TSN Explicit Route Installation: IS-IS or SRP

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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

Step		
1. Implicit routes		
2. PCE learns topology and metrics		
3. PCE performs calculation		
4. PCE installs explicit routes into IS (bridges / routers)		
5. Bandwidth / stream reservation over explicit routes		

PCE Workflow for ER: IETF

Step	Typical IETF	
1. Implicit routes	Mixed (IGP like IS-IS, or OSPF)	
2. PCE learns topology and metrics	Mixed (ISIS-TE, OSPF-TE, …)	
3. PCE performs calculation	(not standardized by IETF)	
4. PCE installs explicit routes into IS (bridges / routers)	RSVP-TE	
5. Bandwidth / stream reservation over explicit routes	DiffServ	

PCE Workflow for ER: IETF and TSN

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

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

  http://www.ieee802.org/1/files/public/docs2013/new-iwk-nfinn-simple-isis-node-0713-v02.pdf

  ✓ 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
    - http://www.ieee802.org/1/files/public/docs2012/new-avb-anfredette-srp-spb-v02.pdf
  - 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

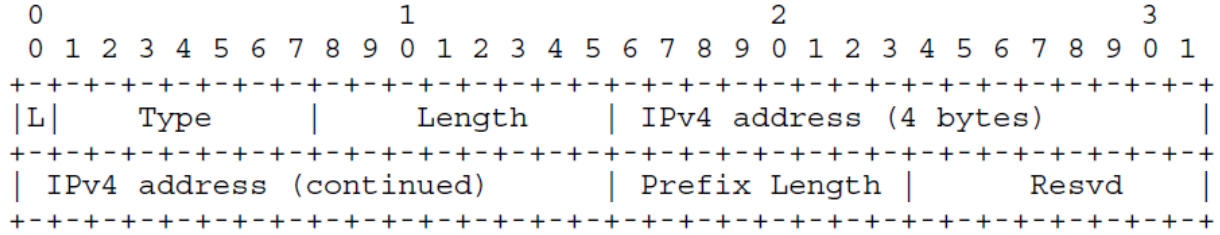
Remaining Slides:
Step 4,
PCE Installs Explicit Routes into IS

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

ERO:

Octet #	Name	Comment
1-6	destination_address	Multicast MAC address of ERO; used to bind ERO to single stream
7-n	one or more ER_address	ER_address = MAC address & flags

ER_ address:

Octet #	Name	Comment
1, bit 0	loose	Loose hop (true) or strict (false)?
1, bit 1	start_of_ER_tree	True flags start of new ER_tree
1, bit 2	start_of_ER_path	True flags start of new ER_path
2-7	MAC_address	Talker, listener, or bridge System ID

- 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
    http://www.ieee802.org/1/files/public/docs2012/new-avb-anfredette-srp-spb-v02.pdf
- 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

