OIF Guideline Document: Signaling Protocol Interworking of ASON / GMPLS Network Domains

IW # OIF-G-Sig-IW-01.0

June 26, 2008

Interworking Guideline created and approved
by the Optical Internetworking Forum
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OIF-G-Sig-IW-01.0

Working Group: **Carrier, Architecture & Signaling**

TITLE: **OIF Guideline Document: Signaling Protocol Interworking of ASON / GMPLS Network Domains**

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ABSTRACT: This document defines signaling protocol interworking methods between network domains utilizing OIF/ITU-T and IETF ASON / GMPLS RSVP-TE. In particular the interworking of ASON UNI and E-NNI (based on GMPLS RSVP-TE with ASON extensions, per G.7713.2 and OIF IAs, OIF UNI 1.0R2 and OIF E-NNI 1.0) and GMPLS interfaces (based on GMPLS RSVP-TE, per RFC 3473) are tackled and potential solutions highlighted. Interworking with GMPLS UNI per RFC 4208 is not in the scope of this version. Finally first implementations are described showing that pragmatic interoperability solutions are fairly easily achievable.

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1 Introduction

As a result of concerted activities spanning ITU-T, OIF, and IETF to marry ASON requirements and supporting GMPLS protocols, in conjunction with OIF interoperability testing, the industry has come a long way on the path towards protocol convergence with the base GMPLS and ASON signaling protocols now largely in common. This effort to marry ASON requirements and protocols is continuing in the routing domain, as exemplified by joint activities of ITU-T, OIF, IETF representatives at IETF in developing RFC 4258.

This document discusses the nature of differences among IETF GMPLS [RFC3473, RFC 4208] and ITU-T/OIF ASON signaling protocols [G.7713.2, OIF E-NNI1.0 SIG, OIF UNI 1.0R2], and defines methods and potential solutions for signaling protocol interworking ASON / GMPLS network domains (Figure 1). It should be noted that this document is focused on a subset of GMPLS specifications used for initial implementations and does not analyze recent GMPLS activities such as GMPLS call and GMPLS interdomain. Furthermore, in this document first implementations are described, that demonstrate that pragmatic interoperability solutions are readily achievable. Methods other than these first implementations may be possible.

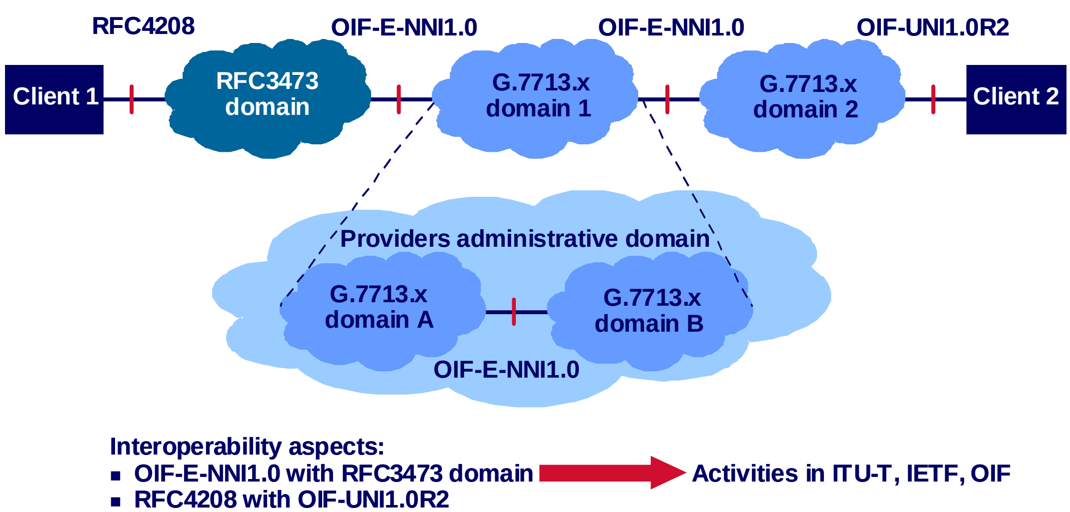


Figure 1: Example of a multi-domain ASON/GMPLS interworking scenario

1.1 ASON Model

The extensions defined in the OIF UNI1.0R2, OIF E-NNI1.0 Signaling, and ITU-T G.7713.2 were introduced in the context of the underlying carrier-oriented ASON network model, which recognizes that the deployment of the optical control plane into new and existing networks occurs within the context of commercial operator business practices and heterogeneous transport networks (even within a single carrier's network). These business and operational considerations led to the need for ASON to inherently enable protection of such commercial business operating practices that, for example, generally segment transport networks into domains according to managerial and/or policy considerations. Consequently, the ASON architecture [G.8080] provides a comprehensive model that takes into account the wide range of business and commercial relationships, organizational structures, and operational practices that may be found in real-world deployments. It should be noted that the ASON control plane architecture of G.8080 and subtending ASON Recommendations are consistent with the transport layer network constructs related to network layering and partitioning [G.805] utilized in all transport network architecture and equipment Recommendations.

The implementation of an ASON architecture-based control plane offers several degrees of freedom; e.g.:

- A single instantiation of an ASON control plane may control multiple transport layer networks [per G.805] with an explicit definition of the interlayer interaction (including none).
- Not all of the reference points need to be instantiated.
- It allows for flexibility in the distribution of control plane functionality; e.g., within each network element, shared among a group of network elements, centralized, or some combination thereof.

The ASON control plane supports establishment of services through the automatic provisioning of end-to-end transport connections across one or more domains, with separation of calls and connections a fundamental underlying architectural principle. The call (service) aspect involves the provisioning of end-to-end services and thus represents end-to-end service associations. The connection aspect involves the automatic provisioning of connections in support of end-to-end services that may span one or more domains.

The interconnection between and within domains is described in terms of reference points. As domains are established via operator policies, inter-domain reference points are service demarcation points (i.e., points where call control is provided).
User devices may attach to the network at the User-Network Interface (UNI) reference point, which represents a user-provider service demarcation point, while peer-level domains meet at the External Network-Network Interface (E-NNI) reference point, which represents a service demarcation point supporting multi-domain connection establishment. (We note the reference point within a domain is an I-NNI, which represents a connection point supporting intra-domain connection establishment).

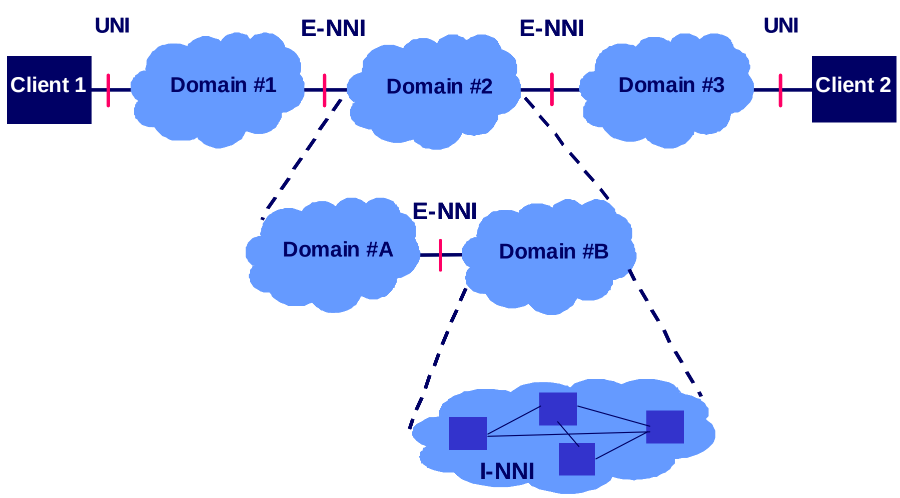


Figure 2: ASON multi-domain network scenario; partitioning of networks and inter-domain interfaces

Referring to **Figure 2**, when a call spans multiple domains (E-NNIs), it is considered to be comprised of call segments. One or more connections may be established in support of individual call segments, and in general a single connection does not span multiple call segments. The set of concatenated connections provides end-to-end connectivity. There are multiple ways in which call segments can be supported within each domain, depending upon operator deployment scenarios, an example of which is shown in **Figure 3** below.

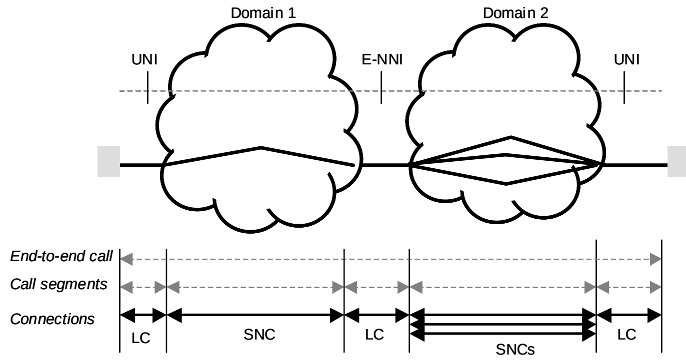


Figure 3: ASON architecture example

It should be noted, that each domain may utilize a different I-NNI protocol or even different control architecture (e.g., one domain may use distributed control while another peer domain may use centralized control). Thus, the control protocols used across the E-NNI reference point are required to be independent of the protocol used within the domains (i.e., should not rely upon any assumptions regarding usage of a particular protocol or distribution of control functionality).

The ITU-T ASON specifications take an approach similar to how G.805 transport network and equipment functional modeling descriptions are defined, as compared to less formalized transport network and equipment descriptions. ITU-T Recommendation G.805 provides a model-based approach that describes network functionality in terms of a small number of abstract architectural entities, which may be associated together in various ways to specify the equipment from which real networks are constructed. This model is capable of supporting all viable transport network and equipment implementations. Recommendation G.8080 provides a control plane model-based approach utilizing components and interfaces that can be associated in various ways to describe actual control plane implementations. This model is capable of supporting all viable control plane scenarios that may be envisioned. Specifically, it may be utilized to describe the GMPLS architecture models; for example, the GMPLS (overlay) model described in Section 1.2 below.

1.2 GMPLS (Overlay and Peer) Model

The optical control plane architecture for IETF GMPLS, provided in RFC 3945, describes the addition of support for circuit/wavelength switching to traditional MPLS. The GMPLS architecture models that are most commonly cited reflect specific distributions of optical control plane functionality and policy application. For example, the GMPLS peer model assumes a community of users with mutual trust and shared goals. There are no inherent policy or security boundaries, and routing and signaling protocols flow within the network without any filtering or other constraints imposed. The GMPLS overlay (RFC 4208) model illustrated in **Figure 4** differs from the peer model in that it is assumed that the core-nodes act more as a closed system. Thus, the edge nodes are not aware of the topology of the core nodes, though core and edge nodes may have a routing protocol interaction for exchange of reachability information to other edge nodes. Please note, a GMPLS domain is one in which the I-NNI is based upon GMPLS protocols (e.g., as defined in RFC 3473 for signaling). In this document the GMPLS overlay model is considered, only.

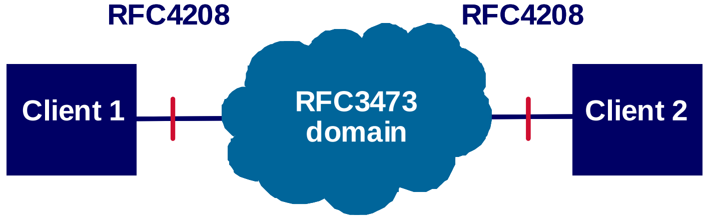


Figure 4: GMPLS overlay network scenario

1.3 Interworking Network Scenarios

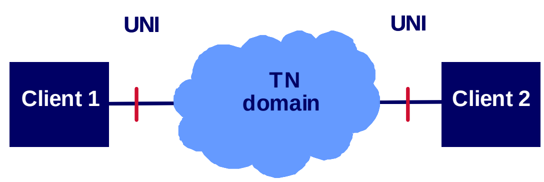
In the standardization area, the most prominent recent attempt to facilitate shared understanding of requirements and architecture was the establishment of IETF routing design teams involving participants from IETF, ITU-T, and OIF, resulting in a first step in "translating" ASON routing architecture and requirements from ITU-T terminology [e.g., RFC4258]. Furthermore an ASON /GMPLS lexicography was set up, to improve the understanding of the different terms and definitions [RFC 4397].

The following tables and figures are showing the manifold ASON / GMPLS interworking scenarios. Starting with single TN domain scenario, the possible combination of TN and customer/client domains are listed in (**Figure 5**) including the interworking issues identified. UNI interworking problems have to be solved if different types of UNI interfaces (GMPLS-UNI and ASON-UNI) have to interoperate. UNI-N (TN side) interoperability problems occur if the same UNI type is connected to a different type of TN domain e.g. GMPLS-UNI to ASON domain or ASON-UNI to GMPLS domain.

For multi-TN domain (ASON and GMPLS) scenarios, all possible client and TN domain combinations and interworking issues are listed in
Figure 6, giving an overview of the problem space to be solved in standardization.

