IEEE 802.1 TSN

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Discussion of Questions related to the proposed P802.1Qcb PAR:

"Frame Replication and Elimination for Reliability" (= Seamless Redundancy)

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Objective

- Email send to the 802.1 mailing list on 02/13/2013 by Norm Finn raises several questions related to the Seamless Redundancy PAR.

- This presentation responds to the questions / concerns raised.

Background

- Representatives of Industrial Control and Automotive have shown significant interest in an IEEE standardized solution for Seamless Redundancy by:
  - Repeatedly presenting use cases and market potential
  - Preparing technical proposals for the integration of Seamless Redundancy techniques into IEEE 802.1
  - Carefully addressing concerns related to the feasibility of the proposed solution.
  - Intensively discussing these topics multiple times within the 802.1 TSN task group in the course of the last 2 years.

Concerns…

- *Concern expressed: (*1)*

  Seamless Redundancy should be implemented on Layer 3

(*1): For the sake of this presentation we have summarized the concerns expressed in the aforementioned email in our own words.

Seamless Redundancy as a Layer 2 Building Block for Control

SR is an important building block for Time Sensitive Networking and a consequent continuation of the work of the TSN group:

- AVB Gen 1 has introduced layer 2 mechanisms to guarantee QoS for streams.
- From the perspective of time sensitive networking, this was a starting point!
- Our goal is the availability of an IEEE standardized network that can be characterized by keywords like:
  - Low Latency, Minimum Jitter, Determinism, Clock Synchronization
  - Robustness & Fault Tolerance
  - QoS Guarantees & Isolation
  - Lean & Inexpensive
  - Adequate for end stations with very limited HW resources !
- Some building blocks that support these characteristics are currently in the process of being put in place as low level mechanisms (layer 2 and below):
  E.g.: Distinguished Minimum Latency Traffic, Scheduled Traffic

Without covering the Robustness and Fault Tolerance requirements, we do not have a complete and viable IEEE 802 standardized solution for our use cases!

Seamless Redundancy on Layer 3 ?

Observation: "There is a market and a need for Seamless Redundancy on Layer 2"

- Several Ethernet variants that provide support for Seamless Redundancy on Layer 2 have been successfully introduced in the past
- The successful introduction of such proprietary solutions clearly underline the feasibility and the market potential of the Layer 2 based control use cases.
- Multiple use cases for Seamless Redundancy on Layer 2 have been presented several times within 802.1 TSN by the authors of this presentation.

Automotive: Main Focus is on Layer 2 !

- For time and safety critical in-vehicle control applications the clear focus on layer 2 solutions (e.g. L2 switches) is perceived to be very consistent across different companies within the automotive industry.
- For certain control applications Layer 3 protocols are not even required and protocol overhead and the use of routers are not justified!
- During the last 1 to 1.5 years we observed a significantly increased interest of automotive companies in Ethernet based time and safety critical control applications.

  This should be perceived as an opportunity!
- For that reason we have started to drive requirements for control applications into 802.1. The clear focus is on Layer 2 !

In the foreseeable future, Layer 3 routers will not play a significant role in architectures for time & safety critical in-vehicle control applications!

Industrial Control: Main Focus is on Layer 2 !

- Industrial control networks are often organized hierarchically in layer 2 and layer 3 domains (many mission-critical networks do the same thing)
- For highly time-critical motion control and industrial control applications the focus on mechanism is based on layer 2 networks. Time-critical traffic very rarely leaves a layer 2 domain.
- The intention of this group is to drive their requirements for control applications into 802.1. The clear focus of this group is on Layer 2 !
  This should be perceived as an opportunity!
- Transmitting Control-Data-Streams over layer 2/3 router with a certain QoS is also an important feature, which will also play an important role in network architectures for industrial networks. However, this approach is not an adequate solution for e.g. highly time critical motion control applications!

  A cost sensitive solutions for the highest industrial control requirements on guaranteed QoS, latency and synchronization can, in the foreseeable future, only be met by pure layer 2 networks.

Complexity and Cost

- *Concern expressed:*

  The proposed mechanism requires an unbounded amount of state and drives cost into components!

Background on Required State Information

- Background:
  - The elimination of duplicates in bridges requires some state information.
  - There are no complex data structures that would cause fundamental concerns w.r.t. hardware implementations.
  - As described in the presentation from the San Antonio meeting, the bridge maintains a very simple bit table.
    (See "Duplicate Drop Data Base" on slide 29 in
    http://www.ieee802.org/1/files/public/docs2012/new-goetz-jochim-Seamless-Redundancy-1112-v01.pdf)

    There are certainly alternative ways to implement this, but the bit table implementation shows the simplicity of what is required.

Number of rows in the bit table

- Number of rows in the bit table:
  - Only TSN streams (reserved traffic, scheduled traffic) will be configured to use seamless redundancy.
  - Typically only a subset of all TSN streams will be configured to use the seamless redundancy feature.
  - The number of rows in the bit table equals the number of those streams only.
- Implementations will limit the number of seamless redundancy streams they support (= Limit the number of rows).
- This is consistent with what has always been done in 802.1 implementations in the past:
  E.g.: Limited number of queues per port. Limited buffer size per queue. Limited number of streams an AVB implementation supports, . . .

Number of columns in the bit table

- Number of columns in the bit table
  - Only dependent on the maximum differences in latency that frames may experience on the two different paths.
  - Since latency guarantees are in place for TSN streams, this number can be calculated for a given topology / selection of paths.
- Again: Implementations can limit the number of columns to a value that makes sense for the applications / the use cases that customers have in mind.

