in order.

b) Otherwise, if the sequence number ≥ the expected sequence number, and the sequence number – the expected sequence number < 32768, then the received packet is considered to be in order.

c) Otherwise, if the sequence number < the expected sequence number, and the expected sequence number – the sequence number ≥ 32768, then the received packet is considered to be in order.

d) Otherwise, the received packet is out of order.

e) If the received packet is in order, then the expected sequence number = the sequence number +1 mod 2^{16}.

f) If the expected sequence number = 0, then the expected sequence number = 1.

NOTE – The initial expected sequence number is set to 1.

7.3.4 ATM-MPLS interworking specific header

The ATM-MPLS interworking specific header (ISH) contains information that is used to reconstruct the ATM cells or AAL type 5 frames from a MPLS packet in the MPLS-to-ATM direction at the egress IWF.

8 AAL type 5 PDU mode encapsulation

This clause provides procedures for the encapsulation of AAL type 5 PDU or an AAL type 5 PDU fragment into a MPLS packet at the ingress IWF. Procedures for fragmentation of AAL type 5 PDU are provided in this clause. This clause also provides procedures for reconstruction of ATM cells from the AAL type 5 PDU or an AAL type 5 PDU fragment at the egress IWF.

8.1 Transport label

The transport label is a four-octet MPLS shim header as specified in [11]. See 7.3.1 for more detail.

8.2 Interworking label

The interworking label is a four-octet MPLS shim header as specified in [11]. See 7.3.2 for more detail.

8.3 Common interworking indicators

This field is always present.

In AAL type 5 PDU mode the common interworking indicators field is comprised of a one-octet length field and a two-octet sequence number field.

The IWF in the MPLS-to-ATM direction shall be aware of whether the common interworking indicators (i.e., all fields together) are used.

8.3.1 Control field

This field is not present when operating in AAL type 5 PDU mode.

8.3.2 Length field

The length indicator function is not used in AAL type 5 PDU mode. The two most significant bits of the length field are set to zero. The remaining six bits are called length indicator (even though not used in this mode). The first two significant bits of the length indicator are set to zero and the remaining four bits are reserved.

8.3.3 Sequence number field

See 7.3.3.3.

8.4 ATM-MPLS interworking specific header

The ATM-MPLS interworking specific header identifies whether ATM cells or AAL type 5 frames are encapsulated. In addition, other elements of the protocol control information constitute parts of this header (see Figure 8.1).

8.5 Payload

The payload consists of the reassembled AAL type 5 CPCS-PDU, including the AAL type 5 padding and trailer or the AAL type 5 fragment.

8.6 Encapsulation

Figure 8.1 shows the MPLS packet format for the AAL type 5 PDU or AAL type 5 fragment.

If the AAL type 5 PDU and other fields as identified in Figure 7.1 exceed the MPLS network MTU size or if OAM cells arrive during reassembly of AAL type 5 frames, the AAL type 5 PDU shall be fragmented (see 8.7).

Mechanisms to detect misconfiguration of the ATM encapsulation mode and the consequent actions to be taken are for further study.

Bits

8	7	6	5	4	3	2	1
Transport label (4 octets)							
Interworking label (4 octets)							
0	0	Length indicator					
Sequence number (2 octets)							
MODE	VCIP	RES			AUU	EFCI	CLP
Payload							

NOTE – Bit 8 is the most significant bit

Figure 8.1/Y.1412 – AAL type 5 PDU encapsulation

Description of ATM-MPLS interworking specific header fields are given below:

MODE (bit 8)

Bit (MODE) indicates whether the MPLS packet contains an ATM cell or an AAL type 5 PDU frame. In this Recommendation, MODE is always set to "1".

MODE = 0, the MPLS packet contains an ATM cell, encapsulated according to the VCC cell one-to-one mode (see Figure 8/Y.1411 [15]).

MODE = 1, the MPLS packet contains an AAL type 5 PDU frame.

NOTE – The bit called MODE is functionally similar to the bit T in the SDU encapsulation format.

VCI Present (bit 7)

This bit is always set to 0.

REServed (bits 6-4)

These bits are reserved and are set to "0".

AUU bit (bit 3)

This bit indicates whether the payload in the MPLS packet contains the last of the cells comprising the AAL type 5 PDU frame or fragment.