Since OIF UNI 1.0R2 and OIF E-NNI 1.0 signaling are generally aligned with G.7713.2, this document will use OIF UNI 1.0R2 in place of the ASON UNI and OIF E-NNI 1.0 in place of the ASON E-NNI functions. (It should be noted that OIF UNI1.0R2 is not 100% aligned with G.7713.2, wrt ResvTear/ResvErr differences covered in section 2.3.2.) For brevity and simplicity, in the remainder of this document, the function supported on an interface will use one of the following terms:

- UNI1.0R2, denoting OIF Implementation Agreement (IA) UNI1.0 Release 2 for the ASON UNI function
- E-NNI1.0, denoting OIF IA E-NNI 1.0 for the ASON E-NNI function
- G.7713.x, denoting ASON I-NNI signaling based on G.7713.1/2/3 (note: I-NNI functionality is designated for further study in the current versions of G.7713.x)
- RFC 4208, denoting GMPLS UNI
- RFC 3473, denoting GMPLS I-NNI



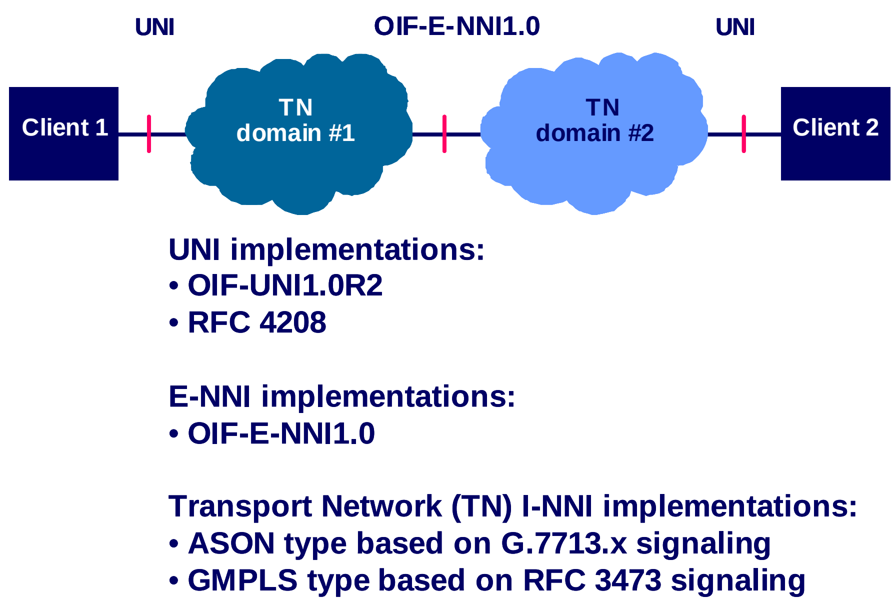
UNI implementations:
• OIF-UNI1.0R2
• RFC 4208

Transport Network (TN) I-NNI implementations:
• ASON type based on G.7713.x signaling
• GMPLS type based on RFC 3473 signaling

Use Case	Client #1	TN domain	Client #2	Comments
1	UNI 1.0R2	G.7713.X	UNI 1.0R2	Basic feature, not covered in this document
2	UNI 1.0R2	G.7713.X	RFC 4208	Interworking with RFC 4208 not covered in this document

3	RFC 4208	G.7713.X	RFC 4208	Interworking with RFC 4208 not covered in this document
4	RFC 4208	RFC 3473	RFC 4208	Basic feature, not covered in this document
5	UNI 1.0R2	RFC 3473	RFC 4208	Interworking with RFC 4208 not covered in this document
6	UNI 1.0R2	RFC 3473	UNI 1.0R2	Interworking UNI1.0-RFC3473 sec. 3.1; 3.5; 3.9; 3.13; 3.17 Interworking RFC3473-UNI1.0 sec. 3.4; 3.8; 3.12; 3.16; 3.20

Figure 5: Single domain ASON-GMPLS interworking scenario overview; SDH/SONET services covered



Use Case	Client #1	TN#1 domain	E-NNI	TN#2 domain	Client #2	Comments
1		G.7713.X	E-NNI 1.0	RFC 3473		Interworking E-NNI-RFC3473 sec. 3.3; 3.7; 3.11; 3.11; 3.15, 3.19
2		RFC 3473	E-NNI 1.0	RFC 3473		Interworking RFC3473-E-NNI sec. 3.2; 3.6; 3.10; 3.14; 3.18 Interworking E-NNI-RFC3473 sec. 3.3; 3.7; 3.11; 3.11; 3.15, 3.19
3	UNI 1.0R2	G.7713.X	E-NNI 1.0	G.7713.X	UNI 1.0R2	Basic features, not covered in this document
4	UNI 1.0R2	G.7713.X	E-NNI 1.0	G.7713.X	RFC 4208	Interworking with RFC 4208 not

						covered in this document
5	RFC 4208	G.7713.X	E-NNI 1.0	G.7713.X	RFC 4208	Interworking with RFC 4208 not covered in this document
6	UNI 1.0R2	RFC 3473	E-NNI 1.0	G.7713.X	UNI 1.0R2	Interworking UNI-RFC3473 sec. 3.1; 3.5; 3.9; 3.13; 3.17 Interworking RFC3473-E-NNI sec. 3.2; 3.6; 3.10; 3.14; 3.18
7	UNI 1.0R2	RFC 3473	E-NNI 1.0	G.7713.X	RFC 4208	Interworking with RFC 4208 not covered in this document
8	RFC 4208	RFC 3473	E-NNI 1.0	G.7713.X	UNI 1.0R2	Interworking with RFC 4208 not covered in this document
9	RFC 4208	RFC 3473	E-NNI 1.0	G.7713.X	RFC 4208	Interworking with RFC 4208 not covered in this document
10	UNI 1.0R2	RFC 3473	E-NNI 1.0	RFC 3473	UNI 1.0R2	Interworking UNI - RFC3473 sec. 3.1; 3.5; 3.9; 3.13; 3.17 Interworking RFC3473 - E-NNI sec. 3.2; 3.6; 3.10; 3.14; 3.18 Interworking E-NNI - RFC3473 sec. 3.3; 3.7; 3.11; 3.11; 3.15, 3.19 Interworking RFC3473-UNI sec. 3.4; 3.8; 3.12; 3.16; 3.20
11	UNI 1.0R2	RFC 3473	E-NNI 1.0	RFC 3473	RFC 4208	Interworking with RFC 4208 not covered in this document
12	RFC 4208	RFC 3473	E-NNI 1.0	RFC 3473	RFC 4208	Interworking with RFC 4208 not covered in this document

Figure 6: Multiple domain ASON/GMPLS interworking scenario overview; SDH/SONET services are covered
Scenarios are applicable for intra- and inter-carrier environments

2

Comparison of the G.7713.2 and RFC 3473 Versions of RSVP

2.1 Application of Call vs. Connection Concept

The ASON model employs the concept of a call, which G.8080 defines as "An association between endpoints that supports an instance of a service", and that "Call control is used to maintain the association between parties and a call may embody any number of underlying connections, including zero, at any instance of time". The detailed protocol requirements in ITU-T Recommendation G.7713 and correspondingly the RSVP implementation (G.7713.2) formally incorporates call objects such as a Call ID. IETF has also defined a Call concept in [RFC4974], but this is not analyzed in this document.

2.2 Single End-to-end Session vs. Multiple Sessions

G.7713.2 specifies that separate RSVP sessions are used at the UNI and E-NNI, determined by the use of the local UNI and E-NNI addresses in the RSVP Session and Sender_Template objects, whereas the end-to-end relationship is identified through the Source and Destination TNAs and the Call ID. The G.7713.2 RSVP extensions are roughly analogous to using LSP stitching [RFC 5150] across the ITU-T domains, in that a separate RSVP session is created at the boundary between any two domains, and a separate session is used within a domain (assuming that it uses RSVP internally).

RFC 3473 does not define a similar model with separate RSVP sessions. With the RFC 4208 interface, it is possible that the session identifiers are "shuffled" so that what is used at the UNI differs from what is used within the network, in order to accommodate some separation of the client and network address spaces. However, there is required to be a one-to-one mapping between the session identifiers used at the UNI and within the network. This difference results in additional mapping of identifiers at an interworking point between G.7713.2 and RFC 3473.

2.3 Other differences between the specifications

2.3.1 Comparison of messages and objects

Messages: The same messages are used in both G.7713.2 and RFC 3473 RSVP specifications, except that use of some messages was considered not necessary for G.7713.2, as will be discussed in section 2.3.2.

Objects: Two new objects defined in the G.7713.2 RSVP specification are the Gen_UNI object (used by OIF UNI 1.0r2 and OIF E-NNI), which carries the Source and Destination TNAs, and the Call_ID object (used by OIF E-NNI) used in support of Call Control. Both of these objects are considered call level objects.

Codepoints for the new objects are assigned in RFCs 3474 and 3476 and are in the range assigned in RSVP for objects to be transparently forwarded by an RSVP implementation that does not recognize them.

C-Types: New C-Types are defined in the G.7713.2 RSVP specification for UNI and ENNI Session objects. 5 new C-Types are defined to be used within G_UNI and 2 new C-Types within Call_ID. For reference, there are approximately 80 or so C-Types defined in the core RFC 3473 GMPLS specifications.

It should be noted that the use of distinct C-Types for UNI and ENNI Session objects may result in G.7713.2 messages being rejected at a RFC 3473 RSVP interface, as these would be unrecognized Session C-Types. As a result, mismatch of interface types (e.g., G.7713.2 on one side and RFC 3473 RSVP on the other) is likely to be detected immediately.

Procedures: The main change to procedures in the G.7713.2 RSVP specification compared to RFC 3473 GMPLS is the elimination of the use of the ResvErr and ResvTear messages, discussed below in section 2.3.2. Note this is also a difference between G.7713.2 and OIF UNI 1.0r2, which supports the ResvErr and ResvTear messages.

2.3.2 ResvTear/ResvErr

In G.7713.2 RSVP [G.7713.2] no procedures are defined requiring the use of ResvTear and ResvErr messages. RFC 3473 supports both of these messages. UNI 1.0r2 supports these messages if received at the UNI-N, but the UNI-C will not originate either type of message. If either ResvTear or ResvErr arrive at an RFC3473-to-OIF

UNI 1.0r2 interworking point (the UNI-N), they should be passed to the UNI-C, with interworking applied for the the different signaling sessions.

E-NNI 1.0 supports neither the ResvTear nor ResvErr message of RSVP. If a ResvTear message is received at a RFC3473-to-OIF E-NNI 1.0 interworking point (going upstream) it will be considered as a forced deletion and will be converted into a PathErr message with the Path_State_Removed flag to the source UNI. If a ResvErr message is received at a RFC3473-to-OIF E-NNI 1.0 interworking point (going downstream) it will be considered an indication of a transport plane error and will be ignored. If the node originating then ResvErr later determines a connection deletion becomes necessary, it can be initiated via other supported procedures.

2.3.3 Support of SPC services

SPC services are supported with the use of a separate SPC_Label sub-object in the G_UNI object in G.7713.2. An equivalent procedure in the RFC 3473 RSVP specifications utilizes the ERO for this purpose, and is documented in a separate RFC [RFC 4003].

2.3.4 Terminology differences

Some terminology differences exist between ITU-T ASON and IETF GMPLS. Efforts have been made to document some of these terminology differences [RFC 4397], and additional terminology mapping may be done in future.

2.3.5 Addressing

G.7713.2 RSVP uses a separate object (G_UNI)_to carry the source and destination client addresses, completely separating the client and network address spaces. TNAs allow the range and choice of client address formats supported to be an option of the carrier. However, this does introduce additional address processing at interworking points between G.7713.2 and RFC 3473.

2.3.6 Backwards Compatibility

G.7713.2 RSVP-TE is not fully backwards compatible with RFC 3473 RSVP-TE in the sense that an interworking function is required between domains using the different specifications. G.7713.2 signaling protocol does operate in such a way as to facilitate interworking of UNI/E-NNI and RFC 3473 signaling:

1) Pre-ASON connections can be supported unchanged within a domain - G.7713.2 is only defined for use at the UNI or E-NNI boundaries, i.e., for ASON services in a domain relying on RFC 3473 RSVP as the I-NNI.

2) Transit switches do not need to be upgraded to support new functionality - transit switches are only required to pass the G_UNI and Call_ID objects transparently, which should naturally occur based on the codepoint range.

3) A message received at a non-capable switch should be rejected due to the use of distinct C-Types for UNI and ENNI Session objects. Since these C-Types are not recognized by a switch that does not support a G.7713.2-based interface, the switch should reject the message, as it has no way to process the unrecognized Session object type.

In summary, G.7713.2 uses the same basic mechanisms as RFC 3473 and facilitate the use of RFC 3473 as an Internal Network-Network Interface (I-NNI) protocol. Some objects are required to be carried transparently, but are allocated code points from the range for transparent forwarding of unrecognized objects in accordance with existing RSVP.

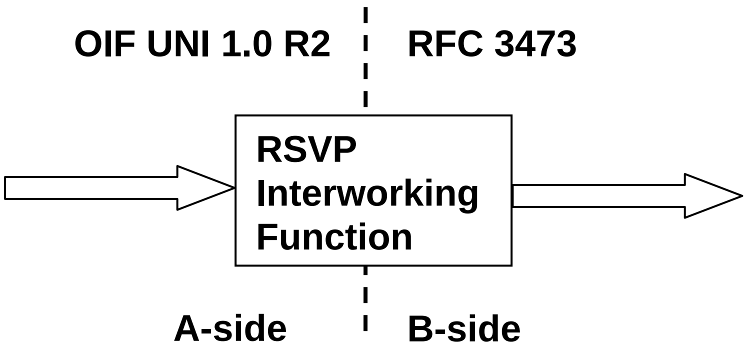
3 Main Interworking Functions Description

This section describes in detail a series of use cases specifies the behavior for RSVP messages requiring interworking (Path, Resv, ResvConf, PathErr, PathTear, ResvErr and ResvTear), one case in each direction (i.e. OIF UNI 1.0r2/E-NNI 1.0 – to - RFC3473 and RFC3473 – to - OIF UNI 1.0r2/E-NNI 1.0). Other RSVP messages supported by OIF UNI/E-NNI and RFC3473 (Hello, Srefresh) involve local actions and do not require an interworking function at this time. One specific case – receiving the ResvTear from at an RFC 3473-to-E-NNI interworking point – requires that a different message (PathErr) be generated on the other side. All other cases involve the manipulation of the contents of specific objects, where the same message type is used on either side of the interworking point.

Each of the use cases includes a table comparing supported objects for the RSVP messages.

- The first 2 columns show <mandatory> and [optional] objects and sub-objects for messages in OIF UNI 1.0r2/E-NNI 1.0 and RFC 3473.
- The shaded objects are those that differ between OIF UNI 1.0r2/E-NNI 1.0 and RFC 3473.
- Additional differences in behavior are noted in the right column. Those differences are stated as rules. Unless otherwise noted, these rules apply to all messages using the specified objects.

