TSN Explicit Route Installation: IS-IS or SRP

Rodney Cummings
National Instruments
TSN Assumptions (My Opinion)

- We don’t speak “service provider”
  - Local network (“customer” or “user”)
  - Loosely connected to Internet
- IETF & 802.1 ISIS-SPB technologies are useful, but
  - Translation is required; this presentation is an attempt
- Transition of existing time-sensitive Ethernet networks to 802.1 TSN will not increase cost or complexity
  - Example: Embed bridge chip in end-station
    - No additional CPU for bridge protocols (control plane)
    - Control-plane protocols use ~5-10% of existing CPU
  - Relative usage of each 802.1 bridge protocol is important
Path Computation Element (PCE)

- Some TSN features may be computationally complex
  - Explicit routes for redundancy (disjoint)
  - 802.1Qbv schedules
  - Network-wide latency analysis for credit-based shaper
- PCE concept = focus complexity where it is practical
  - Avoid complexity in all devices
  - PCE can be one device, or a few
  - PCE can be bridge, or end-station
  - For TSN, PCE can be talker or listener
# PCE Workflow for Explicit Routes

<table>
<thead>
<tr>
<th>Step</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implicit routes</td>
<td></td>
</tr>
<tr>
<td>2. PCE learns topology and metrics</td>
<td></td>
</tr>
<tr>
<td>3. PCE performs calculation</td>
<td></td>
</tr>
<tr>
<td>4. PCE installs explicit routes into IS (bridges / routers)</td>
<td></td>
</tr>
<tr>
<td>5. Bandwidth / stream reservation over explicit routes</td>
<td></td>
</tr>
</tbody>
</table>
# PCE Workflow for ER: IETF

<table>
<thead>
<tr>
<th>Step</th>
<th>Typical IETF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implicit routes</td>
<td>Mixed (IGP like IS-IS, or OSPF)</td>
</tr>
<tr>
<td>2. PCE learns topology and metrics</td>
<td>Mixed (ISIS-TE, OSPF-TE, …)</td>
</tr>
<tr>
<td>3. PCE performs calculation</td>
<td>(not standardized by IETF)</td>
</tr>
<tr>
<td>4. PCE installs explicit routes into IS (bridges / routers)</td>
<td>RSVP-TE</td>
</tr>
<tr>
<td>5. Bandwidth / stream reservation over explicit routes</td>
<td>DiffServ</td>
</tr>
</tbody>
</table>
## PCE Workflow for ER: IETF and TSN

<table>
<thead>
<tr>
<th>Step</th>
<th>Typical IETF</th>
<th>Proposal for TSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implicit routes</td>
<td>Mixed (IGP like IS-IS, or OSPF)</td>
<td>Mixed (STP like ISIS-SPB or MSTP)</td>
</tr>
<tr>
<td>2. PCE learns topology and metrics</td>
<td>Mixed (ISIS-TE, OSPF-TE, …)</td>
<td>802.1Qca (IS-IS)</td>
</tr>
<tr>
<td>3. PCE performs calculation</td>
<td>(not standardized by IETF)</td>
<td>(not standardized by 802.1)</td>
</tr>
<tr>
<td>4. PCE installs explicit routes into IS (bridges / routers)</td>
<td>RSVP-TE</td>
<td>Extensions to SRP (SRP-TE)</td>
</tr>
<tr>
<td>5. Bandwidth / stream reservation over explicit routes</td>
<td>DiffServ</td>
<td>SRP</td>
</tr>
</tbody>
</table>
Step 1: Implicit Routes

- TSN cannot mandate IS-IS computation everywhere
  - Contradicts the goals of the PCE concept
  - Adversely impacts adoption of TSN
- ISIS-SPB mixes well with MSTP today
  - Need to continue this mixed support for TSN
  - Also support mix with S2IS…
S2IS Is a Great Start

• S2IS meets many TSN requirements
  ✓ Avoids computation
  ✓ Bridge stores its own information only
  ✓ Solves step 2: PCE learns topology & metrics
  ✗ Limited to daisy-chain
    • Many TSN bridged end-stations require more than two external ports
    • Key point: TSN physical topologies are typically “engineered” (no loops)

• Reality check: Not all bridges run implicit routing
  • Many “Unmanaged” don’t run a Spanning Tree Protocol (STP)
    • Many of these bridges are used in time-sensitive applications today
    • S2IS could help transition these products into 802.1 visibility
Three Proposals to Improve S2IS