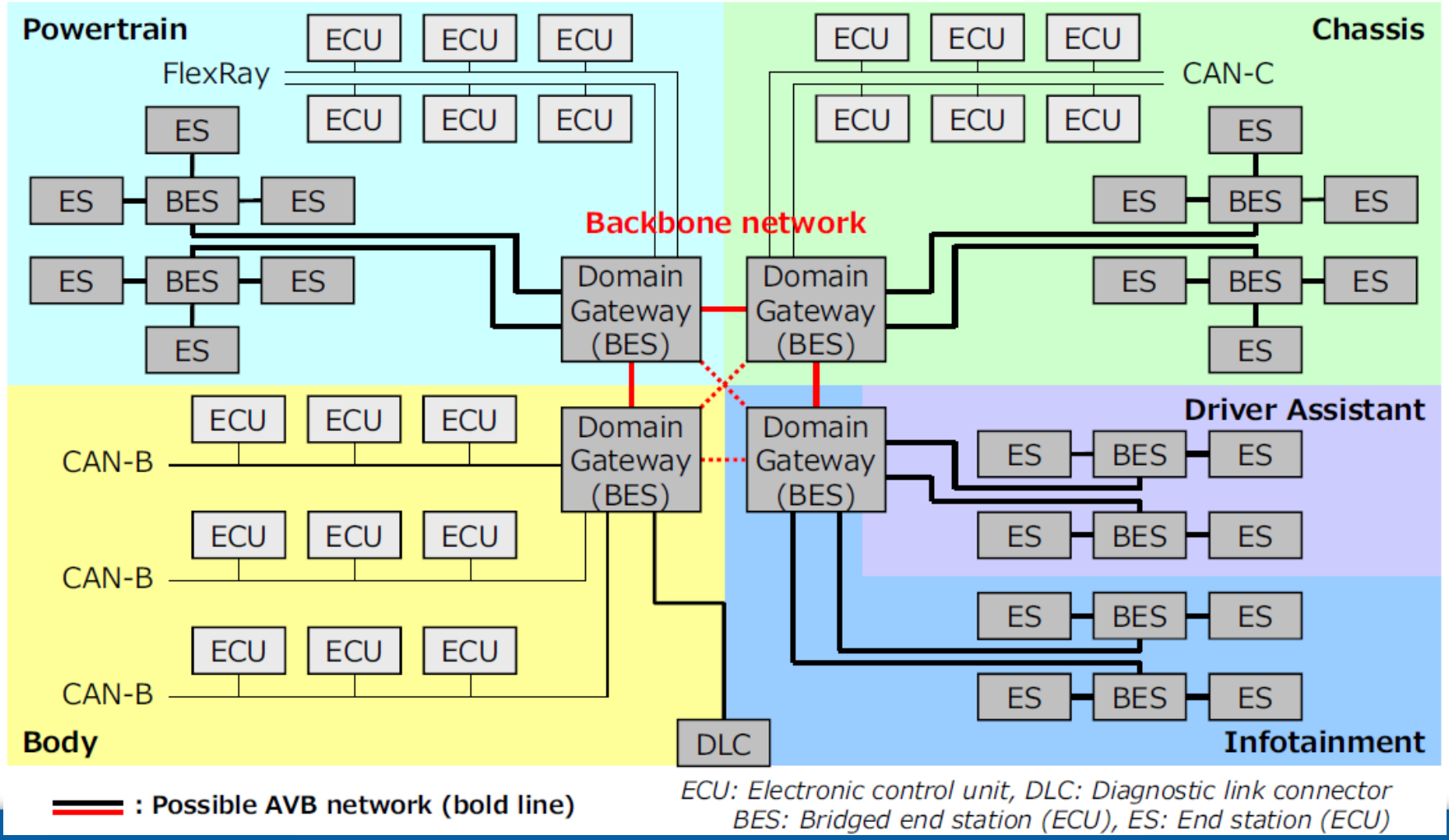
- MRP apps store attribute values to detect changes
- For a bridge, what portion of ERO must be stored?
  - When my System ID is detected…
    - Preceding address tells me the ingress port
      - May be more than one if multiple trees
    - Following address tells me the egress port
      - May be more 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

From http://www.ieee802.org/1/files/public/docs2011/new-avb-nakamura-automotive-backbone-requirements-0907-v02.pdf