3.1 PATH Interworking: OIF UNI 1.0 R2 to RFC 3473



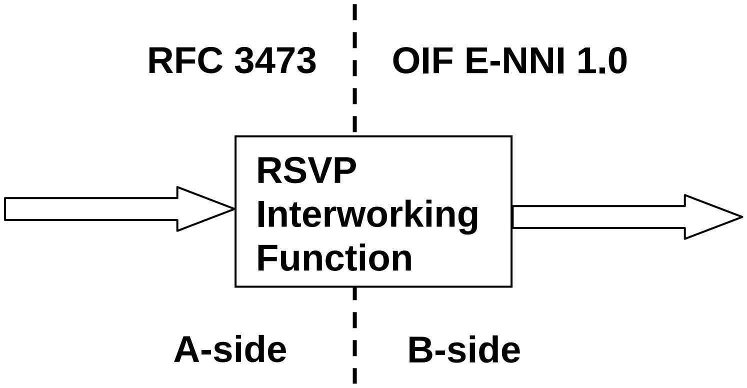
Message type: ***PATH***

- o Scenario: Incoming Path message on A-side is from source UNI-C. IW function provides UNI-N functionality toward A-side and translation to RFC3473 on B-side. These Path message may be requesting a connection setup (OIF UNI 1.0 r2 Figures 1-4), a connection teardown (OIF UNI 1.0 r2 Figures 5, 7) or a recovery from node failure (OIF UNI 1.0 r2 Figure 10). Recovery from a node failure is localized so no interworking is required.

Object comparison:

OIF-UNI1.0 R2 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 3
<TIME_VALUES>	<TIME_VALUES>	
	[<EXPLICIT_ROUTE>]	Rule 7
<GENERALIZED_LABEL_REQUEST> [<LABEL_SET> ...]	<LABEL_REQUEST> [<PROTECTION>] [<LABEL_SET> ...]	Rule 11
[< ADMIN_STATUS>]	[<ADMIN_STATUS>]	Rule 15
<Generalized UNI> = <Common Object Header> <DESTINATION_TNA><SOURCE_TNA> [<DIVERSITY> …][<SERVICE_LEVEL>] [<EGRESS_LABEL>]		Rule 16
	[<SESSION_ATTRIBUTE>]	Rule 19
	[<NOTIFY_REQUEST>]	Rule 23
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_TEMPLATE > <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	 Rule 28 Rule 32 Rule 42 Rule 33

3.2 PATH Interworking: RFC 3473 to OIF E-NNI 1.0



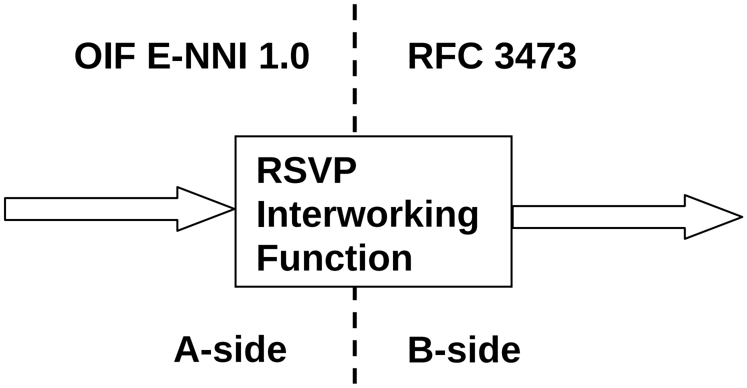
Message type: ***PATH***

Scenario: Outgoing Path message on B-side is to destination eNNI-D. IW function provides eNNI-U functionality toward B-side and translation from RFC3473 on A-side. These Path message may be requesting a connection setup, a connection teardown.

Object comparison:

RFC 3473 (A-side)	**OIF-E-NNI 1.0 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<E-NNI_IPv4_SESSION> <RSVP_HOP>	Rule 5
<TIME_VALUES>	<TIME_VALUES>	
[<EXPLICIT_ROUTE>]	[<EXPLICIT_ROUTE>]	Rule 10
<LABEL_REQUEST>	<GENERALIZED_LABEL_REQUEST>	
	[<CALL_ID>]	Rule 46
[<PROTECTION>]	[<PROTECTION>]	Rule 14
[<LABEL_SET> ...]	[<LABEL_SET> ...]	
[<SESSION_ATTRIBUTE>]	[<SESSION_ATTRIBUTE>]	Rule 22
[<NOTIFY_REQUEST>]	[<NOTIFY_REQUEST>]	Rule 26
[<ADMIN_STATUS>]	[<ADMIN_STATUS>]	Rule 15
	<Generalized UNI> = <Common Object Header> <DESTINATION_TNA><SOURCE_TNA> [<DIVERSITY> ...][<SERVICE_LEVEL>] [<EGRESS_LABEL>]	Rule 18
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <SENDER_ TEMPLATE> <SENDER_TSPEC> [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	 Rule 30 Rule 32 Rule 43 Rule 34

3.3 PATH Interworking: OIF E-NNI 1.0 to RFC 3473



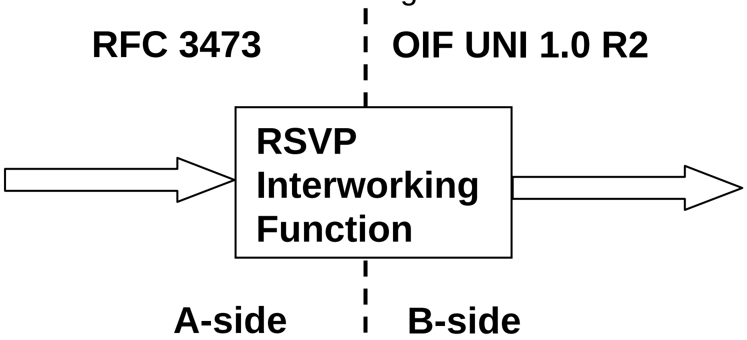
Message type: ***PATH***

- o Scenario: Incoming Path message on A-side is from source eNNI-U. IW function provides eNNI-D functionality toward A-side and translation to RFC3473 on B-side. These Path message may be requesting a connection setup, a connection teardown.

Object comparison:

OIF E-NNI 1.0 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<E-NNI_IPv4_SESSION> <RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 3
<TIME_VALUES>	<TIME_VALUES>	
[<EXPLICIT_ROUTE>]	[<EXPLICIT_ROUTE>]	Rule 8
<GENERALIZED_LABEL_REQUEST>	<LABEL_REQUEST>	
[<PROTECTION>]	[<PROTECTION>]	Rule 12
[<LABEL_SET> ...]	[<LABEL_SET> ...]	
[<CALL_ID>]		Rule 45
[<SESSION_ATTRIBUTE>]	[<SESSION_ATTRIBUTE>]	Rule 21
[<NOTIFY_REQUEST>]	[<NOTIFY_REQUEST>]	Rule 25
[< ADMIN_STATUS>]	[<ADMIN_STATUS>]	Rule 15
<Generalized UNI> = <Common Object Header> <DESTINATION_TNA><SOURCE_TNA> [<DIVERSITY> …][<SERVICE_LEVEL>] [<EGRESS_LABEL>]		Rule 16
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	 Rule 28 Rule 32 Rule 43 Rule 34

3.4 PATH Interworking: RFC 3473 to OIF UNI 1.0 R2



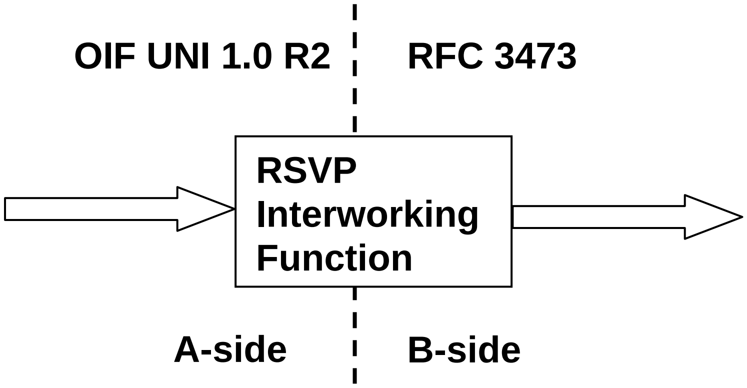
Message type: ***PATH***

Scenario: Outgoing Path message on B-side is to destination UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. These Path message may be requesting a connection setup (OIF UNI 1.0 r2 Figures 1, 4), a connection teardown (OIF UNI 1.0 r2 Figures 5, 7, 8) or a recovery from node failure (OIF UNI 1.0 r2 Figure 10). Recovery from a node failure is localized so no interworking is required.

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	Rule 4
<TIME_VALUES>	<TIME_VALUES>	
[<EXPLICIT_ROUTE>]		Rule 9
<LABEL_REQUEST> [<PROTECTION>] [<LABEL_SET> ...]	<GENERALIZED_LABEL_REQUEST> [<LABEL_SET> ...]	Rule 13
[<ADMIN_STATUS>]	[< ADMIN_STATUS>]	Rule 15
	<Generalized UNI> = <Common Object Header> <DESTINATION_TNA><SOURCE_TNA> [<DIVERSITY> …][<SERVICE_LEVEL>] [<EGRESS_LABEL>]	Rule 17
[<SESSION_ATTRIBUTE>]		Rule 20
[<NOTIFY_REQUEST>]		Rule 24
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_ TEMPLATE> <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	 Rule 29 Rule 32 Rule 42 Rule 33

3.5 RESV Interworking: OIF UNI 1.0 R2 to RFC 3473



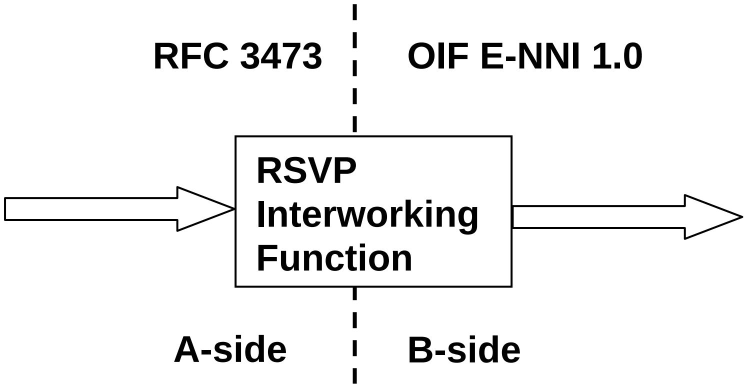
Message type: ***RESV***

Scenario: Incoming Resv message on A-side is from destination UNI-C. IW function provides UNI-N functionality toward A-side and translation to RFC3473 on B-side. These Resv messages may be responding to a connection setup request (OIF UNI 1.0r2 Figure 1) or a connection teardown request (OIF UNI 1.0r2 Figures 6, 8).

Object comparison:

OIF-UNI1.0 R2 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
<TIME_VALUES>	<TIME_VALUES>	
[<IPv4_RESV_CONFIRM>]	[<RESV_CONFIRM>] [<SCOPE>]	Rule 35 Rule 40
	[<NOTIFY_REQUEST>]	Rule 23
[< ADMIN_STATUS>]	[<ADMIN_STATUS>]	Rule 15
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	Rule 44 Rule 42

3.6 RESV Interworking: RFC 3473 to OIF E-NNI 1.0

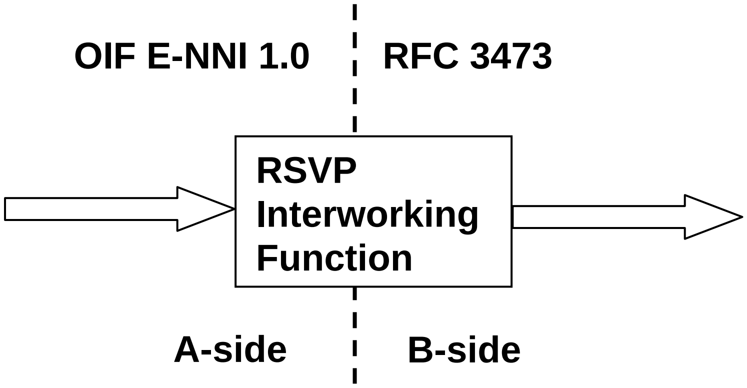


Message type: ***RESV***
Scenario: Outgoing Resv message on B-side is eNNI-D. IW function provides eNNI-D functionality toward B-side and translation from RFC3473 on A-side. Resv messages may be responding to a connection setup request or a connection teardown request.

Object comparison:

RFC 3473 (A-side)	**OIF E-NNI 1.0 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<E-NNI_IPv4_SESSION> <RSVP_HOP>	Rule 6
<TIME_VALUES>	<TIME_VALUES>	
	[<CALL_ID>]	Rule 46
[<RESV_CONFIRM>] [<SCOPE>]	[<RESV_CONFIRM>]	Rule 38 Rule 40
[<NOTIFY_REQUEST>]	[<NOTIFY_REQUEST>]	Rule 26
[<ADMIN_STATUS>]	[< ADMIN_STATUS>]	Rule 15
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	 Rule 44 Rule 43

3.7 RESV Interworking: OIF E-NNI 1.0 to RFC 3473

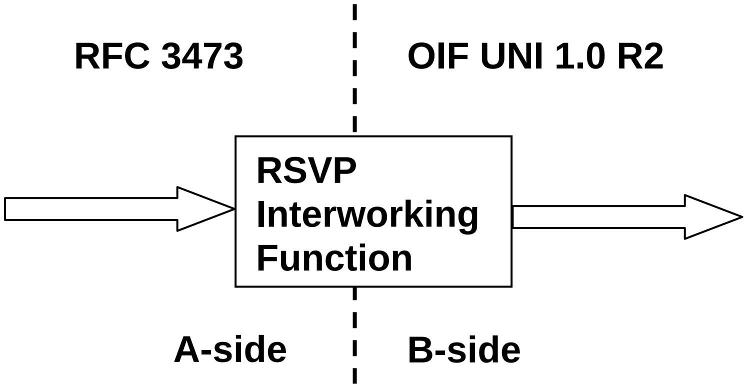


Message type: ***RESV***
Scenario: Incoming Resv message on A-side is from eNNI-U. IW function provides eNNI-D functionality toward A-side and translation to RFC3473 on B-side. These Resv messages may be responding to a connection setup request or a connection teardown request.