1. Allow > 2 “trunk” (external) ports
   - Same egress behavior as proposed for 2-port only
   - Assume end-user knows to avoid physical loops

2. Ring (802.1CB) requires one Full IS-IS bridge
   - Use full implicit routing to resolve intentional loops

3. 802.1Q PICS: Add S2IS as a routing option
   - 802.1Q-2011 requires one of: TMPR, RSTP, MSTP, SPB

   - We presumably need a new PAR for S2IS
     - Need a new name if no longer 2-port
Step 2: Learn Topology & Metrics

• TSN can mandate IS-IS distribution
  • Required as step 2 of PCE concept
    • Optional if PCE concept is not used (e.g. AVB Gen 1)
    • Optional for portions of network where PCE is not used
      ▪ Can run MSTP in those portions
  • Specify in a TSN (Gen 2) standard
    • Similar to 802.1BA
Steps 3 and 5

- Step 3: PCE Performs calculation
  - Inherently PCE-specific… no standard needed
- Step 5: Reservation
  - For TSN, consensus is SRP, as described in “Model 2” of
  - Non-TSN applications use IS-IS as alternative to SRP
    - Concept: PCE performs computation, bridge allocates bandwidth
      - 802.1Qca D0.4 has text for this; We may need 802.1Qcc text
  - For a new reader of 802.1, the direction should be clear
    - TSN (Gen 2) standard: TSN shall use SRP, not IS-IS
Remaining Slides:
Step 4,
PCE Installs Explicit Routes into IS
IETF Installation of Explicit Routes

• No proof-point for using link-state routing (IS-IS)
  • Assumed reason: Store explicit route only along its route
    • Not in every bridge and end-station
    • 802.1Qca D0.3 comment 61 disposition, with a minor edit:
      “Not every node needs to know the scheduling information explicit route of every other node. IS-IS seems to be not the perfect tool for the control of scheduling explicit routes.”

• Proof-point for using signaling: RSVP-TE
  • Explicit Routing Object (ERO): list of IP address per hop
  • Uses the RSVP signaling protocol for explicit routing
  • Doesn’t necessarily use RSVP reservation
    • DiffServ replaced IntServ (RSVP “Classic”)
Summary of RSVP-TE

• LSP_TUNNEL object contains
  • Destination IP address for session (stream)
  • Tunnel ID: MPLS label-switched path, below IP routing

• EXPLICIT_ROUTE object (ERO) contains a list of
  • Address (w/ Prefix Length): Address of router for this hop
  • L flag: Is this hop loose or strict?

• RECORD_ROUTE object (RRO): List of actual hops
  • Optional; Detect changes to route by PCE; Detect problems
TSN Addressing

- 802.1 TSN Gen 1 (AVB) uses multicast MAC addresses
- Talker uses multicast MAC address for destination (DA)
  - Analogous to destination IP address / tunnel ID of RSVP-TE
- Each bridge in hop installs DA for forwarding
  - No SPVID or MAC-in-MAC needed by SRP
- No strong argument to change this for TSN Gen 2
## Proposed ERO for TSN

<table>
<thead>
<tr>
<th>ERO:</th>
<th>Octet #</th>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-6</td>
<td>destination_address</td>
<td>Multicast MAC address of ERO; used to bind ERO to single stream</td>
</tr>
<tr>
<td></td>
<td>7-n</td>
<td>one or more ER_address</td>
<td>ER_address = MAC address &amp; flags</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ER_address:</th>
<th>Octet #</th>
<th>Name</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1, bit 0</td>
<td>loose</td>
<td>Loose hop (true) or strict (false)?</td>
</tr>
<tr>
<td></td>
<td>1, bit 1</td>
<td>start_of_ER_tree</td>
<td>True flags start of new ER_tree</td>
</tr>
<tr>
<td></td>
<td>1, bit 2</td>
<td>start_of_ER_path</td>
<td>True flags start of new ER_path</td>
</tr>
<tr>
<td></td>
<td>2-7</td>
<td>MAC_address</td>
<td>Talker, listener, or bridge System ID</td>
</tr>
</tbody>
</table>

- **ER_tree** = multicast route from talker to listener(s)
  - One is typical; >1 when redundancy is required; List of ER_path

