INTERNATIONAL TELECOMMUNICATION UNION

ITU-T Y.1411

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(02/2003)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE AND INTERNET PROTOCOL ASPECTS

Internet protocol aspects – Interworking

ATM-MPLS network interworking – Cell mode user plane interworking

ITU-T Recommendation Y.1411

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE AND INTERNET PROTOCOL ASPECTS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	**Y.1400–Y.1499**
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation Y.1411

ATM-MPLS network interworking – Cell mode user plane interworking

Summary

This Recommendation addresses required functions of 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.1411 was prepared by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 22 February 2003.

Keywords

ATM, MPLS, interworking, network, user plane.

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.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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

There is a need to focus on required functions of 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.1411

ATM-MPLS network interworking – Cell mode user plane interworking

1 Scope

This Recommendation focuses on required functions for network interworking between ATM and MPLS, specifically the user plane interworking mechanisms and procedures for cell mode transport. In particular it specifies a list of requirements, interworking scenarios and interworking encapsulation format and semantics for ATM-MPLS cell mode network interworking.

This Recommendation enables transport of ATM Permanent Virtual Connections (PVC) or Switched Virtual Connections (SVC) over an MPLS network. The encapsulation allows ATM Virtual Channel Connections (VCCs) or Virtual Path Connections (VPCs) to be carried within MPLS Label Switched Paths (LSPs). The scope includes support of all AAL types as well as OAM and RM cells, and the ability to encapsulate one or multiple ATM cells in a single MPLS Frame.

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

[2] IETF RFC 3031 (2001), *Multiprotocol label switching architecture*.

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

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

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

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

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

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

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

[10] ITU-T Recommendation I.356 (2000), *Muti-protocol Label Switching (MPLS) B-ISDN ATM layer cell transfer performance*.

[11] IETF RFC 3270 (2002), *Muti-protocol Label Switching (MPLS) Support of Differentiated Services*.

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

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

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

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

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

[17] IETF RFC 3260 (2002), *New terminology and clarifications for DiffServ*.

3 Definitions

This Recommendation defines the following terms:

3.1 cell concatenation: The process of bundling a group of cells belonging to VCCs or VPCs into a MPLS frame. Note that this is not AAL segmentation and reassembly.

3.2 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 [1].

3.3 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) [1]. The IWF includes interworking between U-plane, C-plane and M-plane functions.

3.4 ingress IWF/network element: The point where the ATM cells are encapsulated into an MPLS frame (ATM-to-MPLS direction.)

3.5 egress IWF/network element: The point where the ATM cells are de-encapsulated from an MPLS frame (MPLS-to-ATM direction.)

3.6 one-to-one mode: The one-to-one mode specifies an encapsulation method which maps one ATM VCC (or one ATM VPC) to one interworking LSP.

3.7 N-to-one mode: The N-to-one mode specifies an encapsulation method which maps one or more ATM VCCs (or one or more ATM VPCs) to one interworking LSP.

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

B-ISDN Broadband-Integrated Services Digital Network

B-ISUP Broadband ISDN User Part

CES Circuit Emulation Service

CLP Cell Loss Priority

DSS2	Digital Subscriber Signalling System No. 2
E-LSP	EXP-inferred-PSC LSP
EXP	Experimental Bits
FIFO	First In First Out
GFC	Generic Flow Control
HEC	Header Error Control
ILMI	Integrated Local Management Interface
ISDN	Integrated Services Digital Network
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
NNI	Network-to-Network Interface
OAM	Operation And Maintenance
PHB	Per Hop Behaviour
PM	Performance Monitoring
PNNI	Private Network-to-Network Interface
PSC	PHB Scheduling Class
PTI	Payload Type Identifier
PVC	Permanent Virtual Connection
QoS	Quality of Service
RFC	Request for Comments
RM	Resource Management
S-bit	Stack bit
SPVC	Soft PVC
SVC	Switched Virtual Connection
TTL	Time To Live
UNI	User-Network Interface
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 [2] 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 1 provides a general network architecture for ATM-MPLS network interworking where ATM network(s) are interconnected through an MPLS network. For the ATM-to-MPLS direction, the ATM cells are encapsulated into a MPLS frame by the interworking function (IWF). For the MPLS-to-ATM direction, reconstruction of the ATM cells is performed.

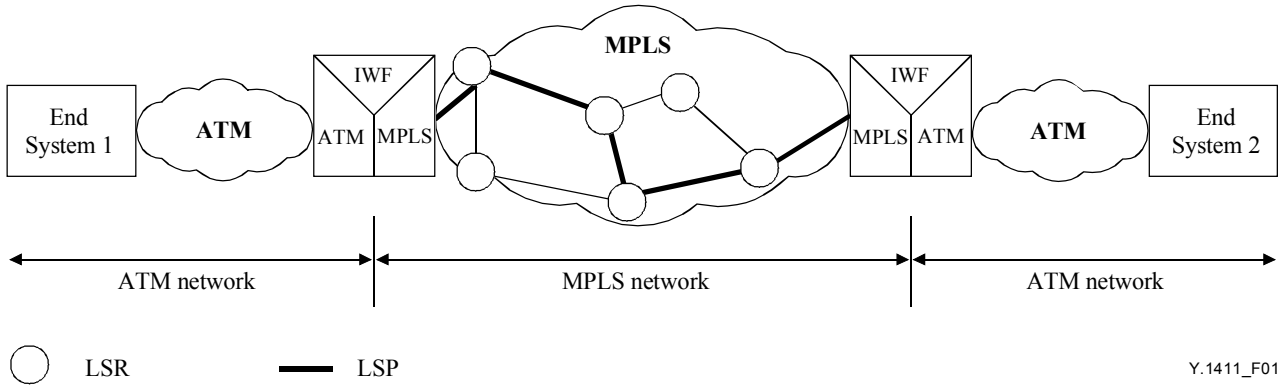


Figure 1/Y.1411 – Reference network architecture for ATM-MPLS network interworking

This Recommendation defines two methods for encapsulation of ATM cells into an MPLS frame:

1) one ATM connection to an interworking LSP, refered to as one-to-one mode;

2) N ATM connections to an interworking LSP, refered to as N-to-one mode.