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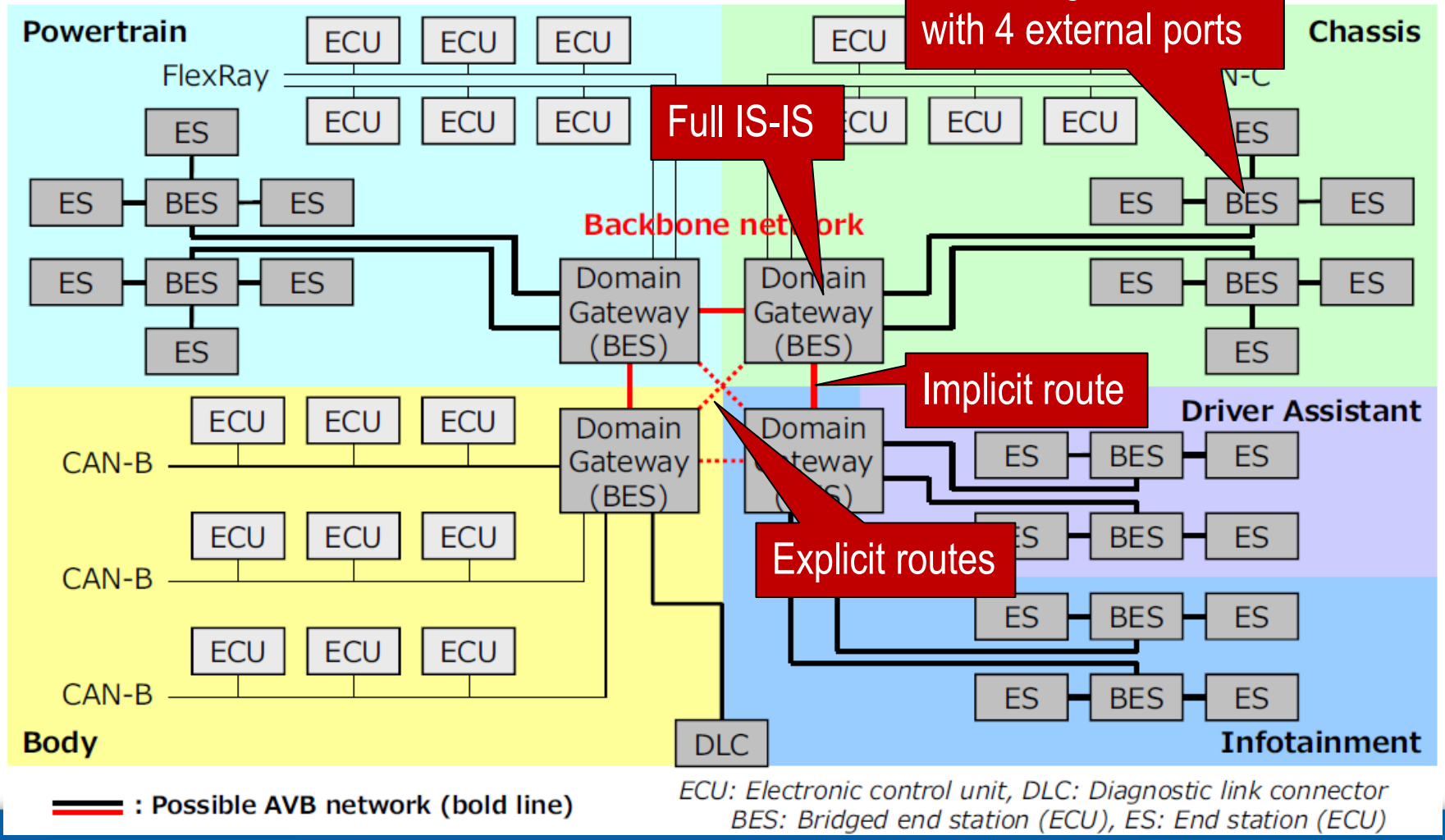
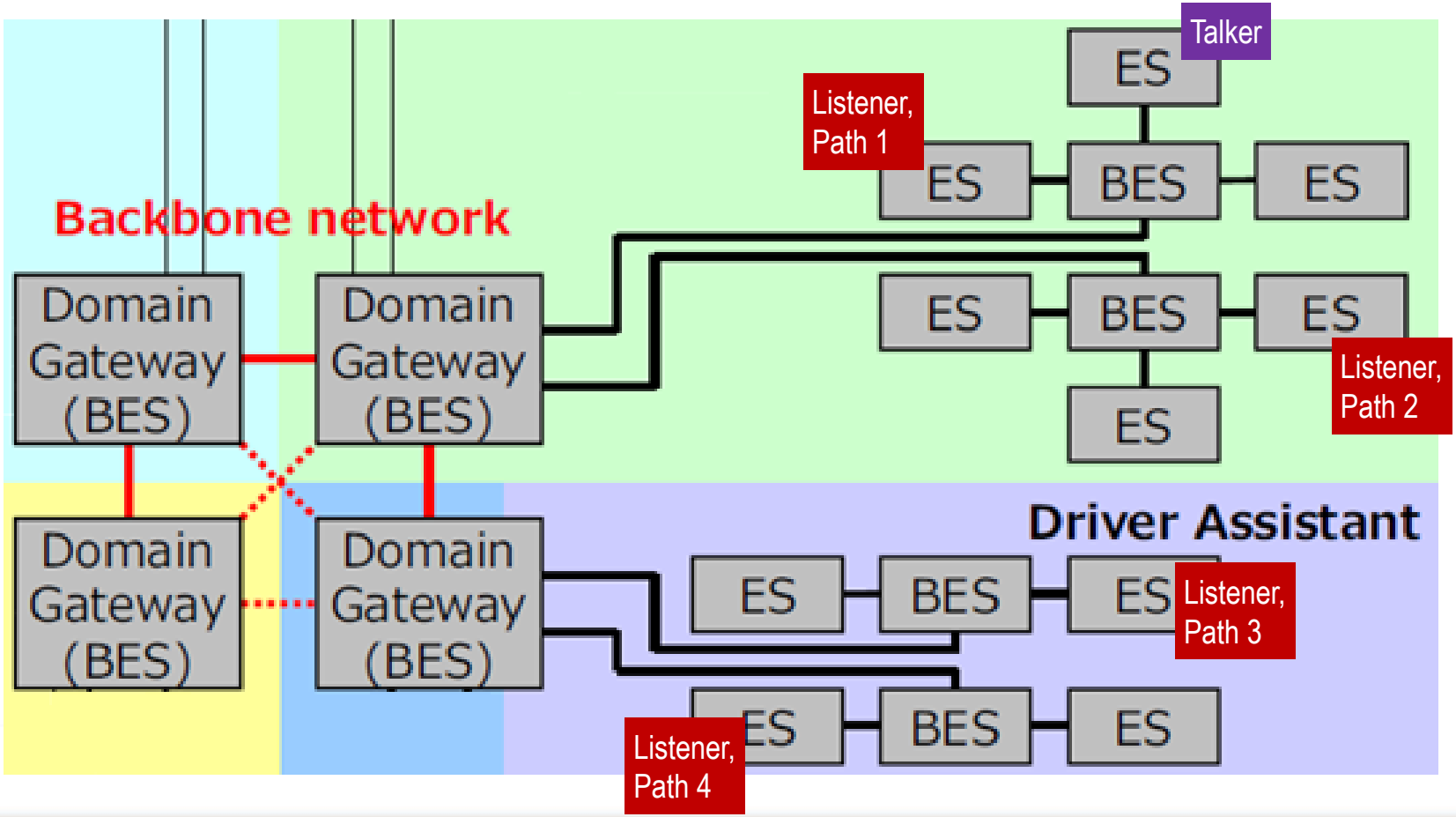