Object comparison:

OIF E-NNI 1.0 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<E-NNI_IPv4_SESSION> <RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
<TIME_VALUES>	<TIME_VALUES>	
[[<CALL_ID>]]		Rule 45
[<RESV_CONFIRM>]	[<RESV_CONFIRM>] [<SCOPE>]	Rule 37 Rule 40
[<NOTIFY_REQUEST>]	[<NOTIFY_REQUEST>]	Rule 25
[< ADMIN_STATUS>]	[<ADMIN_STATUS>]	Rule 15
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	 Rule 44 Rule 43

3.8 RESV Interworking: RFC 3473 to OIF UNI 1.0 R2

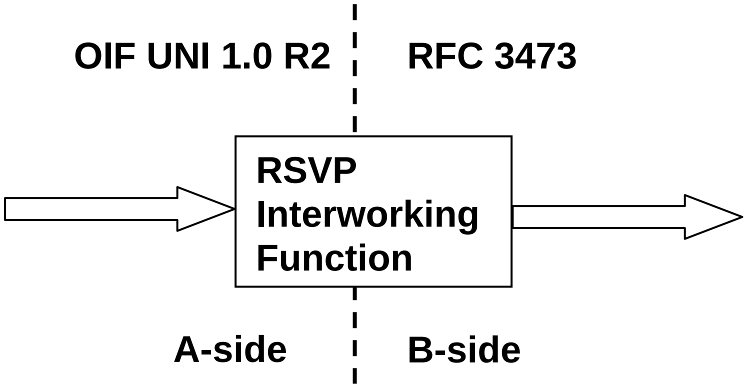


Message type: ***RESV***
Scenario: Outgoing Resv message on B-side is to source UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. Resv messages may be responding to a connection setup request (OIF UNI 1.0r2 Figure 1) or a connection teardown request (OIF UNI 1.0r2 Figures 6, 8).

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	Rule 6
<TIME_VALUES>	<TIME_VALUES>	
[<RESV_CONFIRM>] [<SCOPE>]	[<IPv4_RESV_CONFIRM>]	Rule 36 Rule 40
[<NOTIFY_REQUEST>]		Rule 24
[<ADMIN_STATUS>]	[< ADMIN_STATUS>]	Rule 15
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	 Rule 44 Rule 42

3.9 RESVCONF Interworking: OIF UNI 1.0 R2 to RFC 3473



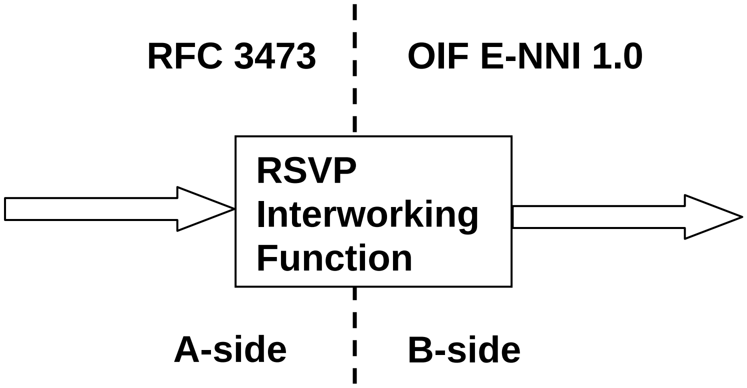
Message type: ***RESVCONF***

Scenario: Incoming ResvConf message on A-side is from source UNI-C. IW function provides UNI-N functionality toward A-side and translation to RFC3473 on B-side. Source UNI-C is responding to a Resv message which included the Resv_Confirm object (OIF UNI 1.0r2 Figure 1).

Object comparison:

OIF-UNI1.0 R2 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
<IPv4_ERROR_SPEC>	<ERROR_SPEC>	
<IPv4_RESV_CONFIRM>	<RESV_CONFIRM>	Rule 39
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	 Rule 44 Rule 42

3.10 RESVCONF Interworking: RFC 3473 to OIF E-NNI 1.0



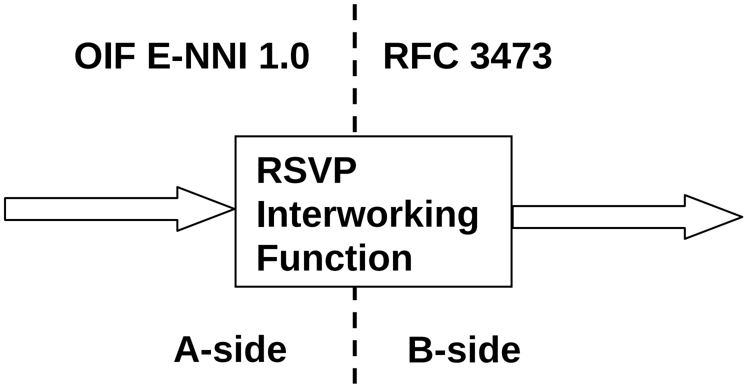
Message type: ***RESVCONF***

Scenario: Outgoing ResvConf message on B-side is to destination UNI. IW function provides eNNU-U functionality toward B-side and translation from RFC3473 on A-side. Destination UNI is receiving a ResvConf message which it requested by including the Resv_Confirm object in the Resv message it previously sent.

Object comparison:

RFC 3473 (A-side)	**OIF E-NNI 1.0 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<E-NNI_IPv4_SESSION> <RSVP_HOP>	Rule 6
<ERROR_SPEC>	<ERROR_SPEC>	
<RESV_CONFIRM>	<RESV_CONFIRM>	Rule 39
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <FLOWSPEC> <FILTER_SPEC> <GENERALIZED_LABEL> [<RECORD_ROUTE>]	 Rule 44 Rule 43

3.11 RESVCONF Interworking: OIF E-NNI 1.0 to RFC 3473



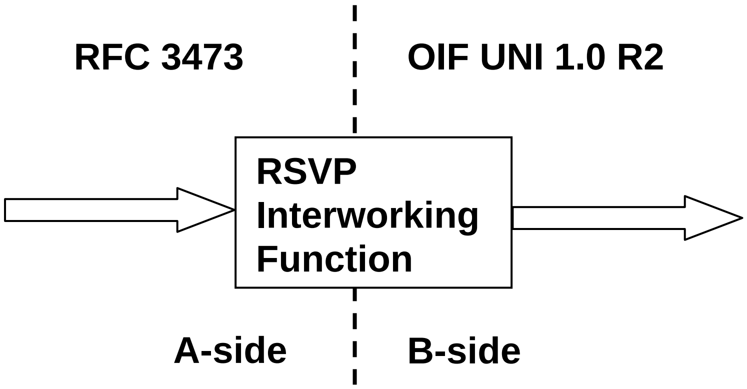
Message type: ***RESVCONF***

Scenario: Incoming ResvConf message on A-side is from eNNI-U. IW function provides eNNI-D functionality toward A-side and translation to RFC3473 on B-side. Source UNI is responding to a Resv message which included the Resv_Confirm object.

Object comparison:

OIF E-NNI 1.0 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<E-NNI_IPv4_SESSION> <RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
<ERROR_SPEC>	<ERROR_SPEC>	
<RESV_CONFIRM>	<RESV_CONFIRM>	Rule 39
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	 Rule 44 Rule 43

3.12 RESVCONF Interworking: RFC 3473 to OIF UNI 1.0 R2

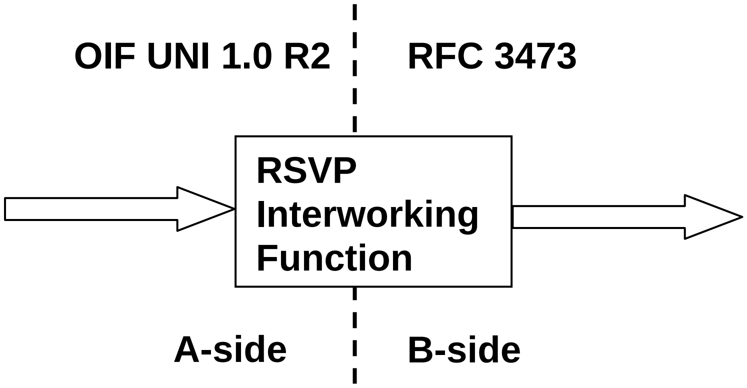


Message type: ***RESVCONF***
Scenario: Outgoing ResvConf message on B-side is to destination UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. Destination UNI-C is receiving a ResvConf message which it requested by including the Resv_Confirm object in the Resv message it previously sent (OIF UNI 1.0r2 Figure 1).

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	Rule 6
<ERROR_SPEC>	<IPv4_ERROR_SPEC>	
<RESV_CONFIRM>	<IPv4_RESV_CONFIRM>	Rule 39
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	 Rule 44 Rule 42

3.13 PATHERR Interworking: OIF UNI 1.0 R2 to RFC 3473



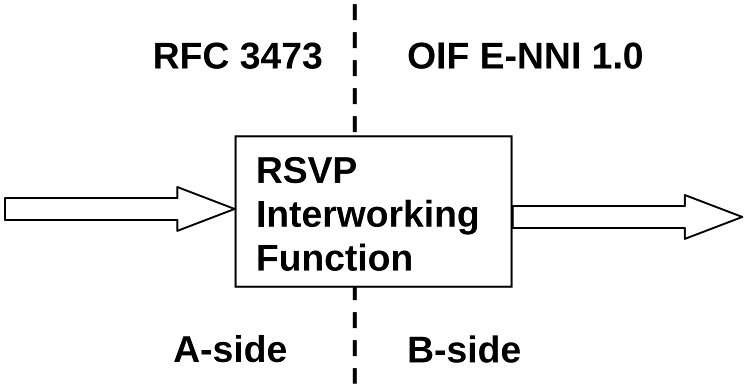
Message type: ***PATHERR***

- o Scenario: Incoming PathErr message on A-side is from destination UNI-C. IW function provides UNI-N functionality toward A-side and translation to RFC3473 on B-side. These PathErr messages may result from rejecting a connection setup request (UNI 1.0r2 Figure 4), a connection teardown initiated by the source UNI-C (UNI 1.0r2 Figure 5) or a connection teardown initiated by the source UNI-N (UNI 1.0r2 Figure 7).

Object comparison:

OIF-UNI1.0 R2 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<UNI_IPv4_SESSION>	<SESSION>	Rule 6
[<ACCEPTABLE_LABEL_SET>]	[<ACCEPTABLE_LABEL_SET>]	
<IPv4_ERROR_SPEC>	<ERROR_SPEC>	
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_TEMPLATE> <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	 Rule 31 Rule 32 Rule 42 Rule 33

3.14 PATHERR Interworking: RFC 3473 to OIF E-NNI 1.0



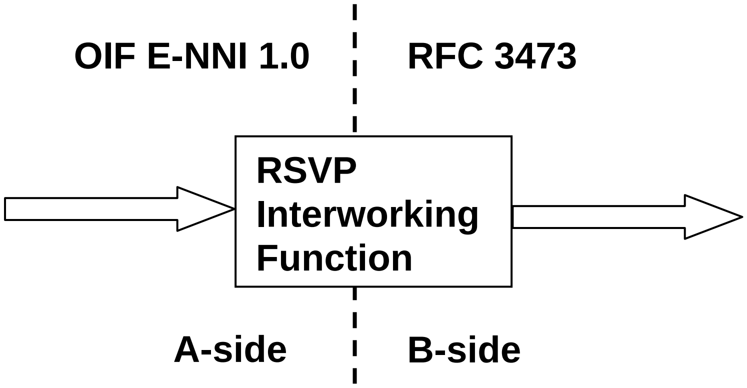
Message type: ***PATHERR***

- o Scenario: Incoming PathErr message on A-side is to the eNNI-U. IW function provides eNNI-D functionality toward B-side and translation from RFC3473 domains on A-side. These PathErr messages may result from rejecting a connection setup request, a connection teardown initiated by the source UNI, a SPC teardown initiated by the SPC source, or a connection teardown initiated by the network.

Object comparison:

RFC 3473 (B-side)	**OIF E-NNI 1.0 (A-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION>	<E-NNI_IPv4_SESSION>	Rule 6
	[<CALL_ID>]	Rule 46
<ERROR_SPEC>	<ERROR_SPEC>	
[<ACCEPTABLE_LABEL_SET>]	[<ACCEPTABLE_LABEL_SET>]	
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	 Rule 31 Rule 32 Rule 43 Rule 34

3.15 PATHERR Interworking: OIF E-NNI 1.0 to RFC 3473



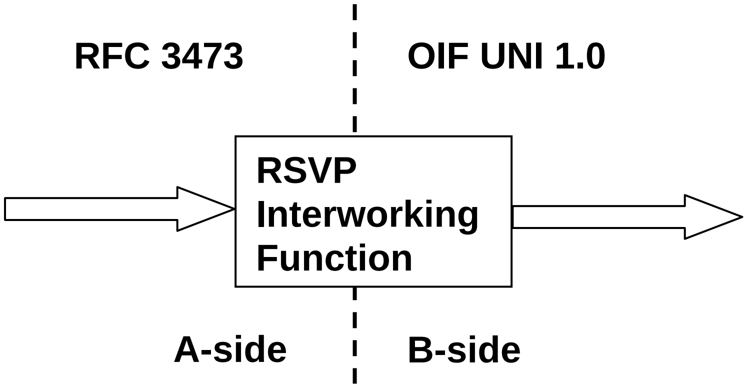
Message type: ***PATHERR***

- o Scenario: Incoming PathErr message on A-side is from eNNI-D. IW function provides eNNI-U functionality toward A-side and translation to RFC3473 on B-side. These PathErr messages may result from rejecting a connection setup request, a connection teardown initiated by the source UNI or a SPC teardown initiated by the SPC source, or a connection teardown initiated by the network.