The one-to-one mode specifies an encapsulation method that maps one ATM VCC or one ATM VPC to one interworking LSP. For VCCs, the VPI/VCI is not included. For VPCs, the VPI is not included. Cells from one VCC or one VPC may be concatenated.

The N-to-one mode specifies an encapsulation method that maps one or more ATM VCCs (or one or more ATM VPCs) to one interworking LSP. For both VCCs and VPCs, the VPI/VCI is always included. Cells from one or more VCCs (or one or more VPCs) may be concatenated.

This Recommendation defines only the encapsulation of ATM cells that use the NNI format [15]. The encapsulation of ATM cells that use the UNI format which includes the GFC field is for further study.

6 General requirements

6.1 User plane requirements

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

a) the ability to multiplex multiple ATM connections (i.e., VPCs and/or VCCs) into interworking LSPs;

b) support for the traffic contracts and the QoS commitments made to the ATM connections;

c) the ability to transparently carry all AAL types;

d) the ability to transparently carry all OAM cells, including the support for proper operation of OAM PM cells;

e) transport of Resource Management (RM) cells;

f) transport of Cell Loss Priority (CLP) indication and Payload Type Indication (PTI) information from the ATM cell header;

g) the ability to encapsulate an ATM single cell or concatenated ATM cells into one MPLS frame;

h) maintaining sequence integrity for all VCCs and VPCs between the IWFs;

i) support of ATM point-to-point and ATM point-to-multipoint connection;

j) support of unidirectional ATM connection;

k) support of bidirectional point-to-point ATM connections with symmetric or asymmetric bandwidth.

Figure 2 shows the network reference model and protocol layers for ATM-MPLS user plane interworking.

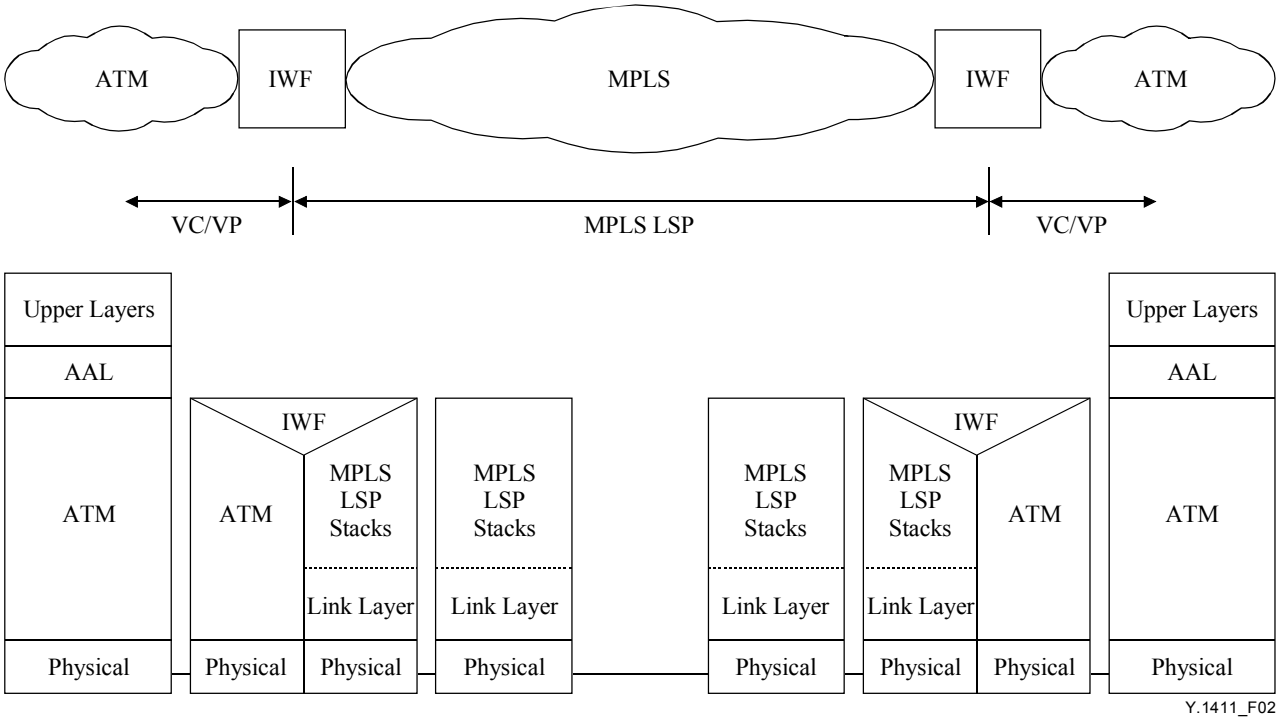


Figure 2/Y.1411 – Network reference model and protocol layers for ATM-MPLS user plane interworking

6.2 Control plane aspects

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

a) exchange of interworking label(s) between IWFs;

b) correlation of interworking labels for one or more bidirectional connections per interworking LSP. Mechanisms are to be defined;

c) operation in one-to-one or N-to-one mode;

d) maximum number of concatenated cells for a given interworking LSP between IWFs;

e) indication of cell encapsulation modes as either single or concatenated;

f) presence of common interworking indicators field;

g) support of the connection types Switched Virtual Connection (SVC) and Soft Permanent Virtual Connection (SPVC);

h) support of ATM point-to-point and ATM point-to-multipoint connections;

i) support of bidirectional ATM point-to-point connections with symmetric or asymmetric bandwidth;

j) the 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-F ILMI), which control the ATM connections across the MPLS, network;

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

l) the control of MPLS Transport LSPs or interworking LSPs via MPLS control protocols by the IWFs;

m) 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.

