802.1Qcc Explicit Scheduling

Rodney Cummings

National Instruments

Presentation Intro

- History
  1. Rationale for non-management protocol to distribute schedules (802.1Qbv); Proposal to use IS-IS
     - http://www.ieee802.org/1/files/public/docs2012/Qbv-cummings-dynamic-config-0712-v1.pdf
  2. Reject use of IS-IS to distribute schedules
     - Avoid memory footprint of global distribution
     - Comment 61 of http://ieee802.org/1/files/private/ca-drafts/d0/802-1Qca-d0-3-dis-v02.pdf
  3. Proposal to use SRP to distribute explicit routes
     - Avoid memory footprint of global distribution
     - http://www.ieee802.org/1/files/public/docs2013/new-tsn-cummings-explicit-routing-1113-v1.pdf
- Goal: Re-visit protocol to distribute schedules
  - Summarize rationale; Proposal to use SRP

PCE Workflow for Explicit Routes: (Repeat)

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

Typical Automotive Control: Flash

- Static
  - Topology does not change
- Network parameters are part of "system" specs
  - E.g. AUTOSAR system template
  - Work flow translates system to each hardware device (ECU)
    - E.g. FlexRay schedule translates to ECU's transmit/receive windows
- Network parameters integrated into ECU firmware
  - Network initialized from firmware (flash)
    - Up and running in less than 100 milliseconds
  - Protocols like SNMP, SRP, and IS-IS are not essential

Typical Industrial Control: Manager

- Dynamic, but engineered
- Computation in a “manager” device
  - Aka master, controller, …
- End devices are simple
  - Trust that manager will provide correct parameters
    - E.g. Limit on how far a robot arm can move
- Manager distributes parameters when system changes state
  - E.g. Controller changes from “program” to “run” state

MIB Fits Automotive Use Case

- 802.1 managed objects (MIB) map well to automotive
  - 802.1Q clauses 12 and 17 specify network parameters
  - Automotive standards can reference 802.1Q parameters for TSN
  - Parameter values contained in flash image of each hardware device
    - E.g. ECU with bridged end-station, standalone bridge, …
- SNMP is not needed

- Conclusion: 802.1Qbv should specify managed objects

PCE Fits Industrial Use Case

- Avoid complexity in end devices
  - PCE sets parameters in simple non-PCE devices
- For 802.1 parameters, 802.1 protocol is desired
  - Rather than each industrial higher-layer protocol
  - Enables “industrial switch” products
- Use of SNMP too slow
  - “Program” to “run” is expected to be fast

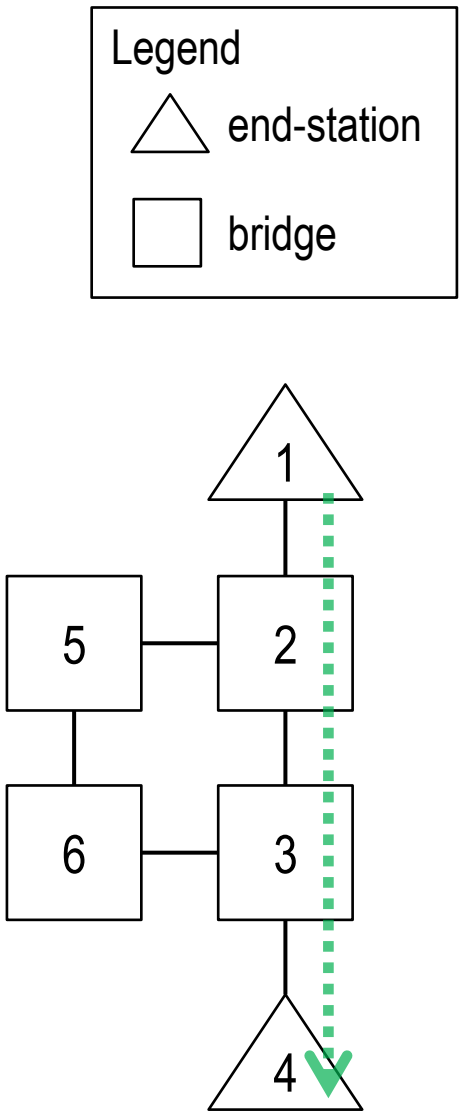
- Conclusion: Non-management protocol for 802.1Qbv

Compare Scheduling and Explicit Routing

- Similar
  - Parameters are explicit: Bound to each hop in route
    - Dynamic (implicit) routing like MSTP or IS-IS cannot apply
  - Parameters not bound to an individual TSN stream
    - >1 stream can use an explicit route, or a schedule window
  - PCE performs computations
    - Non-PCE devices trust parameters from PCE
  - Global distribution is inefficient for non-PCE devices
- Different
  - Explicit routing = Where, Explicit scheduling = When
  - For multi-window schedules, parameters can be larger