AUU = 1 indicates the presence of the last cell. Otherwise it is set to 0.

EFCI (bit 2)

The EFCI state of the reassembled AAL type 5 PDU is conveyed in the EFCI field of the ATM-MPLS interworking specific header. The EFCI state of an AAL type 5 PDU or AAL type 5 fragment is set to 1 if the last ATM cell of the AAL type 5 PDU or AAL type 5 fragment has its EFCI bit set to "1", otherwise it is set to "0". This field carries the EFCI state of the PTI field of the last ATM cell encapsulated within the MPLS packet. The EFCI is the middle bit of the PTI field.

CLP (bit 1)

The CLP state of the reassembled AAL type 5 PDU is conveyed in the CLP field of the ATM-MPLS interworking specific header. The CLP state of the AAL type 5 PDU or the AAL type 5 fragment is set to 1 if any of their constituent ATM cells has its CLP bit set to 1. Otherwise it is set to "0".

8.7 AAL type 5 PDU frame fragmentation

It may not always be possible to reassemble a full AAL type 5 frame at an ATM-MPLS IWF. This may be due to the AAL type 5 PDU and other fields as identified in Figure 7.1 exceed the MPLS network MTU size or if OAM or RM cells arrive during reassembly of an AAL type 5 PDU. In these cases, the AAL type 5 PDU shall be fragmented. Fragmentation is a function that is used to subdivide the payload into a series of fragments. In addition, fragmentation may be used to bound ATM cell delay.

When fragmentation occurs, the procedures described in the following clause shall be followed. Note that fragmentation always occurs at the ingress IWF (i.e., ATM-to-MPLS direction).

8.7.1 Fragmentation procedures

a) Fragmentation shall always occur at cell boundaries within the AAL type 5 PDU.

b) The AUU bit in the ATM-MPLS ISH for the fragment shall be set to the value of the ATM user-to-user bit in the cell header of the last received ATM cell to be included in the MPLS packet (see 8.6).

c) The EFCI and CLP fields in the ATM specific header of the fragment shall be set as per 8.6.

d) If the arriving cell is an OAM or an RM cell, then the current MPLS packet shall be sent immediately followed by the OAM or the RM cell using one-to-one single cell mode defined in ITU-T Rec. Y.1411 [15].

8.8 Procedure at the egress IWF

The following provides procedures at the egress IWF (MPLS-to-ATM direction) when an AAL type 5 frame or AAL type 5 fragment arrives as the payload part of the MPLS packet (see Figure 8.1).

At the egress IWF, cells are constructed from whole AAL type 5 PDU or AAL type 5 PDU fragments. There is no reassembly of the fragments in order to construct the AAL type 5 PDU.

The AAL type 5 PDU or AAL type 5 PDU fragment is an integral multiple of 48 octets.

The information exchanged between the ATM layer and the IWF across the ATM-SAP includes the following primitive (see ITU-T Rec. I.361 [18]):

ATM-DATA request (ATM cell payload (i.e., ATM-SDU), cell loss priority, congestion indication, ATM user-to-user indication (AUU)).

The parameter values for the request for all constituent ATM cells of an AAL type 5 PDU or AAL type 5 fragment are as follows:

– The congestion indication parameter is set to the EFCI value of the ATM-MPLS interworking specific header.
– If the AUU bit of the ATM-MPLS interworking specific header equal to 1 then:
  • The ATM user-to-user indication (AUU) of the last ATM cell in the MPLS packet is set to the value of the AUU bit of the ISH.
  • For all other cells, the ATM user-to-user indication (AUU) is set to zero.
– The cell loss priority parameter is copied from the CLP bit of the ATM-MPLS interworking specific header (ISH).

9 AAL type 5 SDU mode encapsulation

This clause provides procedures for the encapsulation of AAL type 5 SDU into a MPLS packet at the ingress IWF and the reconstruction of AAL type 5 PDU at the egress IWF.

9.1 Transport label

The transport label is a four-octet MPLS shim header as specified in [11]. See 7.3.1 for more information.

9.2 Interworking label

The interworking label is a four-octet MPLS shim header as specified in [11]. See 7.3.2 for more information.

9.3 Common interworking indicators

For AAL type 5 SDU mode, the common interworking indicators field is comprised of a one-octet control field, a one-octet length field and a two-octet sequence number field.

This field is always present.