6.3 Management plane aspects

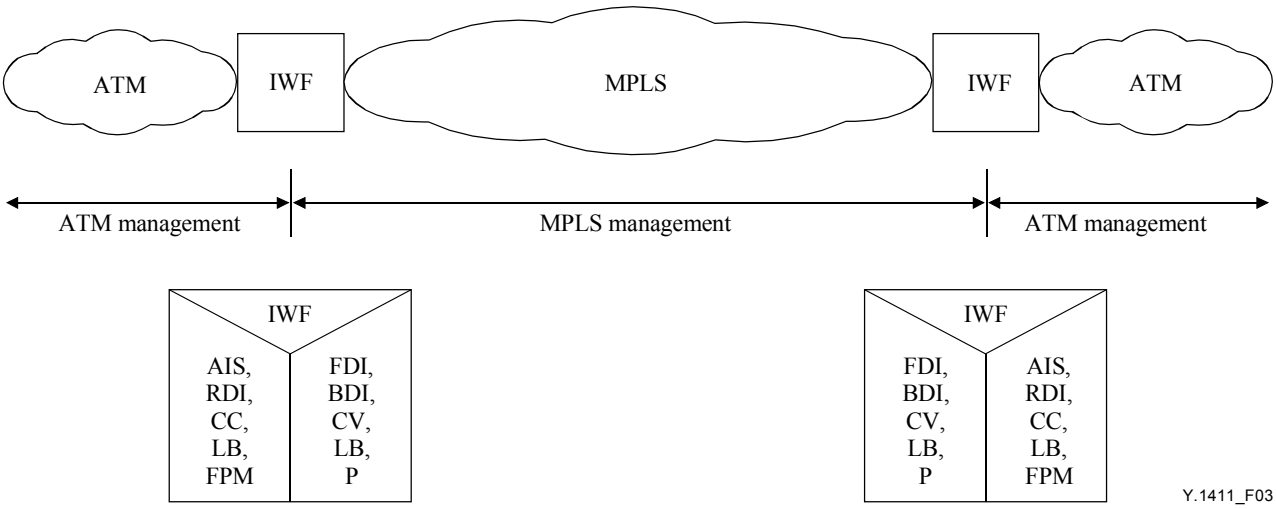
ATM OAM cells carry performance, defect, and protection switching information for VCCs and VPCs on an end-to-end and per segment basis to support the ATM management plane [3], [4] and [5]. OAM functionality in MPLS networks and OAM mechanism for MPLS networks can be found in ITU-T Recs Y.1710 [6] and Y.1711 [7].

For transparent transfer of ATM-related services 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 shall transfer ATM OAM information through the MPLS core network by encapsulating OAM cells in MPLS packets. The encapsulation mechanism supports the ordered delivery of OAM cells in respect to cell flow of that connection.

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 3 shows functional representation of ATM-MPLS management plane.



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

Figure 3/Y.1411 – Functional representation of ATM-MPLS management plane interworking

6.4 Traffic Management aspects

In ATM, a number of different ATM Transfer Capabilities (ATC) [8], [9] and Quality of Service (QoS) classes [10] 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 a 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

If the MPLS network supports Differentiated Services (DiffServ) Behaviour Aggregates defined in [16], MPLS packets can be treated with different priorities on a Per Hop Behaviour (PHB). In this case, two different types of LSPs are defined [11], which can both be used for the transport LSP:

- Label-Only-Inferred-PSC LSPs (L-LSP);
- EXP-Inferred-PSC LSPs (E-LSP).

If a L-LSP is used as a transport LSP, the PHB scheduling class (PSC) [17] 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 pre-configured mapping.

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

6.4.2 Connection admission control for the IWF

Virtual connections (VPCs, 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.

In case there is not sufficient capacity to accept a new ATM connection, the network may consider to increase the bandwidth of the transport LSP.

7 Methods of ATM transport over MPLS

7.1 One-to-one mode

In one-to-one cell mode network interworking, one ATM connection (VPC or VCC) is carried by one interworking LSP (Label Switched Path). Since the interworking LSP is unidirectional therefore for the case of bidirectional ATM connections, there will be two different interworking LSPs, one for each direction of the connection.

Figure 4 shows an illustration of the one-to-one mode.