Object comparison:

OIF E-NNI 1.0 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<E-NNI_IPv4_SESSION>	<SESSION>	Rule 6
[<CALL_ID>]		Rule 45
<ERROR_SPEC>	<ERROR_SPEC>	
[<ACCEPTABLE_LABEL_SET>]	[<ACCEPTABLE_LABEL_SET>]	
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	 Rule 31 Rule 32 Rule 43 Rule 34

3.16 PATHERR Interworking: RFC 3473 to OIF UNI 1.0 R2



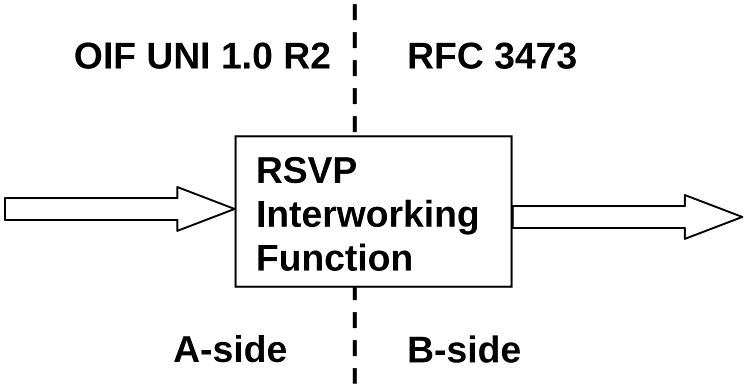
Message type: ***PATHERR***

- o Scenario: Incoming PathErr message on A-side is to the source UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 domains on A-side. These PathErr messages may result from rejecting a connection setup request (UNI 1.0r2 Figures 2-4), a connection teardown initiated by the source UNI-C (UNI 1.0r2 Figure 5), a connection teardown initiated by the source UNI-N (UNI 1.0r2 Figure 7), or a connection teardown initiated by the network (UNI 1.0r2 Figure 9).

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION>	<UNI_IPv4_SESSION>	Rule 6
[<ACCEPTABLE_LABEL_SET>]	[<ACCEPTABLE_LABEL_SET>]	
<ERROR_SPEC>	<IPv4_ERROR_SPEC>	
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_TEMPLATE> <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	 Rule 31 Rule 32 Rule 42 Rule 33

3.17 PATHTEAR Interworking: OIF UNI 1.0 R2 to RFC 3473



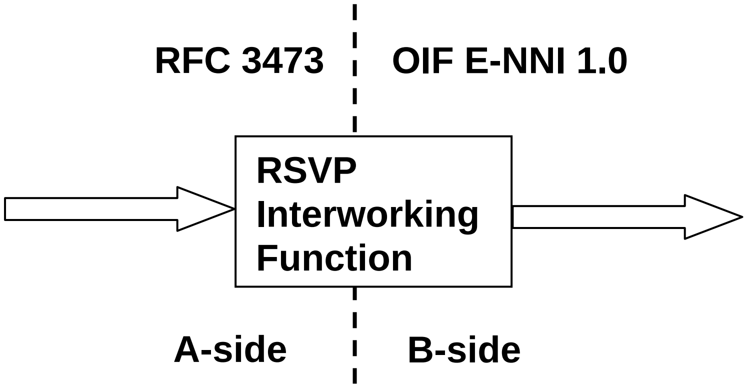
Message type: ***PATHTEAR***

- Scenario: Incoming PathTear message on A-side is from source UNI-C. IW function provides UNI-N functionality toward A-side and translation to RFC3473 on B-side. These PathTear messages may result from rejecting a connection setup request (UNI 1.0r2 Figure 3), a connection teardown initiated by the destination UNI-C (UNI 1.0r2 Figure 6) or a connection teardown initiated by the destination UNI-N (UNI 1.0r2 Figure 8).

Object comparison:

OIF-UNI1.0 R2 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_TEMPLATE> <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	Rule 31 Rule 32 Rule 42 Rule 33

3.18 PATHTEAR Interworking: RFC 3473 to OIF E-NNI 1.0



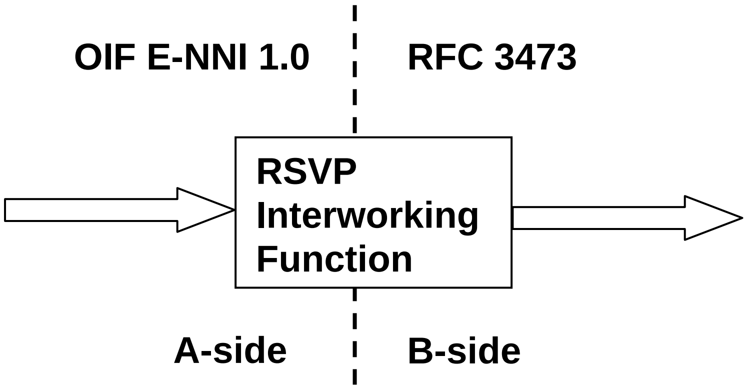
Message type: ***PATHTEAR***

Scenario: Outgoing PathTear message on B-side is to destination eNNI-D. IW function provides eNNI-U functionality toward B-side and translation from RFC3473 on A-side. These PathTear messages may result from rejecting a connection teardown initiated by the destination UNI, a SPC teardown initiated by the SPC destination, or a connection teardown initiated by the network.

Object comparison:

RFC 3473 (A-side)	**OIF E-NNI 1.0 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<E-NNI_IPv4_SESSION> <RSVP_HOP>	Rule 6
	[<CALL_ID>]	Rule 46
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <SENDER_ TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	Rule 31 Rule 32 Rule 43 Rule 34

3.19 PATHTEAR Interworking: OIF E-NNI 1.0 to RFC 3473



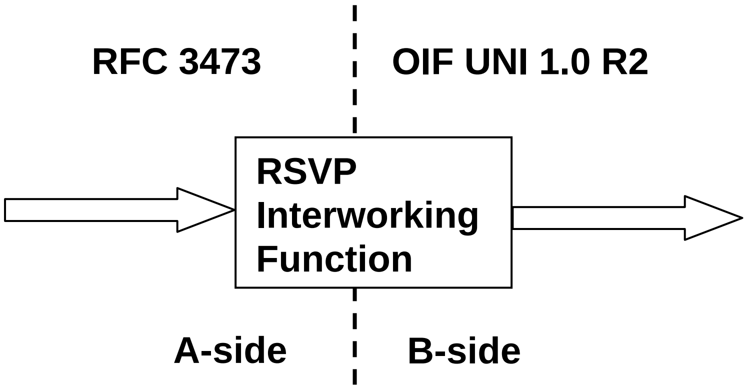
Message type: ***PATHTEAR***

- Scenario: Incoming PathTear message on A-side is from eNNI-D. IW function provides eNNI-U functionality toward A-side and translation to RFC3473 on B-side. These PathTear messages may result from rejecting a connection setup request, a connection teardown initiated by the destination UNI-C or a SPC teardown initiated by the SPC destination, or a connection teardown initiated by the network.

Object comparison:

OIF E-NNI 1.0 (A-side)	**RFC 3473 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 2
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
<MESSAGE_ID>	[<MESSAGE_ID>]	
<E-NNI_IPv4_SESSION> <RSVP_HOP>	<SESSION> <RSVP_HOP>	Rule 6
[<CALL_ID>]		Rule 45
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	 Rule 31 Rule 32 Rule 43 Rule 34

3.20 PATHTEAR Interworking: RFC3473 to OIF UNI 1.0 R2



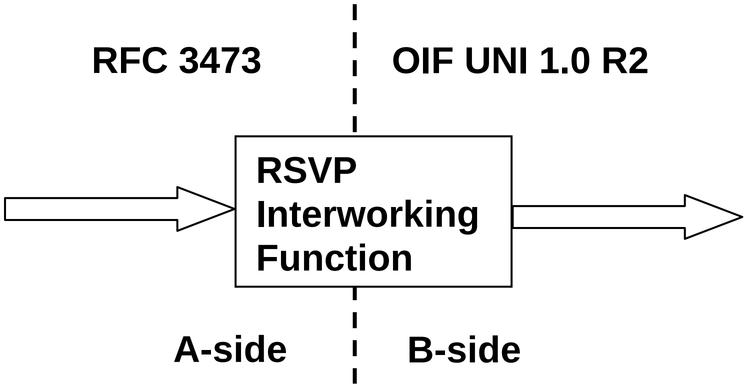
Message type: ***PATHTEAR***

Scenario: Outgoing PathTear message on B-side is to destination UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. These PathTear messages may result from rejecting a connection teardown initiated by the destination UNI-C (UNI 1.0r2 Figure 6), a connection teardown initiated by the destination UNI-N (UNI 1.0r2 Figure 8), or a connection teardown initiated by the network (UNI 1.0r2 Figure 9).

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	Rule 6
<sender descriptor> = <SENDER_TEMPLATE> <SENDER_TSPEC> [<ADSPEC>] [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL>]	<sender descriptor> = <LSP_TUNNEL_IPv4_SENDER_ TEMPLATE> <SONET/SDH_SENDER_TSPEC> [<UPSTREAM_LABEL>] [<RECOVER_LABEL >]	 Rule 31 Rule 32 Rule 42 Rule 33

3.21 RESVTEAR Interworking: RFC3473 to OIF UNI 1.0 R2



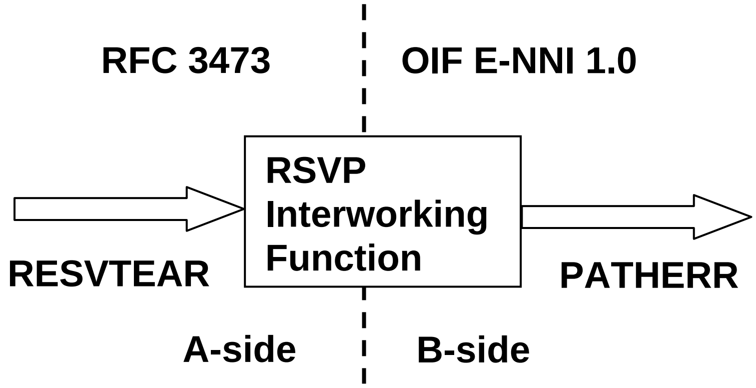
Message type: ***RESVTEAR***

Scenario: Outgoing ResvTear message on B-side is to the source UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. These ResvTear messages may result from a network-internal connection deletion action. This message is supported on UNI 1.0 r2 for compatibility with RSVP.

Object comparison:

RFC 3473 (A-side)	**OIF-UNI1.0 R2 (B-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION> <RSVP_HOP>	<UNI_IPv4_SESSION> <IPv4_IF_ID_RSVP_HOP>	Rule 6
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	 Rule 44 Rule 42

3.22 RESVTEAR - PATHERR Interworking: RFC3473 to OIF E-NNI 1.0



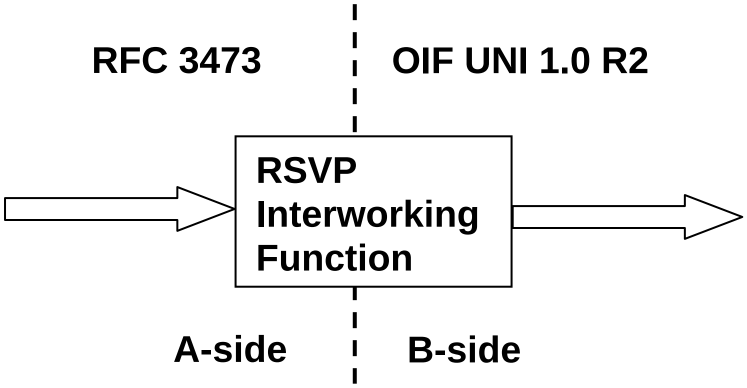
Message type: ***RESVTEAR – to – PATHERR***

Scenario: Incoming ResvTear message from the A-side is an upstream notification of forced deletion. Since E-NNI 1.0 does not support the ResvTear message, it is mapped into a PathErr message for upstream notification of a forced deletion.

Object comparison:

RFC 3473 (A-side) - ResvTear	**OIF-E-NNI 1.0 (B-side) - PathErr**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION>	<E-NNI_IPv4_SESSION>	Rule 6
<RSVP_HOP> <STYLE> <FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]		Rule 47
	[<CALL_ID>]	Rule 46
	<ERROR_SPEC>	Rule 49
	[<ACCEPTABLE_LABEL_SET>] [<POLICY_DATA> ...]	Rule 48
	<sender descriptor> = <SENDER_ TEMPLATE> <SENDER_TSPEC> [<RECORD_ROUTE>] [<SUGGESTED_LABEL>] [<UPSTREAM_LABEL>] [<RECOVERY_LABEL >]	 Rule 49 Rule 48

3.23 RESVERR Interworking: RFC3473 to OIF UNI 1.0 R2



Message type: ***RESVERR***
Scenario: Outgoing ResvErr message on B-side is to the destination UNI-C. IW function provides UNI-N functionality toward B-side and translation from RFC3473 on A-side. These ResvErr messages may result from a network-internal connection deletion action. This message is supported on UNI 1.0 r2 for compatibility with RSVP.

Object comparison:

RFC 3473 (B-side)	**OIF-UNI1.0 R2 (A-side)**	**Differences/Comments**
<Common Header>	<Common Header>	Rule 1
[<INTEGRITY>]	[<INTEGRITY>]	
[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	[[<MESSAGE_ID_ACK> | <MESSAGE_ID_NACK>] ...]	
[<MESSAGE_ID>]	<MESSAGE_ID>	
<SESSION>	<UNI_IPv4_SESSION>	Rule 6
[<ACCEPTABLE_LABEL_SET>]	[<ACCEPTABLE_LABEL_SET>]	
<ERROR_SPEC>	<IPv4_ERROR_SPEC>	
[<POLICY_DATA> ...]	[<POLICY_DATA> ...]	Rule 27
<STYLE>	<STYLE>	Rule 41
<FF flow descriptor list> = <FLOWSPEC> <FILTER_SPEC> <LABEL> [<RECORD_ROUTE>]	<FF flow descriptor> = <SONET/SDH_FLOWSPEC> <LSP_TUNNEL_IPv4_FILTER_SPEC> <GENERALIZED_LABEL>	 Rule 44 Rule 42

3.24 Interworking Rules

This section specifies the interworking rules for various RSVP objects.

<Common Header>

Rule 1 [RFC 3473 to OIF UNI] OIF UNI side will set flag field to 1 to indicate support of the Bundle and Srefresh messages.

Rule 2 [OIF UNI/E-NNI to RFC 3473 and RFC 3473 to E-NNI] RFC 3473 and E-NNI side will set the set the Refresh (Overhead) Reduction Capable flag as appropriate depending whether the Bunndle and Srefresh messages are supported.