9.3.1 Control field

The four most significant bits of the control field are reserved and are set to zero. The four least significant bits are the T bit, the E bit, the C bit and the U bit. These bits are explained in 9.6.

9.3.2 Length field

The two most significant bits of the length field are reserved and are set to zero. The remaining six bits are called length indicator.

The length indicator provides, in octets, the size of the MPLS packet payload without padding bits if performed (see 9.5). The length indicator value is comprised of:

a) size of the common interworking indicators; and

b) size of the payload.

The length field is always used.

9.3.2.1 Setting the length indicator in the ATM-to-MPLS direction

The IWF shall use the following procedures:

– If the MPLS packet payload size is greater than or equal to 64 octets, the length indicator field shall be set to 0.

– If the MPLS packet payload size is less than 64 octets, the length field shall be set to the packet length (see 9.5).

9.3.3 Sequence number field

See 7.3.3.3.

9.4 ATM-MPLS interworking specific header

There is no ATM-MPLS interworking specific header field present when operating in AAL type 5 SDU mode.

9.5 Payload

The payload consists of the reassembled AAL type 5 CPCS-SDU without the padding bits and the trailer. If the length of the MPLS packet payload is less than 64 octets then padding will be performed (see 7.3.3.2). The new MPLS packet payload is then comprised of the old MPLS packet payload plus additional padding.

9.6 Encapsulation

Figure 9.1 shows structure of the common interworking indicators and the ATM AAL type 5 SDU payload.

Mechanisms to detect misconfiguration of the ATM encapsulation mode and the consequent actions to be taken are for further study.

<table>
<tr><th colspan="8">Bits</th></tr>
<tr><th>8</th><th>7</th><th>6</th><th>5</th><th>4</th><th>3</th><th>2</th><th>1</th></tr>
<tr><td colspan="4">Reserved</td><td>T</td><td>E</td><td>C</td><td>U</td></tr>
<tr><td colspan="2">Reserved</td><td colspan="6">Length indicator</td></tr>
<tr><td colspan="8">Sequence number (2 octets)</td></tr>
<tr><td colspan="8">Payload</td></tr>
</table>

NOTE – Bit 8 is the most significant bit.

Figure 9.1/Y.1412 – AAL type 5 SDU encapsulation

Descriptions of the constituent parts of the control fields are given below.

Reserved (bits 8-5)

The reserved bits in the control field shall be set to zero when transmitting and shall be ignored on receipt.

T (transport type, bit 4)

Bit (T) indicates whether the MPLS packet contains an ATM cell or an ATM AAL type 5 SDU frame.

T = 1, the MPLS packet contains an ATM cell, encapsulated according to the N-to-one cell mode (see Figure 10/Y.1411 [15]).

T = 0, the MPLS packet contains an AAL5 SDU frame.

NOTE – The bit T is functionally similar to the mode bit in the PDU encapsulation format.

E (EFCI, bit 3)

Bit E is set to 1 if the last constituent ATM cell of the AAL5 SDU has its EFCI bit set to “1”, otherwise it is set to "0".

C (CLP, bit 2)

The CLP state of the reassembled AAL type 5 SDU is conveyed in as the C bit. The CLP bit of the AAL type 5 SDU is set to 1 if any of the AAL type 5 SDU constituent ATM cells has its CLP bit set to 1, otherwise it is set to 0.

U (Command/Response indicator, bit 1)

An AAL type 5 SDU is created by removing the padding and the trailer from AAL type 5 PDU. One of the constituent parts of an AAL type 5 trailer is the CPCS-UU (CPCS user-to-user indication). For AAL type 5 SDU mode, only the least significant bit of this octet, i.e., the U bit, is transported in the control field.

If the AAL type 5 frame is the result of frame relay (FR) and ATM service interworking as per frame relay FRF.8.1 [17], then the least significant bit of the CPCS-UU is the same as the Command/Response bit of the frame relay frame.

The least significant bit of the CPCS-UU of the AAL type 5 PDU trailer is set as the U bit.

9.7 Procedures at the egress IWF

The following provides procedures at the egress IWF (MPLS-to-ATM direction) when an MPLS packet arrives.

The AAL type 5 PDU is reconstructed from the payload part of the MPLS packet (see Figure 9.1) and the control field.