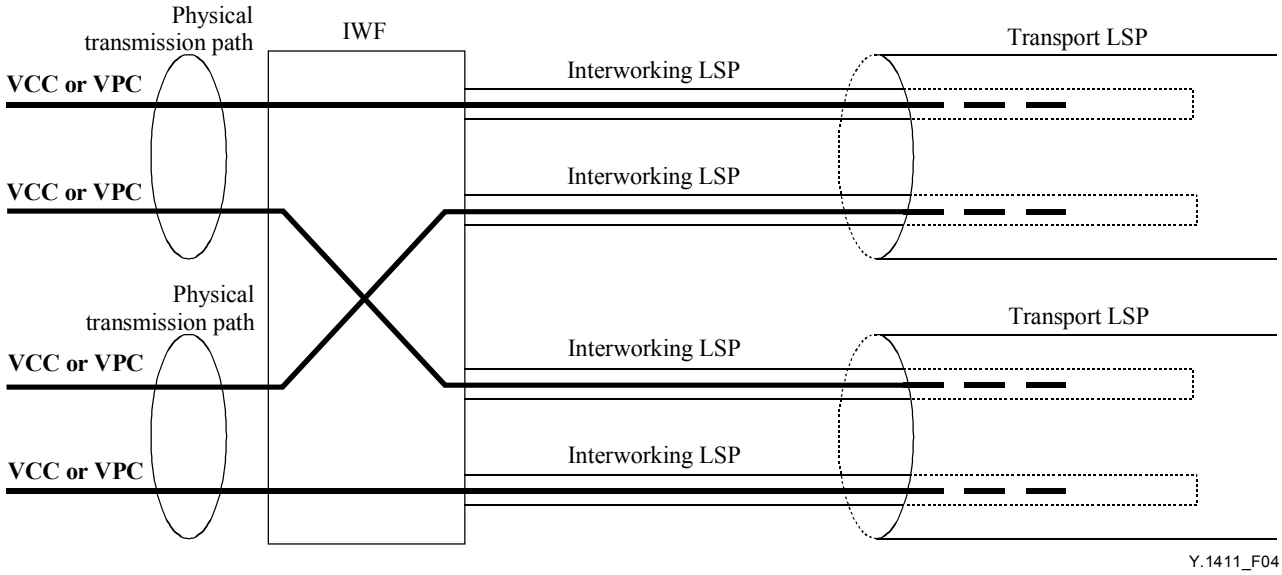


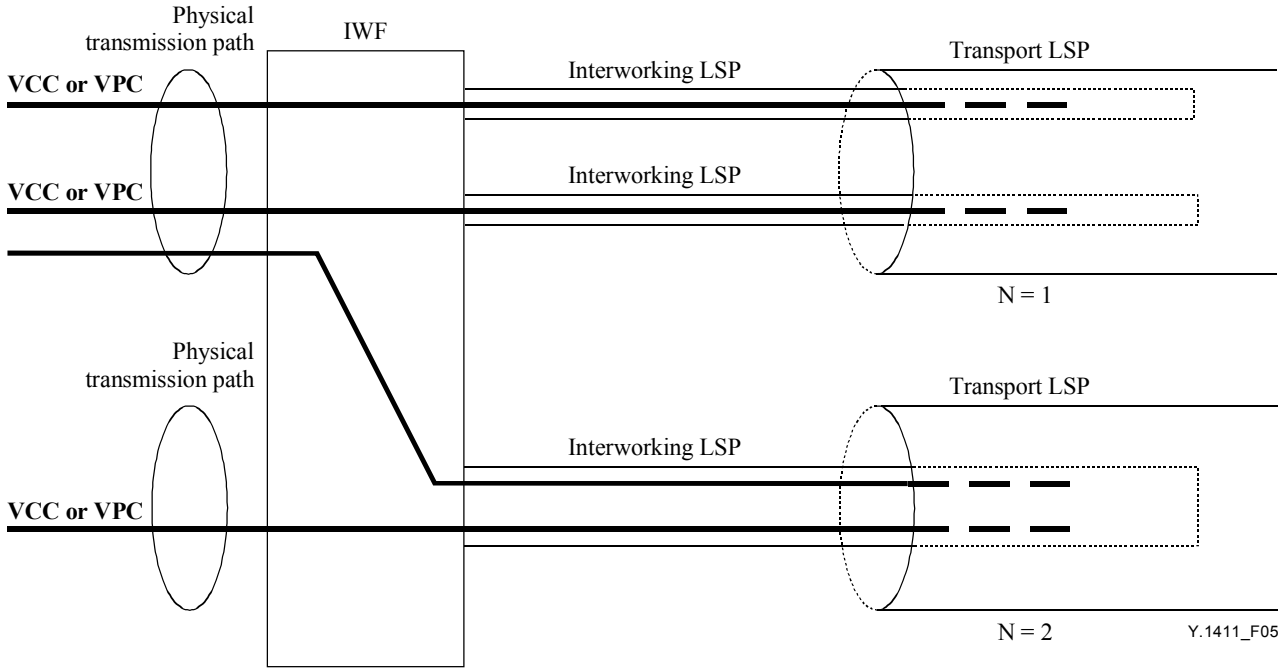
Figure 4/Y.1411 – Illustration of one-to-one mode

7.2 N-to-one mode

The N-to-one mode specifies an encapsulation method that maps one or more ATM VCCs (or one or more ATM VPCs) to one Interworking LSP. For both VCCs and VPCs, the VPI/VCI is always included. Cells from one or more VCCs (or one or more VPCs) may be concatenated. The interworking LSP is unidirectional; thus, for the case of bidirectional ATM connections, there will be two different interworking LSPs, one for each direction of the connection.

Figure 5 illustrates the N-to-one mode. The illustration where N = 1 indicates encapsulation of one VCC or one VPC into one interworking LSP. This is similar to one-to-one mode. In the figure where N = 2, this indicates encapsulation of two VCCs or two VPCS into one interworking LSP.

Figure 6 is an illustration of grouping of ATM connections with similar attributes using N-to-one mode to various IWFs.



NOTE – When multiple VCCs or VPCs are transported in one interworking LSP, VPI/VCI values shall be unique. When the multiple VCCs or VPCs are from different physical transmission paths, it may be necessary to assign unique VPI/VCI values to the ATM connections. If they are from the same physical transmission path, the VPI/VCI values are unique.

Figure 5/Y.1411 – Illustration of N-to-one mode

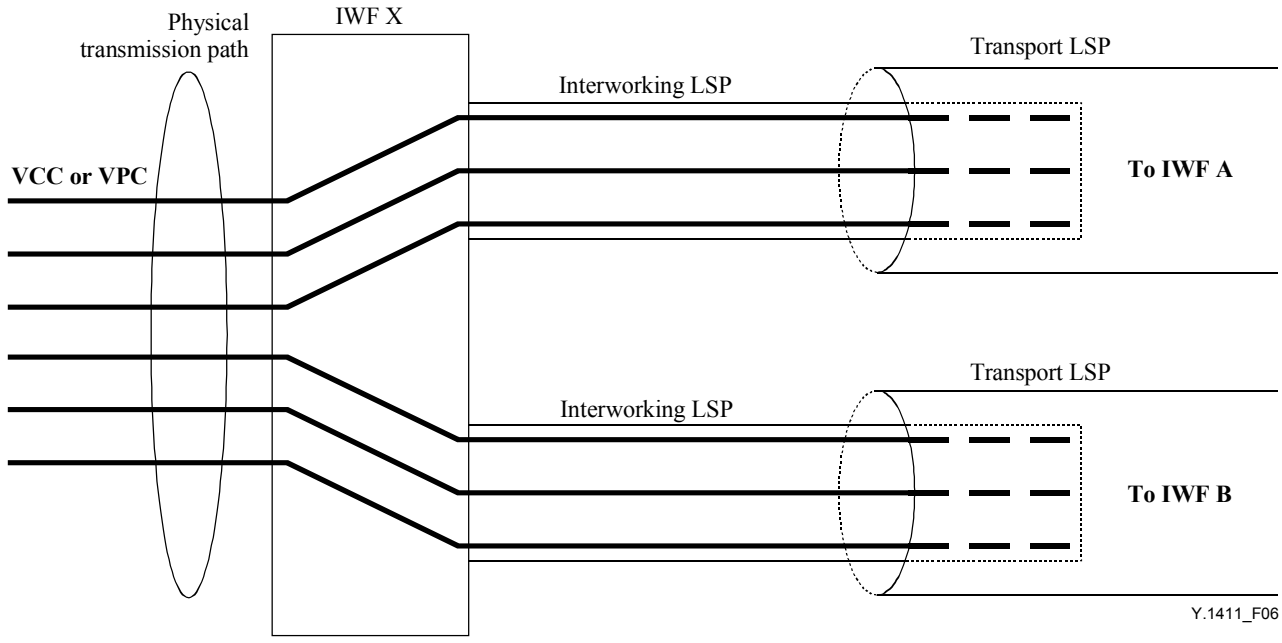


Figure 6/Y.1411 – Illustration of grouping in N-to-one mode

7.3 Functional group considerations for ATM-MPLS Network interworking

Figure 7 provides an illustration of functional grouping for ATM-MPLS network interworking.