<SESSION>

Rule 3 [OIF UNI/E-NNI to RFC 3473] IW function terminates the session of the OIF UNI or E-NNI side and initiates a new session on RFC 3473 side. The tunnel endpoint address of the SESSION object is set to the value contained in the Destination TNA of the GENERALIZED_UNI object. The Tunnel ID is set to a value that ensures uniqueness for the SESSION object. The Extended Tunnel ID should be set to the IP address of the ingress node to narrow the scope of the ingress-egress pair.

Rule 4 [RFC 3473 to OIF UNI] IW function terminates the RFC 3473 session and initiates a new session on OIF UNI side. Based on the Destination TNA of the GENERALIZED_UNI object, the tunnel endpoint address is set to the Node ID of the destination UNI-C. The Extended IPv4 address is set to the Node ID of the destination UNI-N. Tunnel ID unique to the UNI is used in the SESSION object.

Rule 5 [RFC 3473 to OIF E-NNI] IW function terminates the RFC 3473 session and initiates a new session on OIF E-NNI side. The tunnel endpoint address is set to the signaling controller ID of the eNNI-D. The Extended IPv4 address is set to the signaling controller ID of the eNNI-U. A Tunnel ID unique to the E-NNI is used in the SESSION object.

Rule 6 [OIF UNI/E-NNI to/from RFC 3473] The contents of the SESSION object for the Resv, ResvConf, PathTear and PathErr messages should be the same as the SESSION object used in the Path message on the appropriate side of the interworking point. This is to guarantee the same use of the Tunnel ID and Extended Tunnel ID for all messages.

<EXPLICIT_ROUTE>

Rule 7 [OIF UNI to RFC 3473] RFC3473 side may originate EXPLICIT_ROUTE, using hops within RFC3473 domain.

Rule 8 [OIF E-NNI to RFC 3473] EXPLICIT_ROUTE object is forwarded to RFC3473 side. RFC3473 side may add hops within RFC3473 domain to the forwarded EXPLICIT_ROUTE objects.

Rule 9 [RFC 3473 to OIF UNI] EXPLICIT_ROUTE object not forwarded to OIF UNI side. Last hop in ERO should be on RFC3473 side.

Rule 10 [RFC 3473 to OIF E-NNI] EXPLICIT_ROUTE object is forwarded to OIF E-NNI side. Any hops within the RFC3473 domain should be removed.

<PROTECTION>

Rule 11 [OIF UNI to RFC 3473] PROTECTION object may be originated within, and is restricted to the RFC3473 domain.

Rule 12 [OIF E-NNI to RFC 3473] PROTECTION object is not forwarded to the RFC3473 side. A new PROTECTION object may be originated within, and is restricted to the RFC3473 domain.

Rule 13 [RFC 3473 to OIF UNI] PROTECTION object is not forwarded to OIF UNI side.

Rule 14 [RFC 3473 to OIF E-NNI] PROTECTION object is not forwarded to OIF E-NNI side. A new PROTECTION object may be originated on, and is restricted to the OIF E-NNI.

<ADMIN_STATUS>

Rule 15 [RFC 3473 to/from OIF UNI/E-NNI] If the D and R bits are set in the ADMIN_STATUS object, they should remain set in the forwarded object. If the A bit in the ADMIN_STATUS object is set in the RFC 3473 domain, the IW function should either clear this bit before forwarding the object to the UNI/E-NNI, or not forward the object. See Limitations section for further details.

<Generalized UNI>

Rule 16 [OIF UNI/E-NNI to RFC 3473] Generalized UNI must be transparently forwarded.

Rule 17 [RFC 3473 to OIF UNI] Generalized UNI must be transparently forwarded if present. If the Source TNA, Destination TNA, or Egress_Label sub-objects are not present in the Generalized UNI, they need to be created. If they must be created, the following procedure applies.

- The Source TNA is set to the Tunnel sender address field of the SENDER_TEMPLATE of the RFC 3473 domain.

- The Destination TNA is set to the Tunnel endpoint address of the SESSION of the RFC 3473 domain.

- If final object on ERO is unnumbered and TE Router ID matches SESSION's end point address, then the Egress_Label Logical Port ID is set to the ERO's Interface ID. In addition if final object on ERO contained label information, then
  the Egress_Label is set to the value of the ERO label. If these conditions are not met, it may not be possible to ensure interworking.

- Other sub-objects in the Generalized UNI object (Service Level and Diversity) are not created.

Rule 18[RFC 3473 to OIF E-NNI] If the Source TNA, Destination TNA, and Egress_Label or SPC_Label sub-objects are not present in the Generalized UNI, they need to be created. If they are present, they are passed transparently. If they must be created, the following procedure applies.

- The Source TNA is set to the Tunnel sender address field of the SENDER_TEMPLATE of the RFC 3473 domain.
- The Destination TNA is set to the Tunnel endpoint address of the SESSION of the RFC 3473 domain.
- To maximize interworking potential, the SPC_Label is included in the Generalized UNI instead of the Egress_Label. If final object on ERO is unnumbered and TE Router ID matches SESSION's end point address, then the SPC_Label Logical Port ID is set to the ERO's Interface ID. In addition if final object on ERO contained label information, then
the SPC_Label is set to the value of the ERO label. If these conditions are not met, it may not be possible to ensure interworking.
- Other sub-objects in the Generalized UNI object (Service Level and Diversity) are not created.

<SESSION_ATTRIBUTE>

Rule 19 [OIF UNI to RFC 3473] SESSION_ATTRIBUTE object may be originated within, and is scoped to the the session in the RFC3473 domain.

Rule 20 [RFC 3473 to OIF UNI] SESSION_ATTRIBUTE object is not forwarded to the OIF UNI side.

Rule 21 [E-NNI to RFC 3473] E-NNI SESSION_ATTRIBUTE object is not forwarded to the RFC3473 domain. A new SESSION_ATTRIBUTE object may be originated in the RFC3473 domain. Each SESSION_ATTRIBUTE object is scoped to its respective signaling session.

Rule 22 [RFC 3473 to OIF E-NNI] RFC3473 SESSION_ATTRIBUTE object is not forwarded to the OIF E-NNI. A new SESSION_ATTRIBUTE object may be originated on the OIF E-NNI. Each SESSION_ATTRIBUTE object is scoped to its respective signaling session.

<NOTIFY_REQUEST>

Rule 23 [OIF UNI to RFC 3473] NOTIFY_REQUEST object may be originated within, and is scoped to, the RFC3473 domain.

Rule 24 [RFC 3473 to OIF UNI] NOTIFY_REQUEST object not forwarded to OIF UNI side. Any nodes requesting Notify must be within RFC3473 domain.

Rule 25 [OIF E-NNI to RFC 3473] E-NNI NOTIFY_REQUEST object is not forwarded to the RFC3473 domain. A new NOTIFY_REQUEST object may be originated in the RFC3473 domain. Each NOTIFY_REQUEST object is scoped to its respective signaling session.

Rule 26 [RFC 3473 to OIF E-NNI] RFC3473 NOTIFY_REQUEST object is not forwarded to the OIF E-NNI. A new NOTIFY_REQUEST object may be originated on the OIF E-NNI. Each NOTIFY_REQUEST object is scoped to its respective signaling session.

<POLICY_DATA>

Rule 27 [OIF UNI/E-NNI to RFC 3473 or RFC 3473 to OIF UNI/E-NNI] Policy object supported on both sides, contents may differ (POLICY_DATA on OIF UNI or E-NNI side may specify a client Contract ID that is not applicable on RFC3473 side). Local policy determines whether to forward the POLICY_DATA object.

<SENDER_TEMPLATE>

Rule 28 [OIF UNI/E-NNI to RFC3473] The IW function puts the value contained in the Source TNA of the GENERALIZED_UNI object into the Tunnel sender address field of the SENDER_TEMPLATE object on the RFC3473 side. An LSP ID for the RFC3473 domain, assigned by the sender of the Path message, is put into the SENDER_TEMPLATE.

Rule 29 [RFC3473 to OIF UNI] The IW function puts the destination UNI-N Node ID in the Tunnel sender address field of the SENDER_TEMPLATE object on the OIF UNI side.

Rule 30 [RFC3473 to OIF E-NNI] The IW function puts the signaling controller ID of the eNNI-U in the Tunnel sender address field of the SENDER_TEMPLATE object on the OIF E-NNI side.

Rule 31 [OIF UNI/E-NNI to/from RFC 3473] The contents of the SENDER_TEMPLATE object for the PathTear and PathErr messages should be the same as the SENDER_TEMPLATE object used in the Path message on the appropriate side of the interworking point. This is to guarantee the same use of the LSP ID for all messages.

<ADSPEC>

Rule 32 [OIF UNI/E-NNI to/from RFC3473] ADSPEC object may be originated within, and is restricted to the RFC3473 domain. It is not supported on the OIF UNI or E-NNI side.

<SUGGESTED_LABEL>

Rule 33 [OIF UNI to/from RFC3473] SUGGESTED_LABEL object may be originated within, and is restricted to the RFC3473 domain. It is not supported on the OIF UNI side.

Rule 34 [OIF E-NNI to/from RFC3473] Both RFC3473 and OIF E-NNI optionally support the SUGGESTED_LABEL object, but it is locally significant and is not forwarded unchanged across the interworking point.

<RESV_CONFIRM>

Rule 35 [OIF UNI to RFC3473 RESV Message] If OIF UNI originates a RESV_CONFIRM object, the RFC3473 side should also send a RESV_CONFIRM object. If the OIF UNI side does not originate a RESV_CONFIRM object, the RFC3473 side should not send a RESV_CONFIRM object (see Limitations section). The Receiver Address in the RESV_CONFIRM object from the OIF UNI side is the destination UNI-C's Node ID. The IW function changes the Receiver Address to the IP address of the node in the RFC3473 domain.

Rule 36 [RFC3473 to OIF UNI RESV Message] If the RFC3473 side receives a RESV_CONFIRM object from its downstream RFC3473 node, the IW function should include a RESV_CONFIRM object on the OIF UNI side. If it does not receive a RESV_CONFIRM object, it should not send one to the OIF UNI side. The IW function changes the Receiver Address in the RESV_CONFIRM object to the source UNI-N Node ID.

Rule 37 [OIF E-NNI to RFC3473 RESV Message] If the OIF E-NNI side receives a RESV_CONFIRM object, the IW function should include a RESV_CONFIRM object on the RFC3473 side. If it does not receive a Resv_confirm object, it should not send one to the RFC3473 side. The IW function changes the Receiver Address in the RESV_CONFIRM object to the IP address of the node in the RFC 3473 domain.

Rule 38 [RFC3473 to OIF E-NNI RESV Message] If the RFC3473 side receives a RESV_CONFIRM object from its downstream RFC3473 node, the IW function should include a RESV_CONFIRM object on the OIF E-NNI side. If it does not receive a RESV_CONFIRM object, it should not send one to the OIF E-NNI side. The IW function changes the signaling controller address in the RESV_CONFIRM object to the signaling controller ID of eNNI-D.

Rule 39 [OIF UNI/E-NNI to/from RFC3473 RESVCONF Message] The RESV_CONFIRM object is a copy of that object in the RESV message that triggered the confirmation.

<SCOPE>

Rule 40 [RFC3473 to/from OIF UNI/E-NNI] The optional SCOPE object is defined in RFC 2205 for use with WF style, which is not supported for OIF UNI or E-NNI. IW function ensures no SCOPE object is forwarded to the OIF UNI or E-NNI side.

<STYLE>

Rule 41 [RFC3473 to/from OIF UNI/E-NNI] Currently only Fixed-Filter supported on OIF UNI/E-NNI side. The IW function ensures no messages with STYLE other than Fixed Filter is forwarded to the OIF UNI or E-NNI side. Other actions associated with an unexpected STYLE (such as initiating a tear down or reporting an error code) would be local decisions.

<RECORD_ROUTE>

Rule 42 [OIF UNI to/from RFC3473] RECORD_ROUTE object may be originated within, and is restricted to the RFC3473 domain. It is not supported on the OIF UNI side.

Rule 43 [OIF E-NNI to/from RFC3473] Both RFC3473 and OIF E-NNI optionally support the RECORD_ROUTE object, but it is restricted in scope to each side of the IW interface and is not forwarded unchanged across the interworking point.

<FILTER_SPEC>

Rule 44 [OIF UNI/E-NNI to/from RFC 3473] The contents of the FILTER_SPEC object for the Resv and ResvConf messages should be the same as the SENDER_TEMPLATE object used in the Path message on the appropriate side of the interworking point. This is to guarantee the same use of the LSP ID for all messages.

<CALL_ID>

Rule 45 [OIF E-NNI to RFC3473] Call_ID is not used by RFC3473 side and must be transparently forwarded. The IW function should keep the association between the Call ID and RFC3473 side LSP.

Rule 46 [RFC3473 to OIF UNI/E-NNI] Call_ID is not used by RFC3473 side but transparently forwarded object (if present) must be re-inserted to the OIF UNI/E-NNI side.

3.25 Rules for Creating a PathErr message on E-NNI 1.0 from a ResvTear message on RFC 3473.

The following rules apply to the situation where an incoming ResvTear message from an RFC 3473 domain must be mapped into a PathErr message on an E-NNI 1.0 to provide upstream notification of a forced deletion. Since the supported objects for each message differ, objects that are unique to the ResvTear message are omitted from the PathErr message and objects that are unique to the PathErr message must be created. Other objects that are common to both message types are covered by existing rules.

Rule 47 The following objects may exist in a ResvTear message, but not a PathErr message and are not forwarded in the PathErr message:

<RSVP_HOP>
<STYLE>
<FF flow descriptor list>

Rule 48 The following objects are allowed in a PathErr message but would not be present in the incoming ResvTear message. These objects are not created for the outgoing PathErr message:

<ACCEPTABLE_LABEL_SET>
<POLICY_DATA>
<SUGGESTED_LABEL>
<UPSTREAM_LABEL>
<RECOVERY_LABEL >
<RECORD_ROUTE>

Rule 49 The following objects are required in a PathErr message but would not be present in the incoming ResvTear message. These objects are created for the outgoing PathErr message:

<ERROR_SPEC>
<SENDER_ TEMPLATE>
<SENDER_TSPEC>

The ERROR_SPEC must have the Path State Removed flag set for notification of forced deletion. The SENDER_ TEMPLATE is created as described in Rule 31. The contents of the SENDER_TSPEC object should be the same as the SENDER_TSPEC object used in the Path message on the E-NNI.