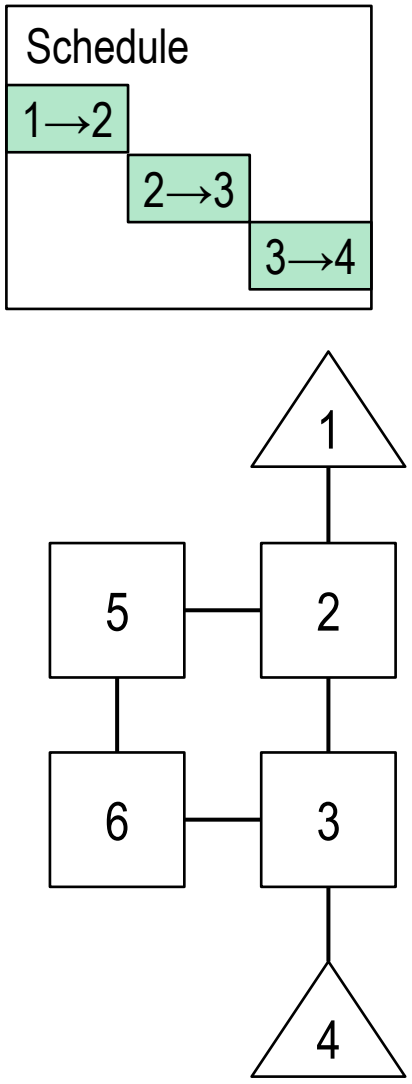
Example: Explicit Routing

- 1st PCE distributes ERO 1,2,3,4 for stream X
  - Where X is the data frame's identification (Dest MAC and/or VID)
- 2nd PCE distributes ERO 1,2,3,4 for stream Y
- Bridges do not return failure (e.g. "ERO already exists"); re-use the ERO for both X and Y



Example: Scheduling

- Schedule is bound to ERO 1,2,3,4
  - Hops must be strict
  - If link 2⟶3 faults, and route changes to 1,2,5,6,3,4 then schedule is broken
- 1st PCE distributes schedule for stream X
- 2nd PCE distributes same schedule for stream Y
- Bridges do not return failure; trust that PCEs coordinated X and Y



Proposal to use SRP for Explicit Scheduling

SRP Schedules: Protection Concept

- Scheduling in 802.1Qbv applies to all traffic classes
- For SRP, define concept of “protecting” an SR class with scheduling
  - When gate open for SR class, gates closed for all other classes (and vice versa)
- Assume only one SR class can be protected (SR class A or B, but not both)
  - Supporting both does not provide value
    - Any schedule that protects 2 priorities could use 1 priority instead
  - Simplifies SRP design
  - Management allows for more complex schedules

Scheduling in SRP Domain

- SRP Domain: consistency for all streams of an SR class
  - http://www.ieee802.org/1/files/public/docs2013/cc-cummings-configurable-sr-classes-1113-v1.pdf
- Add new boolean parameter: Scheduling Protection
  - This is not Transmission Selection; not a new shaper
  - When true, domain boundary where 802.1Qbv not supported
- Re-use domain's Observation Interval as the 802.1Qbv gating cycle
  - Assume all in domain use the same gating cycle
    - 99% use case
  - Simplifies SRP design
  - Management allows for more complex schedules

Relationship of Domain to Management

- If management is used for scheduling on a port, SRP domain boundary at that port if protection=true
  - Talker fails across boundary as usual
- Determination of “used” deferred to 802.1Qbv
  - List of gating events is non-empty?
  - At least one gating event is closed (not all open)?
  - Parameter specifies management versus SRP?

Schedule sub-TLV in ERO (1 of 2)

- Goal: 802.1Qcc (SRP) Explicit Route attribute will re-use ERO encoding from 802.1Qca (ISIS-PCR)
- Qca's "Explicit Path" (ERO) contains list of "EP Hop"
  - 45.1.7 and 45.1.8 of http://ieee802.org/1/files/private/ca-drafts/d0/802-1Qca-d0-5.pdf
  - Each EP Hop specifies a LAN (link between systems)
  - EP Hop itself contains sub-TLVs
    - E.g. Delay Constraint sub-TLV thus far
- Proposal: SRP specifies "Explicit Schedule" sub-TLV, contained in EP Hop
  - Provides the protected schedule for egress at that hop

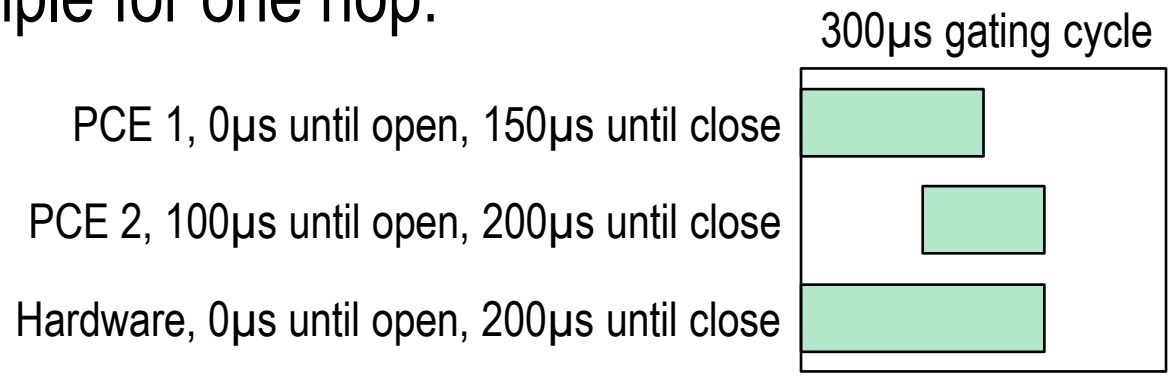
Schedule sub-TLV in ERO (2 of 2)

- Explicit Schedule sub-TLV is simply a list of tuples
  - SR Class Gate: boolean, 0=closed, 1=open
  - Time Interval: integer, change gate after this time elapses
- Open means to open egress for protected SR class, close all other traffic classes
- Close means to close SR class, open all others

- Q: How does bridge know the priority to open/close?
  - A: Explicit Path is bound to stream (Dest MAC and/or VID), stream has SR class, domain for SR class has priority

Tie Breaker for >1 PCE

- When domain joins with Schedule Protection, initialize gates to SR class closed, all others open
- When >1 attributes join with Explicit Schedule, the actual schedule for hardware is the logical OR of the SR Class Gates
  - Merger of open gates from all attributes
- Example for one hop:



Thank You