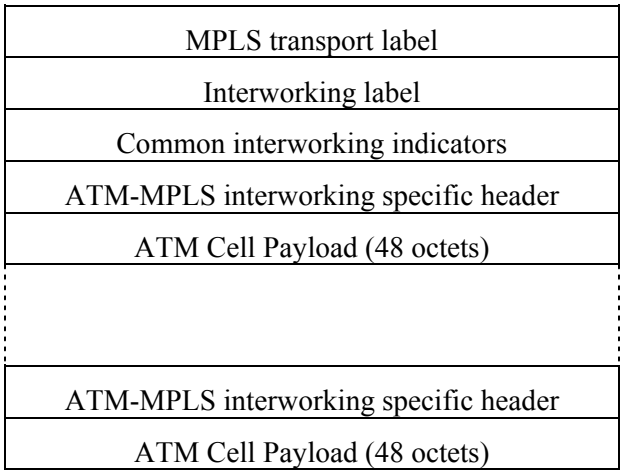


Figure 7/Y.1411 – ATM-MPLS interworking functional groups

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 transport label is a standard MPLS shim header [12]. This label is processed at each LSR. Since MPLS LSPs are unidirectional, a pair of 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 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. Between any two ATM-MPLS IWFs, there may exist more than one transport LSP in each direction at any time.

7.3.2 Interworking label

The 4-octet interworking label uniquely identifies one interworking LSP carried inside a MPLS transport LSP. The interworking label has the structure of a standard MPLS shim header [12]. More than one interworking LSP may be supported by one MPLS transport LSP.

Since MPLS LSPs are unidirectional, for the case of bidirectional ATM VCCs or VPCs, 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.

7.3.3 Common interworking indicators

The functions in the common interworking indicators are related to the interworking LSP and are independent of any specific service or encapsulation. This does not imply identical encapsulation formats in the one-to-one and N-to-one mode.

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

7.3.3.1 Control field

The control field does not exist for one-to-one mode. It only exists in N-to-one mode.

If the common interworking indicators is present, in N-to-one mode, this field shall be present. However its use is optional (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 interworking packet payload in order to reach this minimum packet size. The padding size can be determined from the length field so that the padding can be extracted at the egress.

If the common interworking indicators is present, this field shall be present. However, its use is optional (see 8.3.2 and 9.3.2).

The two most significant bits of the length field are reserved for future use. They are set to zero in this Recommendation for both one-to-one and N-to-one modes. The remaining six bits are called length indicator.

7.3.3.3 Sequence number field

The sequence number field is used to check on the sequence integrity of MPLS frames sent from the ingress IWF to the egress IWF. In general, ATM services require that the sequence integrity of cells on a VCC or VPC 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 frames.

Even under the normal "first in first out" (FIFO) operation, it is possible that mis-ordering of the frames still could occur. As an option, the sequence number field is set by the IWF in the ATM-to-MPLS direction. The sequence number is a 2-octet field that may be used to monitor packet order delivery. The sequence number space is a 16-bit, unsigned circular space.

If the common interworking indicators is present, this field shall be present. However, its use is optional (see 8.3.3 and 9.3.3).

7.3.3.3.1 Setting the sequence numbers

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

- The sequence number shall be set to 1 for the first MPLS frame transmitted on the interworking LSP.
- For each subsequent MPLS frame, the sequence number shall be incremented by 1.
- If the result of incrementing is a value of 65 535 for the current MPLS frame, the sequence number shall be reset to 1 for the next MPLS frame.

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:

- 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.
- Otherwise, if the sequence number ≥ the expected sequence number and the sequence number – the expected sequence number < 32 768, then the received packet is considered to be in order.
- Otherwise, if the sequence number < the expected sequence number and the expected sequence number – the sequence number ≥ 32 768, then the received packet is considered to be in order.
- Otherwise, the received packet is out of order.

- If the received packet is in order, then the expected sequence number = the sequence number +1 mod 2^{16}.
- 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 interworking specific header contains the information, which is used to reconstruct the ATM cells from an MPLS frame in the MPLS-to-ATM direction at the IWF.

8 One-to-one mode encapsulation

8.1 Transport label

The transport label is a four-octet MPLS shim header as specified in [12]. See 7.3.1 for more information.

8.2 Interworking label

The interworking label is a four-octet MPLS shim header as specified in [12]. See 7.3.2 for more information.

The interworking function maintains context information that associates ATM connections with the interworking LSP. This information is referenced by means of the 20-bit label field of the interworking label.

The context of the interworking label field implies:

- Connection type: VCC or VPC.
- For VPC connection types, VPI value to be inserted in the ATM cells headers in the MPLS-to-ATM direction.
- For VCC connection types, the VPI and VCI value to be inserted in the ATM cells headers in the MPLS-to-ATM direction.

This does not preclude the inclusion of other context information.

Procedures for the generation and parsing of the interworking label are as follows:

ATM-to-MPLS direction

In the case of a VPC, translation of the VPI to the 20-bit label field is performed. In the case of a VCC, the VPI and VCI are translated to the 20-bit label field. This association is signalled or provisioned between a pair of peer IWFs.

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 one hop.

The TTL value in the Interworking label is set to 2.

The settings of the EXP bits are for further study.

MPLS-to-ATM direction

In the case of a VPC, translation of the 20-bit label field to the VPI is performed. In the case of a VCC, the 20-bit label field is translated to the VPI and VCI. This association is signalled or provisioned between a pair of peer IWFs. MPLS frames received with an invalid or unassigned interworking label are discarded.

8.3 Common interworking indicators

Presence and use of the common interworking indicators is optional.

If present, in one-to-one mode the Common interworking indicators field is comprised of a length field and a 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) is used. See item f in 6.2.

8.3.1 Control field

This field does not exist for one-to-one mode.

8.3.2 Length field

If the common interworking indicators is present, this field shall be present. The use of the length indicator function is not required in the one-to-one mode. The two most significant bits of the length field are reserved and are set to zero. The remaining six bits are called length indicator.