9.7.1 Processing the length indicator

The IWF shall follow the following procedures:

a) If the length field is 0, or if the packet size is the same as that indicated by the length field, then no action shall be taken. The payload is the SDU.

b) If the MPLS packet payload size is larger than that indicated by the length field, the padding is removed.

c) If the MPLS packet payload size is smaller than that indicated by the length field, the packet is discarded.

9.7.2 Reconstruction of AAL type 5 PDU

The IWF provides the capabilities to transfer the AAL type 5 SDU from MPLS packet to the ATM network. ITU-T Rec. I.363.5 [14] is used for reassembly of the AAL5 PDU.

The information exchanged between the AAL type 5 layer and the IWF across the AAL-SAP is identical to the CPCS primitives (see 7.2/I.363.5 [14]). The following primitive is used:

> CPCS-UNITDATA invoke (CPCS-SDU, CPCS-Loss Priority (CPCS-LP), CPCS Congestion Indication (CPCS-CI), CPCS User-to-User indication (CPCS-UU)).

The parameter values of the "request" for an AAL type 5 SDU are as follows:

1) The CPCS congestion indication parameter is set to the E (EFCI) value of the control field;
2) The CPCS user-to-user indication is copied from U (Command/Response indicator) bit;
3) The CPCS loss priority parameter is copied from the C (CLP) bit of the control field.

10 OAM and RM cell treatment

10.1 ATM-to-MPLS direction

10.1.1 OAM cells

Several types of OAM cells are defined in [2], [3] and [4]. Applications, such as those identified in [13], utilize these OAM cells. These cells are categorized as:

a) Fault management cells;
b) Performance monitoring and reporting, both in forward and backward directions;
c) User OAM cells (e.g., security OAM cells).

At the ATM layer, two types of OAM cell flows are identified: F4 (OAM flow on virtual path level) and F5 (OAM flow on virtual channel level). F4 and F5 OAM cells are either segment flows for communicating OAM-related information within the boundary of the VPC or VCC, or end-to-end flows for information regarding end-to-end VPC or VCC operations. From an OAM perspective, the IWF behaves as an ATM switch.

OAM cells are always encapsulated using cell mode encapsulation, regardless of the encapsulation format implemented for user data (see 8.6 and 9.6/Y.1411 [15]).

In frame mode encapsulation of user data, OAM cells that arrive during the reassembly of an AAL type 5 frame the following procedures to be invoked:

For AAL type 5 PDU mode the partially reassembled AAL type 5 PDU is sent as a fragment, immediately followed by the OAM cell. Reassembly of the AAL type 5 PDU is then resumed. If an OAM cell arrives between AAL type 5 PDUs, then it is sent using cell mode encapsulation (see 8.6/Y.1411 [15]). This procedure ensures cell sequence integrity for user cells and OAM cells.

For AAL type 5 SDU mode, OAM cells that arrive during the reassembly of a single AAL type 5 CPCS-PDU are sent immediately using cell mode encapsulation (see Figure 10/Y.1411 [15]) on the LSP followed by the AAL type 5 SDU payload. This service does not attempt to maintain the relative order of these OAM cells with respect to the ATM cells that comprise the AAL type 5 frame.

The general functional architecture of an ATM network element is provided in Figure 4-2/I.732 [12]. This functional model is used below to describe the treatment of F4 and F5 OAM cells at the IWF.

VP switching

This case is not supported by this Recommendation.

VC switching

F4 OAM cells may be inserted or extracted at the VP link termination; such OAM cells are not seen at the VC link termination and are, therefore, not sent across the LSP. F5 OAM cells are inserted or extracted at the VC link termination or VC termination. These cells are then sent across the LSP according to procedures specified in [12].

10.1.2 RM cells

VC RM cells use a PTI value of 110 and VP RM cells are identified by a VCI of 6 [18]. VP/VC RM cells are treated the same way as F4/F5 OAM cells in order to maintain cell ordering.

10.2 MPLS-to-ATM direction

OAM and RM cells are received as single encapsulated cells. They are treated at the IWF in accordance with procedures described in [2], [3], [4] and [7].

11 Security considerations

There are no security related issues identified in this Recommendation.

Appendix I

Bibliography

[I-1] IETF RFC 2475 (1998), *An Architecture for Differentiated Services*.

[I-2] IETF RFC 3260 (2002), *New terminology and clarifications for Diffserv*.

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Geneva, 2004