3.26 Additional Limitations and restrictions

- OIF UNI 1.0 R2 may not be compatible to RFC 4208 client on the far end. The far end must either be an OIF UNI-C, OIF UNI-N, or be capable of providing the necessary objects and messages to an OIF UNI. This could be accomplished using some of the above rules to create objects (such as Source TNA, Destination TNA, and Egress_Label sub-objects) that are required by an OIF UNI, when one endpoint supports RFC 4208. There may be other interworking issues for compatibility with RFC 4208 such as the handling of Resv_Confirm objects. While there may be solutions to these issues, interworking with RFC 4208 is not within the current scope of this document.
- There are potential incompatibilities with respect to the ResvConf message. UNI 1.0r2 uses ResvConf as a reliable message scheme. It removes the Resv_Confirm object from the Resv message upon receipt of the ResvConf message. This is not required by RFC 3473. There may be interworking issues where a UNI 1.0r2 source would never see the Resv_Confirm object removed when the destination is a RFC 4208 UNI. Also, the destination may see periodic ResvConf messages.
- There is a potential incompatibility for the optional Resv_Confirm object in the Resv message and the resulting ResvConf message. For OIF UNI, the ResvConf is an end-end process. For RFC3473, the ResvConf is scoped to the RSVP session. For example, consider an RFC3473 domain with an interworking function at the edges to support UNI-C devices on each end. If the destination UNI-C includes a Resv_Confirm object in its Resv message, it is requesting a ResvConf message be sent to it from the source. If a Resv_confirm object is received at the egress of the RFC3473 domain an interworking function at the source UNI-N will infer that the destination UNI-C requested the Resv_Confirm. However it is possible that the destination UNI-C did not request it and the RFC3473 domain autonomously originated a Resv_Confirm; in this case a destination UNI-C may receive a ResvConf message that it did not request. To alleviate this, a node in an RFC 3473 domain that is providing interworking with OIF E-NNI or UNI should only forward a ResvConf message if it had received a Resv_Confirm request in the Resv message from a node downstream; if the RFC 3473 node was the originator of the Resv_Confirm request in the Resv message, the ResvConfirm message should not be forwarded.
- RFC 3473 supports an Admin Down function using the A&R bits of the ADMIN_STATUS object. However, UNI 1.0r2 and E-NNI 1.0 do not support the Admin Down function. Additionally, a UNI-N may initiate deletion procedures by setting the A&R bits in a Path or Resv message to its associated UNI-C. If this occurs, the UNI-C will continue the deletion procedure by reflecting the ADMIN_STATUS object in the corresponding Resv or Path message, but clear the A-bit and set the D-bit. The consequence is that if an ADMIN_STATUS object with A&R bits set arrives at a interworking point between an RFC 3473 domain and either UNI or E-NNI, it should not be forwarded to the UNI or E-NNI; if it is forwarded, the result will be a connection deletion procedure, rather than a change of the connection to the Admin Down state.
- If the Generalized UNI object is not present at an interworking point and it is necessary to create sub-objects within the Generalized UNI object, it may not be possible to ensure interworking (see **Rule 17** and **Rule 18**.)

4 Conclusion

While some aspects of discussions between ITU-T/OIF and the IETF arise from a need for more understanding of transport network infrastructures and their differences from packet networks, the most challenging discussion areas have revolved around aspects of the classical Internet architecture. Examples of such areas, which are the root cause of the remaining differences in signaling protocol details discussed earlier, include aspects related to a more complex interpretation of the classical Internet end-to-end principle, assumptions regarding sharing of address spaces, and “overloading” of IP addresses (location and identity).

However, the extensive work efforts since 2000 among participants from ITU-T, OIF, and IETF has resulted in a remarkable degree of commonality among control plane signaling protocols. UNI1.0R2 and E-NNI procedures for GMPLS RSVP-TE use the same basic mechanisms as, and are intended to be compatible with, RFC 3473 when using RFC 3473 as an Internal Network-Network Interface (I-NNI) protocol. The IETF RFC 4208 and ITU-T/OIF UNI1.0R2 RSVP protocols are virtually identical, except for assumptions related to shared GMPLS address space and single end-to-end session, and supplementary service capabilities related to edge-node reachability information exchange. There are currently active communications, and liaisons, between ITU-T SG 15 and IETF, in which information is being shared regarding evolution of new requirements and capabilities, and possible solutions for such.

Aided by the tremendous degree of commonality among signaling protocols, differences are readily bridgeable via pragmatic interworking solutions, which have been detailed in this document. And facilitated by a common understanding of business and operational drivers, with cooperation, it should be possible to ultimately establish common protocol mechanisms for common features amongst ITU-T/OIF and IETF.

5 References

OIF inter-domain control plane interface specifications

- [UNI 1.0R2] Signaling Specification, Release 2:
  - OIF-UNI-01.0-R2-Common - User Network Interface (UNI) 1.0 Signaling Specification, Release 2: Common Part
  - OIF-UNI-01.0-R2-RSVP - RSVP Extensions for User Network Interface (UNI) 1.0 Signaling, Release 2
- [E-NNI SIG] OIF-E-NNI-Sig-01.0 - Intra-Carrier E-NNI Signaling Specification
- [oif2007.351] Signaling Interworking Cookbook Example for OIF UNI and RFC 4208 GMPLS UNI based on the Kei-han-na Open Lab's implementation

ASON standards

- [G.8080] Architecture for ASON
- [G.7713] Distributed Connection Management
- [G.7713.1] DCM based on PNNI
- [G.7713.2] DCM based on RSVP-TE
- [G.7713.3] DCM based on CR-LDP

IETF standards

- [RFC 2205] Resource ReSerVation Protocol (RSVP) -- Version 1 Functional Specification
- [RFC 2961] RSVP Refresh Overhead Reduction Extensions
- [RFC 3209] RSVP-TE: Extensions to RSVP for LSP Tunnels
- [RFC 3471] Generalized Multi-Protocol Label Switching (GMPLS) Signaling, Functional Description
- [RFC 3473] Generalized Multi-Protocol Label Switching (GMPLS) Signaling, Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions
- [RFC 3474] Documentation of IANA assignments for Generalized Multi-Protocol Label Switching (GMPLS) Resource Reservation Protocol – Traffic Engineering (RSVP-TE) Usage and Extensions for Automatically Switched Optical Network (ASON)
- [RFC 3476] Documentation of IANA Assignments for Label Distribution Protocol (LDP), Resource Reservation Protocol (RSVP), and Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Extensions for Optical UNI Signaling
- [RFC 3477] Signalling Unnumbered Links in Resource ReSerVation Protocol - Traffic Engineering (RSVP-TE)
- [RFC 3945] Generalized Multi-Protocol Label Switching (GMPLS) Architecture
- [RFC 4003] GMPLS Signaling Procedure for Egress Control
- [RFC 4208] Generalized Multi-Protocol Label Switching (GMPLS) User-Network Interface (UNI): Resource Reservation Protocol-Traffic Engineering (RSVP-TE) Support for the Overlay Model
- [RFC 4258] Requirements for Generalized Multi-Protocol Label Switching (GMPLS) Routing for the Automatically Switched Optical Network (ASON).
- [RFC 4397] Igor Bryskin, Adrian Farrel: A Lexicography for the Interpretation of Generalized Multiprotocol Label Switching (GMPLS) Terminology within The Context of the ITU-T's Automatically Switched Optical Network (ASON) Architecture
- [RFC4606] Generalized Multi-Protocol Label Switching (GMPLS) Extensions for Synchronous Optical Network (SONET) and Synchronous Digital Hierarchy (SDH) Control
- [RFC 4974] Generalized MPLS (GMPLS) RSVP-TE Signaling Extensions in Support of Calls
- [RFC 5150] Label Switched Path Stitching with Generalized Multiprotocol Label Switching Traffic Engineering (GMPLS TE)

Implementations of ASON-GMPLS inter-domain interworking

- [KDDI-Hayashi] Michiaki Hayashi et al.: Peer/overlay hybrid optical network using protocol gateways of GMPLS and OIF-UNI/NNI, OFC2005, paper OThP2

- [KDDI Otani] Tomohiro Otani: ASON – GMPLS interworking – practical implementation of interoperable solutions, ECOC2005 Workshop on Interoperability topics in Next Generation Transport Networks, presentation: www.ist-mupbed.org
- [Alcatel-Jones] Jim Jones et al: Alcatel presentation at the OIF Worldwide Interoperability Demonstration SUPERCOMM 2005, www.oiforum.com/public/downloads/Alcatel-05.pdf
- [Japan-Okamoto] Satoru Okamoto et al.: Field Trial of Signaling Interworking of Multi-carrier ASON/GMPLS Network Domains, OFC/NFOEC2006, post deadline paper PD47

6 Appendix A - First Implementation Examples of ASON-GMPLS Domain Interworking

In the following sections contain short descriptions of already existing pragmatic ASON-GMPLS interworking solutions enabling seamless interoperability among ASON and GMPLS domains.

6.1 ASON-GMPLS inter-domain interworking demonstration using protocol gate ways at KDDI R&D Laboratories

Peer/overlay hybrid optical networks with protocol gateways of GMPLS and OIF-UNI/E-NNI were demonstrated for the first time. UNI connections were successfully established over a single TDM/photonic GMPLS domain as well as ASON, E-NNI-1.0 interconnected multiple domains [KDDI-Hayashi, KDDI-Otani]. A GMPLS-based domain (domain-1) controlled by GMPLS RSVP-TE and OSPF-TE was configured with two PXCs and two ADMs, and ADM 1-1 and ADM 1-2 accommodated TDM-based UNI client equipment (UNI-C1-1) and an OC-3 soft permanent connection (SPC) termination point, as shown in **Figure 7**. The domain-1 was connected with two other domains at two protocol gateways implementing both GMPLS/UNI and GMPLS/E-NNI gateway functions. To abstract the topology of domain-1, a FA-LSP between ADMs was initiated by ADM1-1, and then the policy of advertisement was manually inputted from management software to abstract domain-1 based on the FA-LSP. Domain-2 and 3 consisted of two control plane-based ADMs. In the two attached domains, ADM2-1 and ADM3-2 accommodated UNI-C equipment and an OC-3 SPC termination point. Each domain was connected with OC-48-based E-NNI links terminated by E-NNI protocol speakers at both edges. Over the E-NNI interfaces, link state updates based on abstracted topologies and resource reservation requests were messaged with an OSPF-based E-NNI routing and a RSVP-based signaling protocols, respectively. Using protocol gateways of GMPLS and OIF-UNI/NNI with an FA-based GMPLS topology abstraction scheme, a TDM/photonic GMPLS-based peer network and OIF-UNI/NNI-based overlay networks have been successfully cooperated in a multi-domain environment.

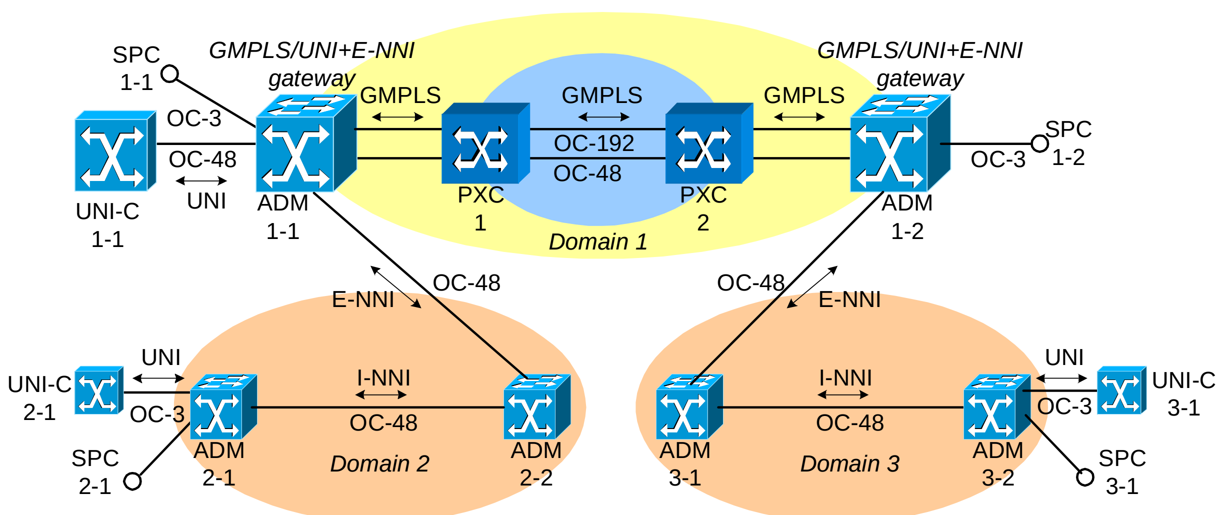


Figure 7: Multi-domain ASON – GMPLS network topology including protocol gateway functions between GMPLS domain and UNI1.0R2 & E-NNI interfaces

6.2 ASON-GMPLS inter-domain interworking demonstration from Alcatel

This multi-node, single vendor domain shown in **Figure 8** supported RFC 3473 I-NNI signaling, routing and discovery, while supporting both OIF UNI-N signaling and E-NNI signaling/routing in the border nodes [Alcatel-Jones]. In addition it supported the multi-layer control plane aspects demonstrated in this event. The implementation demonstrated has applicability to Use Case 6 from **Figure 5** and Use Cases 1, 2, 6 and 10 from **Figure 6**. Due to the large similarity of the OIF UNI 1.0r2, OIF E-NNI 1.0 and RFC 3473 signaling, each function can be realized by invoking instances of RSVP from a common base, with minor differences to differentiate each function. In addition, each RSVP instance should either discover or be configured as to which role it performs. This can provide important coupling between link discovery, signaling and routing functions at each node. In the

OIF Worldwide Interoperability Demonstration 2005, specific objects supporting OIF UNI 1.0r2 and OIF E-NNI 1.0 signaling (i.e. G_UNI and CALL_ID) were opaquely forwarded by the RFC 3473 I-NNI signaling due to the C-type values of these objects. The session paradigm described in Section **2.2** was followed, utilizing LSP stitching with separate RSVP sessions between the different UNI, E-NNI and I-NNI reference point combinations. Objects and messages that had to be examined and/or modified at the boundary between I-NNI and UNI-N/E-NNI points included the Session, SenderTemplate, ERO, and G_UNI. The Session and SenderTemplate are recreated for each RSVP session. The ERO is used to determine the next type of RSVP session is to be instantiated. The G_UNI is examined to obtain the protection/restoration mechanism to be employed within the domain based on the ServiceLevel subobject. The TNA to transport node address mapping relies on the OIF extension to OSPF (i.e. TNA Address TLV) which is not yet recognized by the IETF.