If the common interworking indicators is present and length indicator field is not used, this field is set to all zeros at the ATM-to-MPLS direction IWF and is not processed at the MPLS-to-ATM direction IWF.

8.3.3 Sequence number field

If the common interworking indicators is present, this field shall be present. However, the use of sequence number field is optional. The sequence number is a 2-octet field that may be used to monitor the MPLS frame ordered delivery and is set by the IWF in the ATM-to-MPLS direction. The sequence number space is a 16-bit, unsigned circular space.

If the common interworking indicators is present and sequence number function is not used, this field is set to all zeros at the ATM-to-MPLS direction IWF.

8.3.3.1 Procedures for setting the sequence number in the ATM-to-MPLS direction

See 7.3.3.3.1.

8.3.3.2 Processing the sequence number in the MPLS-to-ATM direction

See 7.3.3.3.2.

The treatment of packets that are received out of order is for further study.

8.4 ATM-MPLS interworking specific header

The ATM-MPLS interworking specific header (ISH) identifies whether encapsulation is to be performed for ATM cells or AAL 5 frames. In addition, other elements of the protocol control information constitute parts of this header.

8.5 ATM payload

This consists of one ATM cell payload (i.e., 48 octets).

8.6 Encapsulation

Two cell encapsulation methods are considered, the single cell encapsulation and the concatenated cell encapsulation. Both methods are allowed in one-to-one mode.

For single cell encapsulation, one ATM cell is encapsulated into a single MPLS frame.

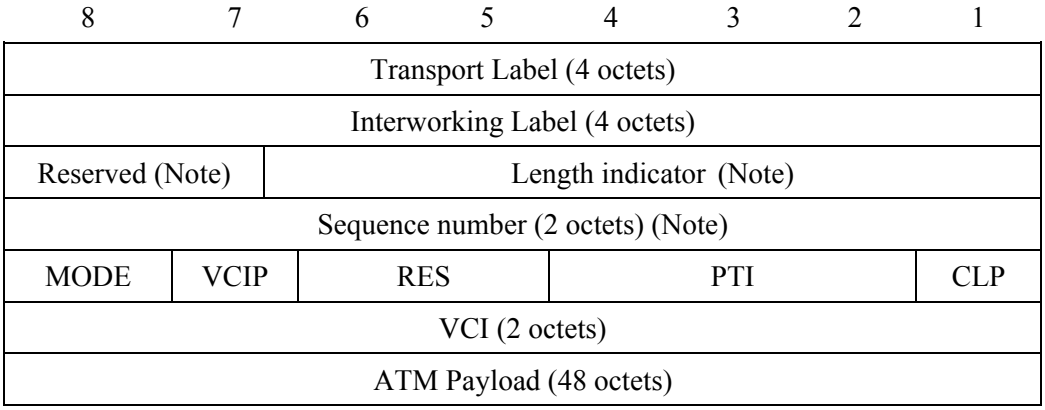
For concatenated cell encapsulation, multiple ATM cells are encapsulated in a single MPLS frame. These cells shall belong to the same VCC or VPC. In the case of a VPC, the concatenated cells may belong to different VCCs.

The maximum number of concatenated ATM cells is determined by considerations such as the MTU size of the transport medium and QoS requirements for the ATM connection.

The IWF may be configured via provisioning or via signalling to transmit and receive MPLS frames which contain concatenated cells.

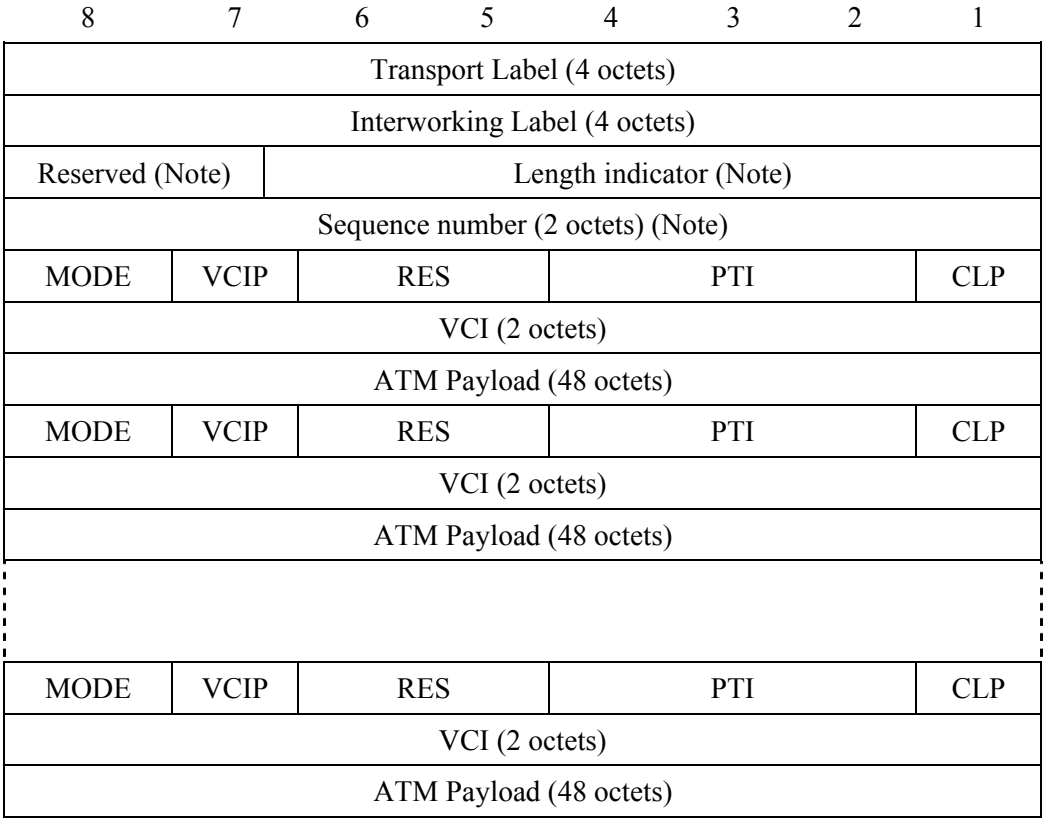
In the case of mis-configuration, a receiver that is not configured to support cell concatenation shall discard a received MPLS frame that contains more than one ATM cell payload (i.e., 48 bytes). The event should be reported to the management plane.

