ATM – MPLS Network Interworking
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Topics

- Introduction to ATM–MPLS Interworking
- Encapsulation Formats
- Interworking Procedures
- Other Technical Issues
- Future Work
- Summary
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ATM–MPLS–ATM Reference Diagram (Network Interworking)

“INE” = Interworking Network Element
MPLS–ATM-MPLS Reference Diagram (Network Interworking)

“INE” = Interworking Network Element
ATM–MPLS Reference Diagram (Service Interworking)

ATM Network

MPLS Network

“INE” = Interworking Network Element
ATM Forum Specifications

- The ATM Forum is specifying methods for ATM-MPLS interworking:
  - Addresses future co-existence of ATM & MPLS technologies within networks.
  - First fruits: AF-AIC-0178.000
  - Ambitious follow-on plan
Requirements

- Initial ATM Forum specification focuses on *user plane* aspects of ATM-MPLS-ATM network interworking:
  - Multiple ATM VCCs and/or VPCs within a MPLS LSP,
  - Support ATM traffic contracts and QoS,
  - Transport all AAL types,
  - Transport OAM and RM cells,
  - Transport single or multiple ATM cells within a single MPLS frame, and
  - Provide transparency to ATM cells.
ATM Cells to/from MPLS Frames

ATM Network

MPLS Network

ATM Network

INE

INE

LSP

= user cells from VC #1
= user cells from VC #2
= user cells from VC #3
= OAM cells
Topics

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ATM Cell Format

Fixed-length cells are used to transport data, voice, and video inside ATM networks.

<table>
<thead>
<tr>
<th></th>
<th>GFC</th>
<th>VPI</th>
<th>VCI</th>
<th>VCI</th>
<th>PTI</th>
<th>CLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM cell</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>payload</td>
<td>(48</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>octets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **GFC**: Generic Flow Control
- **VPI**: Virtual Path Identifier
- **VCI**: Virtual Channel Identifier
- **PTI**: Payload Type Identifier
- **CLP**: Class of Service
- **HEC**: Header Error Control
- **ATM cell payload**: (48 octets)
**AAL-5 PDU Frame Format**

Variable-length AAL-5 frames are segmented into cells for transport across ATM networks.

<table>
<thead>
<tr>
<th>Bit Position</th>
<th>Description</th>
<th>Octets</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Payload</td>
<td>1 – 65,535 octets</td>
</tr>
<tr>
<td>7</td>
<td>Pad</td>
<td>0 - 47 octets</td>
</tr>
<tr>
<td>6</td>
<td>UU</td>
<td>1 octet</td>
</tr>
<tr>
<td>5</td>
<td>CPI</td>
<td>1 octet</td>
</tr>
<tr>
<td>4</td>
<td>Length</td>
<td>2 octets</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CRC** (4 octets)
MPLS Frame Format

Variable-length frames are used to transport data, voice, and video inside MPLS networks.

<table>
<thead>
<tr>
<th>Label (20 bits)</th>
<th>Exp (3 bits)</th>
<th>Stack (1 bit)</th>
<th>TTL (8 bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label (20 bits)</td>
<td>Exp (3 bits)</td>
<td>Stack (1 bit)</td>
<td>TTL (8 bits)</td>
</tr>
<tr>
<td>Payload</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ATM-MPLS-ATM Encapsulation Modes

- Single Cell Mode - mandatory
  - Each MPLS frame contains a single ATM cell
- Concatenated Cell Mode - optional
  - More efficient than single cell mode
- Frame Mode - optional
  - Most efficient of all modes
  - No support for AAL types 1, 2, 3, and 4
  - Loss of ATM cell header transparency
# Single Cell Mode

<table>
<thead>
<tr>
<th></th>
<th>MPLS Transport Label (4 octets)</th>
<th>Interworking Label (4 octets)</th>
<th>Mode</th>
<th>VCIP</th>
<th>reserved</th>
<th>PTI</th>
<th>CLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>VCIC (2 octets, if present)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>ATM cell payload (48 octets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Concatenated Cell Mode

<table>
<thead>
<tr>
<th></th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPLS Transport Label</td>
<td>(4 octets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interworking Label</td>
<td>(4 octets)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode</th>
<th>VCIP</th>
<th>reserved</th>
<th>PTI</th>
<th>CLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCI (2 octets, if present)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ATM cell payload</th>
<th>(48 octets)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCI (2 octets, if present)</td>
<td></td>
</tr>
<tr>
<td>ATM cell payload</td>
<td>(48 octets)</td>
</tr>
</tbody>
</table>
### Frame Mode

<table>
<thead>
<tr>
<th>Mode</th>
<th>VCIP</th>
<th>reserved</th>
<th>FRAG</th>
<th>EFCI</th>
<th>CLP</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCI</td>
<td></td>
<td>(2 octets, if present)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **MPLS Transport Label** (4 octets)
- **Interworking Label** (4 octets)