- **ER_path** = route from talker to a single listener
Propagation with MSRP

- Use SRP as the signaling protocol for ERO
  - Repeat idea from IETF: Re-use signaling protocol that works
  - SRP works, and we have an open PAR
    - This is not a proposal to literally use RSVP for 802.1 TSN
  - “SRP-TE” described in “Model 2” of
    

- New MSRP Attribute Type (e.g. 5): Explicit Route
  - Declare prior to Talker Advertise; DA binds to stream
  - Propagation follows MSRP’s context (all Bridge Ports)
    - Initial declaration from anywhere
    - Distinct from reservation
Attribute Value Storage with MSRP

- MRP apps store attribute values to detect changes
- For a bridge, what portion of ERO must be stored?
  - When my System ID is detected…
    - Preceding address tells me the ingress port
      - May be more than one if multiple trees
    - Following address tells me the egress port
      - May be more than one if multiple paths (multiple listeners)
      - I use egress ports to keep forwarding tables up to date
    - All other addresses in paths are irrelevant… no need to store
  - If my System ID is not detected…
    - I am not in the explicit route: Propagate but do not store
- Talker and listeners do not store ERO… route obvious
Record Route (RRO) for TSN?

• When loose hops are used, loops can occur due to transients in implicit routing protocol
  • RSVP-TE RRO along explicit route: Each checks for loops
    • Bad for TSN: Computation everywhere; PCE may not be along route

• 802.1Qca (IS-IS distribution) can solve this for TSN
  • Explicit routes distribute back to PCE
  • PCE detects loop, and uninstalls (leaves) ERO

• Add “Explicit Route” boolean to Talker Advertise
  • Additional error check
  • If true, and ERO not installed, propagate Talker Failed
Comparison: Start with Toyota’s

Comparison: Start with Toyota’s


"unmanaged" S2IS with 4 external ports

Full IS-IS

Implicit route

Explicit routes

ECU: Electronic control unit, DLC: Diagnostic link connector
BES: Bridged end station (ECU), ES: End station (ECU)
Comparison: Subset for One Stream

- One ES is talker, all other ES shown are listener
Comparison: Subset for One Stream

- One ES is talker, all other ES shown are listener
Comparison: ERO w/ SRP

- BES stores only relevant ER_address (7 bytes each)
- BES near Talker: All trees same, 1 ingress, 2 egress
  - ERO = destination (6) + 7 + 14 = 27 bytes
- Each Domain Gateway stores 4 distinct trees
  - 1 ingress and 1 egress each tree
  - ERO = 6 + (4 * 14) = 62 bytes
- BES outside of this subset store nothing
- Total storage required for all ECUs: 335 bytes
  - 27 + (4 * 62) + (3 * 20)
Comparison: ERO w/ IS-IS

- Each talker, listener, and bridge stores same database
  - All EROs, each with all trees, each with all paths
- Path 1 = 21 bytes, path 2 = 35, path 3 = 42, path 4 = 42
- Tree 1 = 140 bytes, tree 2 = 154 (+14 for 2 extra hops), tree 3 = 147, tree 4 = 147
- Plus 6 bytes for destination = ERO of 594 bytes
- 13 ECUs are in explicit route, but 33 ECUs overall
  - Every ECU must store the ERO, even if not in the route
- Total storage required for all ECUs: 19602 bytes
  - 33 * 594; approximately 58 times more than SRP
# PCE Workflow for ER: (Repeat)

<table>
<thead>
<tr>
<th>Step</th>
<th>Typical IETF</th>
<th>Proposal for TSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implicit routes</td>
<td>Mixed (IGP like IS-IS, or OSPF)</td>
<td>Mixed (STP like ISIS-SPB or MSTP)</td>
</tr>
<tr>
<td>2. PCE learns topology and metrics</td>
<td>Mixed (ISIS-TE, OSPF-TE, …)</td>
<td>802.1Qca (IS-IS)</td>
</tr>
<tr>
<td>3. PCE performs calculation</td>
<td>(not standardized by IETF)</td>
<td>(not standardized by 802.1)</td>
</tr>
<tr>
<td>4. PCE installs explicit routes into IS (bridges / routers)</td>
<td>RSVP-TE</td>
<td>Extensions to SRP (SRP-TE)</td>
</tr>
<tr>
<td>5. Bandwidth / stream reservation over explicit routes</td>
<td>DiffServ</td>
<td>SRP</td>
</tr>
</tbody>
</table>