Figures 8 and 9 show the MPLS frame format of single and concatenated cell encapsulations respectively.



NOTE – Presence and use of the common interworking indicators is optional.

Figure 8/Y.1411 – Single cell encapsulation (One-to-one mode)



NOTE – Presence and use of the common interworking indicators is optional.

Figure 9/Y.1411 – Concatenated cell encapsulation format (One-to-one mode)

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

MODE (bit 8)

Identifies payload as either cell (= 0), as set for this case, or frame (= 1). In this Recommendation, mode is always set to "0".

VCI Present (bit 7)

This bit is set to "1" when VCI field is present, set to "0" when no VCI field is present.

For VPCs, the VCI field is present for every cell in the MPLS frame. In a particular case where all the VCI values are the same, VCIP optimization can be used for further bandwidth efficiency. When VCIP optimization is used, the VCI field shall be present in the following cases:

- The cell is the first cell within the MPLS frame.
- The previous cell within the MPLS frame belongs to a different VCC.

However, the default mode is when there is no VCIP optimization.

REServed (bits 6 & 5)

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

PTI (bits 4-2)

Payload Type Identifier incorporates the ATM layer PTI coding of each encapsulated cell. The PTI bits are carried from the ATM cell header without modification by the ATM-to-MPLS direction IWF. This does not preclude the ATM function of the network element in which the IWF resides from modifying the PTI bits, in accordance with ITU-T Rec. I.371 [8], before the interworking conversion.

CLP (bit 1)

Cell Loss Priority indicates the CLP value of each encapsulated cell. The CLP bit is carried from the ATM cell header without modification by the ATM-MPLS direction IWF. This does not preclude the ATM function of the network element in which the IWF resides from modifying the CLP bit, in accordance with ITU-T Rec. I.371 [8], before the interworking conversion.

VCI (2 bytes)

The VCI value, if present, is the same as that of the encapsulated ATM cell.

9 N-to-one mode encapsulation

9.1 Transport label

The transport label is a four-octet MPLS shim header as specified in [12]. See 7.3.1 for more information.

9.2 Interworking label

The interworking label is a four-octet MPLS shim header as specified in [12]. See 7.3.2 for more information.

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 one hop. The TTL value in the Interworking label should be set to 2.

The setting of the EXP bits are for further study.

9.3 Common interworking indicators

Presence and use of the common interworking indicators is optional.

If present in N-to-one mode, the Common interworking indicators is comprised of a control field, a length field and a 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) is used. See 6.2 item (f).

9.3.1 Control field

If the common interworking indicators is present, this field shall be present. If present, it is set to all zeros at the ATM-to-MPLS direction IWF and is not processed at the MPLS-to-ATM direction IWF.

9.3.2 Length field

If the common interworking indicators is present, this field shall be present. The use of length indicator function is not required in the N-to-one mode. The two most significant bits of the length field are reserved and are set to zero. The remaining six bits are called length indicator.

If the common interworking indicators is present and length indicator field is not used, this field is set to all zeros at the ATM-to-MPLS direction IWF and is not processed at the MPLS-to-ATM direction IWF.

9.3.3 Sequence number field

If the common interworking indicators is present, this field shall be present. However, the use of sequence number field is optional. The sequence number is a 2-octet field that may be used to monitor the MPLS frame ordered delivery and is set by the IWF in the ATM-to-MPLS direction. The sequence number space is a 16-bit, unsigned circular space.

If the common interworking indicators is present and sequence number function is not used, this field is set to all zeros at the ATM-to-MPLS direction IWF.

9.3.3.1 Procedures for setting the sequence number in the ATM-to-MPLS direction

See 7.3.3.3.1.

9.3.3.2 Processing the sequence number in the MPLS-to-ATM direction

See 7.3.3.3.2.

The treatment of packets that are received out of order is for further study.

9.4 ATM-MPLS interworking specific header

In the N-to-one mode, the ATM-MPLS interworking specific header is composed of the ATM cell header minus the HEC field [15].

9.5 ATM payload

This consists of one ATM cell payload (i.e., 48 octets).

9.6 Encapsulation

Two cell encapsulation methods are considered: the single cell encapsulation and the concatenated cell encapsulation. Both methods are allowed in N-to-one mode.

For single cell encapsulation, one ATM cell is encapsulated into a single MPLS frame.

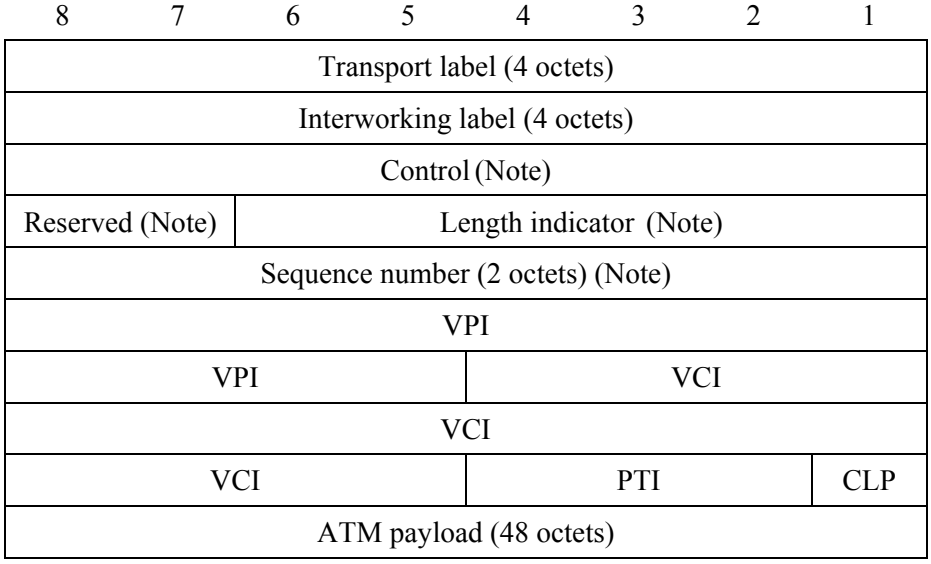
For concatenated cell encapsulation, multiple ATM cells are encapsulated in a single MPLS frame. These cells consists of cells from one or more VCCs and/or VPCS. That is, cells may be concatenated from only one VCC (or VPC) or from multiple VCCs (or VPCs).