**AAL-5 PDU fragment** (multiple of 48 octets)

**Fragment Options:**
1. Complete AAL-5 PDU
2. Start of AAL-5 PDU
3. Middle of AAL-5 PDU
4. End of AAL-5 PDU
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“Transport” & “Interworking” Labels

- A transport label identifies an MPLS transport LSP.
- An interworking label identifies an interworking LSP.
Interworking Label Context

- An interworking label is associated with the following ATM connection parameters:
  - Connection type (i.e. VCC or VPC),
  - VPI of the ATM cell header,
  - VCI of the ATM cell header (VCC only), and
  - Perhaps other parameters.
ATM to MPLS Cell Mode Procedures

- An INE performs the following to convert ATM cells to MPLS frames (cell mode only):
  - The VPI and VCI are translated into an interworking label (VPC case uses only VPI).
  - For a VPC, the VCI is carried within the frame.
  - The PTI and CLP are carried within the frame.
MPLS to ATM Cell Mode Procedures

- An INE performs the following to convert MPLS frames to ATM cells (cell mode only):
  - The interworking label is translated to the VPI and VCI (VPC case results in only VPI).
  - For a VPC, the VCI is copied from the frame.
  - The PTI and CLP are copied from the frame.
ATM to MPLS Frame Mode Procedures

- An INE performs the following to convert ATM cells to MPLS frames (frame mode):
  - As ATM cells are received, they are reassembled into an AAL-5 PDU.
  - The VPI and VCI fields are handled in the same manner as cell mode.
  - The EFCI field (within frame) is set according to the most recently received ATM cell.
  - The CLP field (within frame) is set if any constituent ATM cells had their CLP field set.
  - The AAL-5 PDU may be fragmented.
MPLS to ATM Frame Mode Procedures

- An INE performs the following to convert MPLS frames to ATM cells (frame mode):
  - The AAL-5 PDU may arrive in several fragments.
  - The VPI and VCI fields are handled in the same manner as cell mode.
  - The EFCI field (within frame) is copied to all ATM cells.
  - The CLP field (within frame) is copied to all ATM cells.
  - The AAL-5 PDU is segmented into ATM cells.
Fragmentation

- Fragmentation applies only to frame mode.
- Common reasons for fragmentation:
  - An OAM cell arrives while an AAL-5 PDU is being reassembled
  - The AAL-5 PDU exceeds the MPLS MTU
  - To bound ATM cell delay
- Fragmentation is always performed on 48-octet boundaries of the AAL-5 PDU.
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Transport of Control Plane Protocols

Control Plane virtual circuits include ILMI, Signaling, & PNNI RCC.
Control Plane Aspects

- An INE contains PNNI functionality.
- The MPLS Transport LSP appears as a physical link between two adjacent PNNI nodes.
  - Single hop, as viewed by PNNI routing algorithms
  - Role of PNNI routing remains the same as in a traditional ATM network.
  - MPLS LSRs ignorant of ILMI, Signaling, and PNNI protocols.
- During SVC setup, an interworking label is negotiated for each direction and bound to the VPI/VCI values.
Transparency Concerns

- MPLS does not guarantee FIFO delivery!
  - Version 1 of the ATM Forum spec assumes a “well designed” MPLS network.
  - Next version will add sequence numbers.
- MPLS QoS mechanisms are still evolving!
- MPLS frames can degrade cell loss ratio!
  - A single link bit error has a greater chance of corrupting an MPLS frame versus an ATM cell header.
- Both concatenated cell mode & frame mode increase cell delay!
- Frame mode does not preserve EFCI state & the CLP field for every ATM cell.
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Remaining Work Items

- ATM-MPLS-ATM Network Interworking:
  - Sequence numbers to preserve FIFO ordering
  - Control plane details
  - Management plane details
  - Mapping of ATM traffic classes & QoS requirements to MPLS mechanisms.
- MPLS-ATM-MPLS Network Interworking
- ATM-MPLS Service Interworking
Joint Work Effort with MPLS Forum

- ATM Forum and MPLS Forum are working together on ATM-MPLS interworking.
  - Joint Email exploder
  - Monthly teleconference calls
  - Invitations to each other’s meetings
- The goal is to produce identical technical specs for ATM-MPLS interworking.
Related Activities in Other Groups

- ITU-T (Q8/11)
- ITU-T (Q5/13)
- IETF PWE3 Working Group:
  - “Fischer Draft” is aligned with ATM Forum.
  - “Brayley Draft” is an evolution from the earlier “Martini Draft”.

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Summary

- The ATM Forum is engaged upon the task of specifying ATM-MPLS interworking.
- AF-AIC-0178.000 addresses user plane aspects of ATM-MPLS-ATM network interworking.
- Multiple ATM connections are carried over an MPLS LSP.
- Three encapsulation modes have been defined, providing trade-offs of efficiency versus complexity.
- Maintaining ATM cell transparency over an MPLS network is challenging.
- Other bodies (e.g. MPLS Forum, ITU-T, IETF) are also engaged in related work items.
- This tutorial is available at the ATM Forum’s web site (www.atmforum.com); click “Library”, then “Presentations”.


This concludes the presentation provided by The ATM Forum