Comparison: Subset for One Stream

- One ES is talker, all other ES shown are listener



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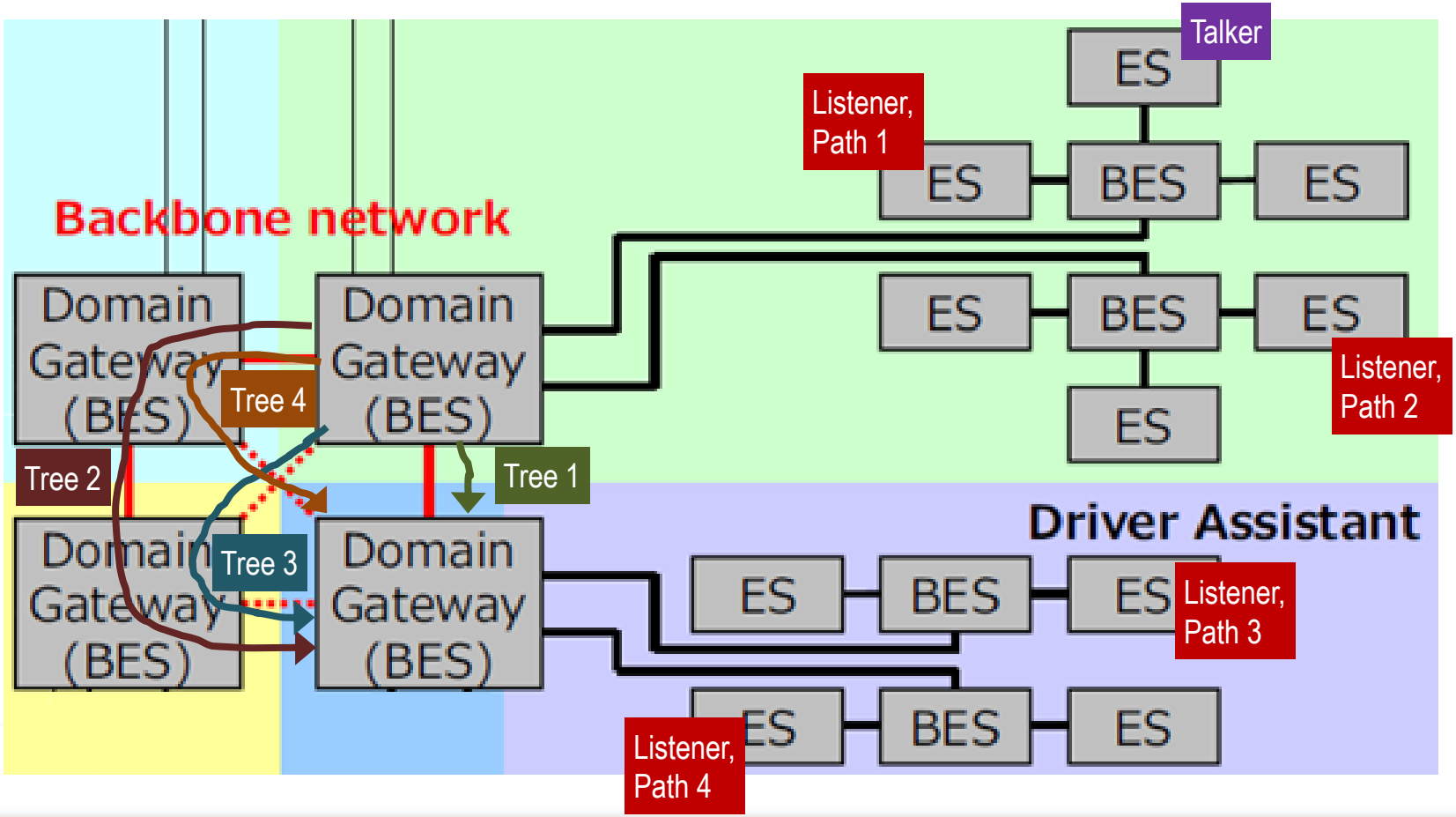

Comparison: ERO w/ SRP

- 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

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