The maximum number of concatenated ATM cells is determined by considerations such as the MTU size of the transport medium and QoS requirements for the ATM connection.

The IWF may be configured via provisioning or via signalling to transmit and receive MPLS frames which contain concatenated cells.

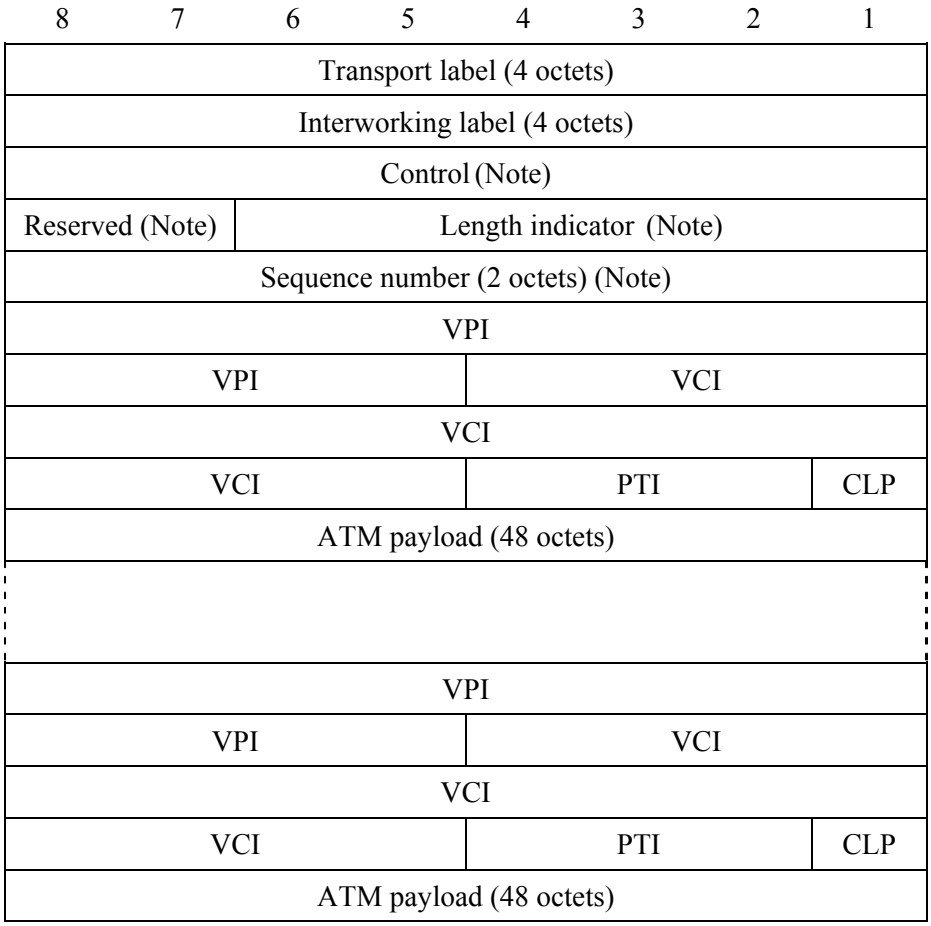
In the case of mis-configuration, a receiver that is not configured to support cell concatenation shall discard a received MPLS frame that contains more than one ATM cell payload. The event should be reported to the management plane.

Figures 10 and 11 show the MPLS frame format for single and concatenated cell encapsulation respectively.



NOTE – Presence and use of the common interworking indicators is optional.

Figure 10/Y.1411 – Single cell encapsulation (N-to-one mode)



NOTE – Presence and use of the common interworking indicators is optional.

Figure 11/Y.1411 – Concatenated cell encapsulation format (N-to-one mode)

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

VPI

The ingress IWF shall copy the VPI field from the incoming cell into this field. See Note in Figure 5 for more detail. The egress IWF may generate a new VPI.

VCI

The ingress IWF shall copy the VCI field from the incoming ATM cell header into this field. See note in Figure 5 for more detail. The egress IWF may generate a new VCI.

PTI

Payload Type Identifier incorporates the ATM layer PTI coding of each encapsulated cell. The PTI bits are carried from the ATM cell header without modification by the ATM-MPLS ingress IWF. This does not preclude the ATM function of the network element in which the IWF resides from modifing the PTI bits, in accordance with ITU-T Rec. I.371 [8], before the interworking conversion.

CLP

Cell Loss Priority indicates the CLP value of each encapsulated cell. The CLP bit is carried from the ATM cell header without modification by the ATM-MPLS ingress IWF. This does not preclude the ATM function of the network element in which the IWF resides from modifying the CLP bits, in accordance with ITU-T Rec. I.371 [8], before the interworking conversion.

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 [3]. Applications, such as those identified in [14], utilize these OAM cells. These cells are categorized as:

- fault management cells;
- performance monitoring and reporting, both in forward and backward directions;
- 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 network element in which the IWF resides behaves as an ATM switch.

For cell mode encapsulation of user data, OAM cells are encapsulated in the same manner as user data cells.

The general functional architecture of an ATM network element is provided in Figure 4-2/I.732 of [13]. This functional model is used below to describe the treatment of F4 and F5 OAM cells at the network element in which the IWF resides.

The network element in which the IWF resides performs switching at either the VP or the VC level.

VP switching

F4 OAM cells may be inserted or extracted by the network element in which the IWF resides. These cells are then sent across the LSP according to procedures specified in [13]. F5 OAM are not inserted or extracted here and are therefore simply encapsulated and sent across the LSP.

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 [13].

10.1.2 RM cells

VC RM cells are identified by a PTI value of 110 and VP RM cells are identified by a VCI value of 6 [15]. VP/VC RM cells are treated the same way as F4/F5 OAM cells respectively 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 network element in which the IWF resides in accordance with procedures described in [3], [4], [5] and [8].

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	**Global information infrastructure and Internet protocol aspects**
Series Z	Languages and general software aspects for telecommunication systems

Geneva, 2003