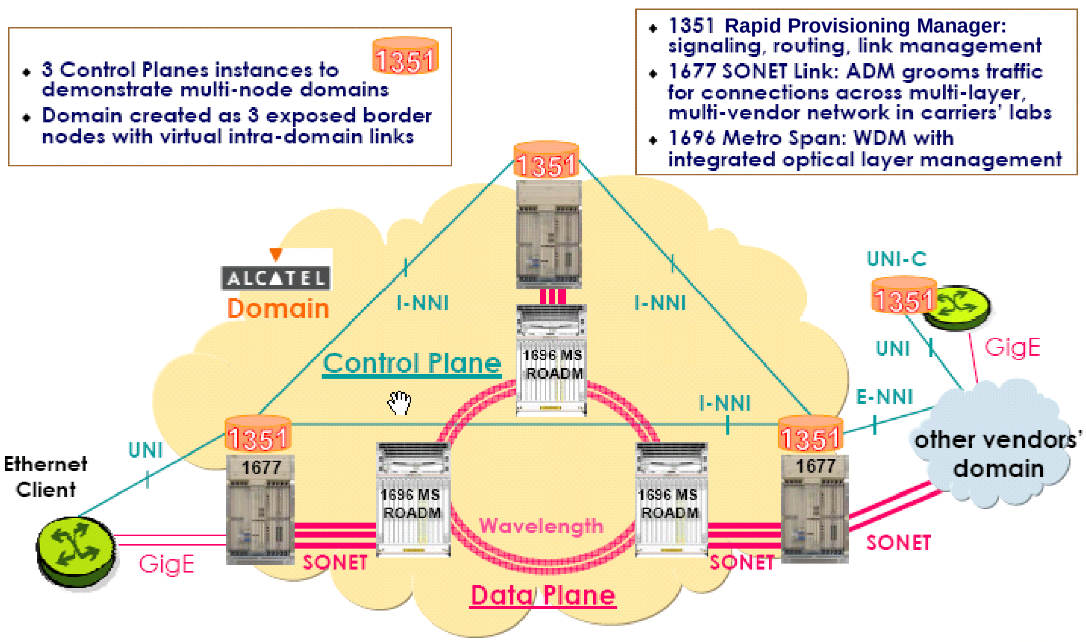


Figure 8: Alcatel Multi-domain client – RFC 3473 – OIF E-NNI 1.0 - OIF UNI 1.0r2 network topology at Verizon during the OIF Worldwide Interoperability Demonstration 2005

6.3 Kei-han-na Info-Communication Open Laboratory Interoperability Working Group

This experimental demonstration covers the multi domain interworking scenario composed of two GMPLS domains which are interconnected by an ASON E-NNI. This setup was demonstrated at the exhibition of the MPLS2005 conference Oct. 2005 in Washington D.C. It was a joint research work of NTT, KDDI Labs., NEC, Mitsubishi Electric., Fujitsu Labs, Keio University, and the National Institute of Information and Communications Technologies (NICT).

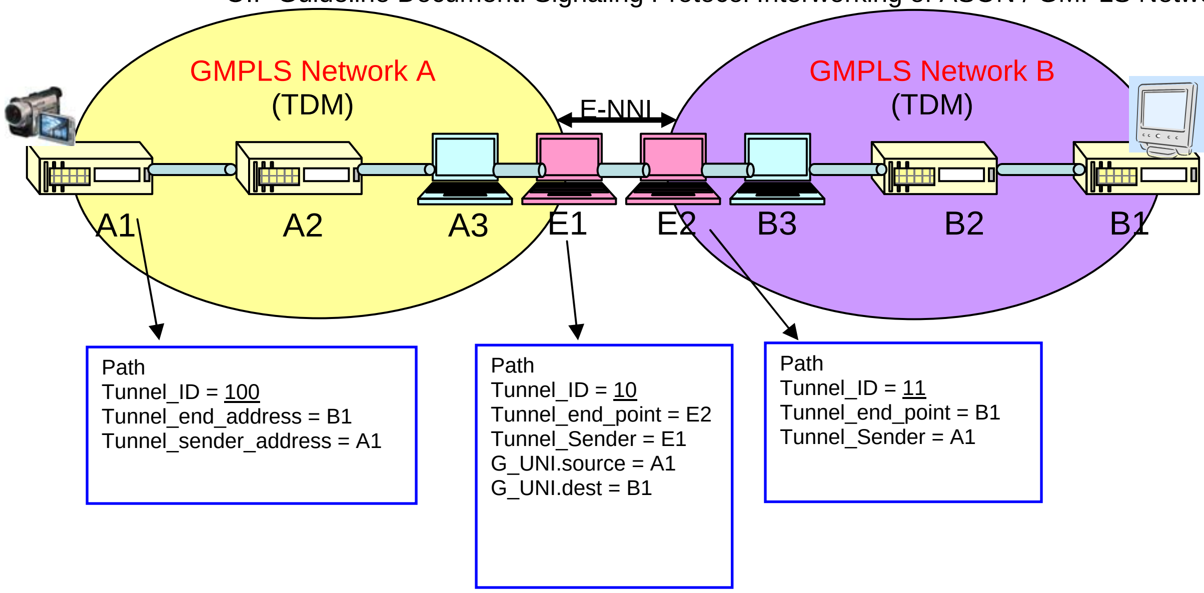


Figure 9: Multi-domain GMPLS – ASON E-NNI - GMPLS network topology

In the following the sequences for connection setup are listed:

- The ingress node A1 sends RFC3743 RSVP Path message to the egress node B1.
- E-NNI node E1 generates ASON E-NNI RSVP Path message to E2.
- E-NNI node E2 generates RFC3743 RSVP Path message from the G_UNI object.
- Same mechanism is applied to Resv messages.
- STM-16 Link is set up between A1 and B1, video data could be displayed.

Successfully demonstrated connection configuration scenarios were:

- Setup from A1 and tear down from A1.
- Setup from A1 and tear down from B1.

A next major step towards ASON-GMPLS domain interworking was achieved in Japan (**Figure 10**, **Figure 11**), coordinated by the Kei-han-na Info-Communication Open Laboratory, by demonstrating ASON E-NNI based interworking among 7 network domains, 5 of them GMPLS and two ASON based [Japan-Okamoto].

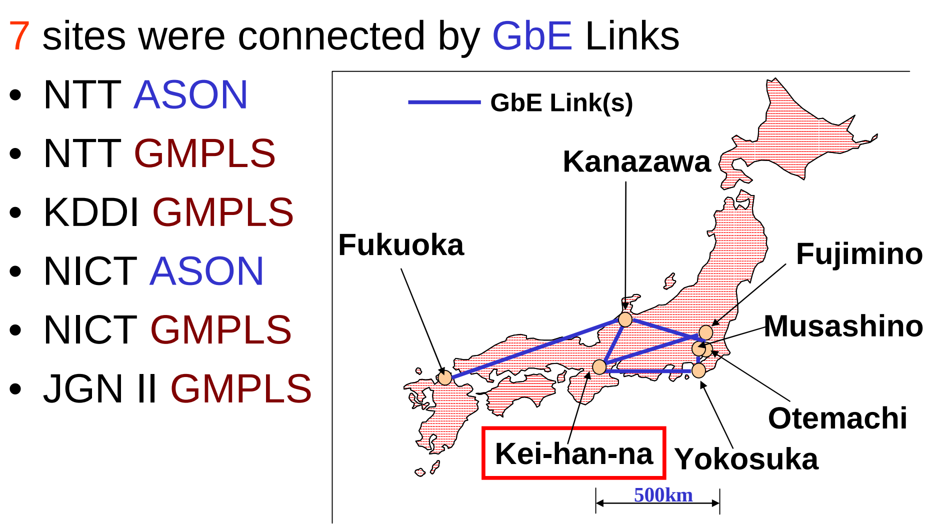


Figure 10: Overview of the Japanese national field trial and the involved sites

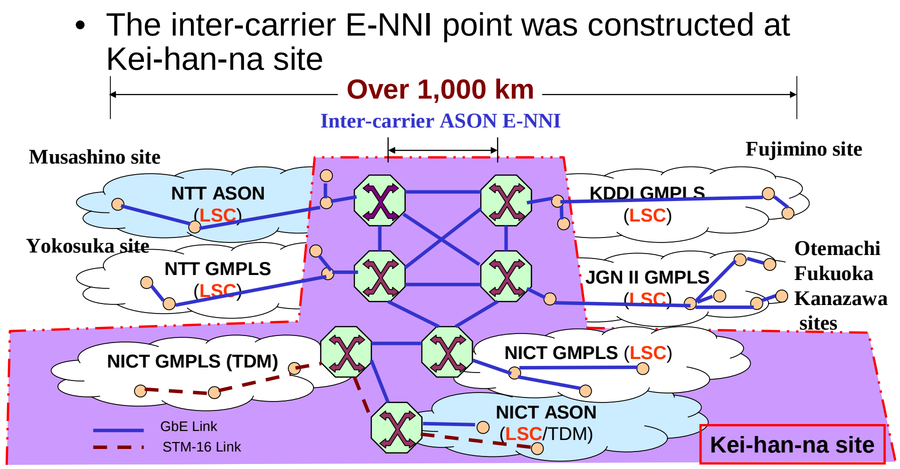


Figure 11: Topology of the multi-domain field trial

6.4 ASON-GMPLS domain interworking experiment at Telecom Italia

The test bed is based on a GMPLS network made up by six Optical Cross Connects (OXCs) with Fiber Switching Capability (FSC) provided by Telecom Italia and two SDH client equipment provided by Siemens (**Figure 12**).

The OXC network is based on the control plane architecture specified in Rec. ITU-T G.8080 and the GMPLS signaling specified in IETF RFC 3471 and RFC 3473. Control Plane is distributed on each node. SCN is based on a point-to-point Fast Ethernet network. On the client side, interworking occurs by OIF UNI1.0 R2.

A single instance of the RSVP protocol is able to manage all different interfaces (UNI-N, I-NNI). The GENERALIZED_UNI Object is transparently forwarded by I-NNI GMPLS signaling exploiting the specific class number adopted. Separate RSVP sessions are used between the different UNI and I-NNI reference points and the related LSPs are stitched together.

The SESSION Object, the SENDER_TEMPLATE Object and the GENERALIZED_UNI Object are used to determine if ASON/GMPLS gateway functionality need to be invocated for signaling adaptation.

Every node hosting UNI interfaces advertises its TNAs by OSPF extension proposed by OIF (i.e. TNA Address TLV).

The experiment successfully demonstrated interworking between UNI1.0R2 equipped nodes and GMPLS domain.

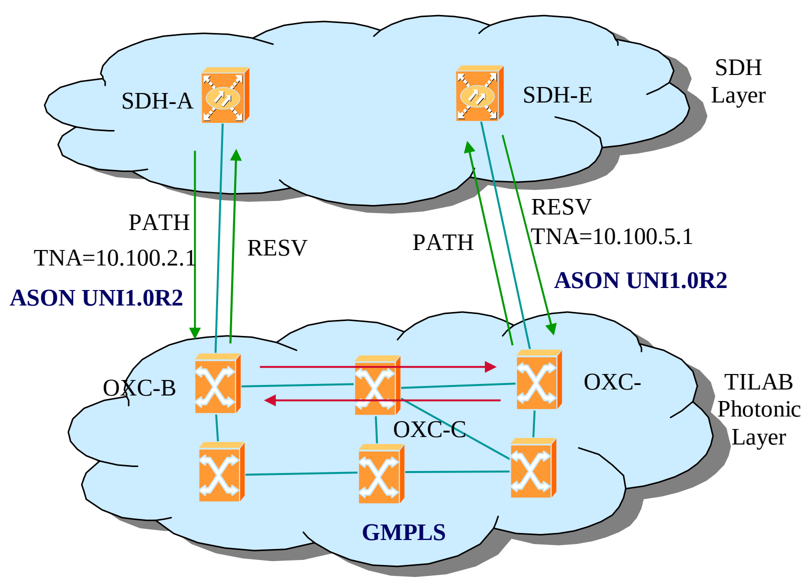


Figure 12: Multi-domain ASON-GMPLS-ASON network topology at Telecom Italia

7

Appendix B: List of companies belonging to OIF when document is approved

ADVA Optical Networking
Alcatel-Lucent
Altera
AMCC
Analog Devices
Anritsu
AT&T
Avago Technologies Inc.
Avalon Microelectronics
Avanex Corporation
Bookham
Broadcom
BT
China Telecom
Ciena Corporation
Cisco Systems
ClariPhy Communications
CoreOptics
Cortina Systems
Data Connection
Department of Defense
Deutsche Telekom
Emcore
Ericsson
Finisar Corporation
Flextronics
Force 10 Networks
France Telecom
Freescale Semiconductor
Fujitsu
Furukawa Electric Japan
Huawei Technologies
IBM Corporation
IDT
Infinera
IP Infusion
JDSU
KDDI R&D Laboratories
Level 3 Communications
LSI Logic
Marben Products
MergeOptics GmbH
Mintera
MITRE Corporation
Mitsubishi Electric Corporation

Molex
Music Semiconductors
NEC
NeoPhotonics
Nokia Siemens Networks
Nortel Networks
NTT Corporation
Opnext
PMC Sierra
Sandia National Laboratories
Santur
Sierra Monolithics
Silicon Logic Engineering
Soapstone Networks
Sycamore Networks
Syntune
Tektronix
Telcordia Technologies
Telecom Italia Lab
Tellabs
Texas Instruments
Time Warner Cable
Tyco Electronics
Verizon
Vitesse Semiconductor
Yokogawa Electric Corporation
ZTE Corporation