Conclusions: Limited Amount of State Information

- The required amount of state can be clearly bounded by implementations.
- There is no need for the standard to define:
  - the minimum number of Seamless Redundancy TSN Streams an implementation needs to support.
  - the maximum 2-path latency differences an implementation needs to be able to tolerate.
- Users will know (at design time of their Ethernet systems) whether or not the hardware resources provided by a given implementation will allow them to implement the seamless redundancy streams that meet their particular requirements.
- It is not mandatory for bridges to implement the Seamless Redundancy feature.

- *Concern expressed:*

  Seamless Redundancy and Protection Switching are two solutions for one problem!

One solution per problem

- Protection switching is a type of dynamic redundancy. It is not intended to define a new type of dynamic redundancy. The proposed project will define an enhancement for static redundancy in 802 networks. (see p. 28 "TSN Assumptions", http://www.ieee802.org/1/files/public/docs2013/avb-pannell-gen2-assumptions-0113-v13.pdf)
- Static redundancy is needed in applications which require seamless availability for time sensitive streams and close to zero frame loss, i.e. this streams need zero reconfiguration time. There is no time to retransmit.
- Any type of reconfiguration (dynamic redundancy) results in packet loses, this affects especially streams with transmission periods of 125µs and less.
- The proposed project solves a completely different problem than protection switching does (ITU G.8032 and ITU G.8031 both rely on reconfiguration).

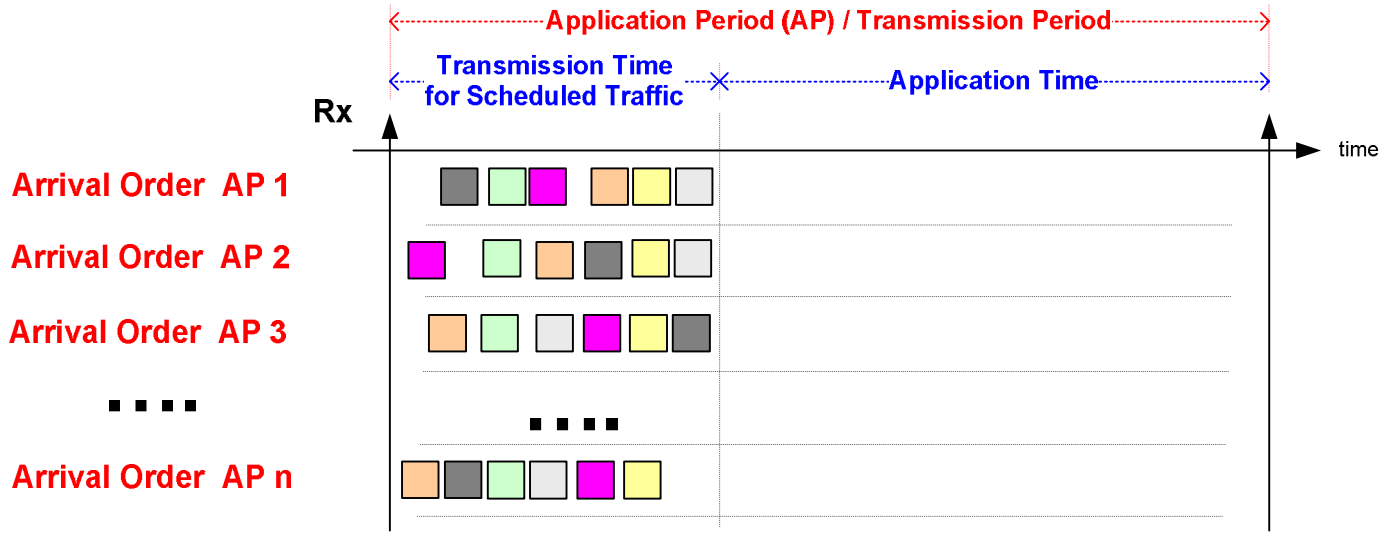
- *Concern expressed:*

  Violation of out-of-order delivery guarantees

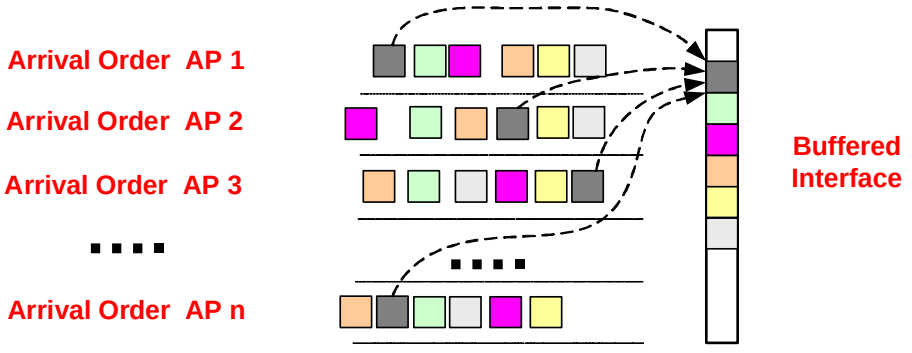
Out-of-order delivery

- In the fault free case, in order delivery *is guaranteed*:
  - without any need for additional queue capacity, etc., …
  - … just by the proposed mechanism, i.e. duplicate frame elimination and …
  - … even with significant latency differences on redundant paths
- If one of two paths fails, in-order delivery is *not guaranteed* (nor can RSTP guarantee this), however:
  - The mechanism will be used by fail-operational applications that require static redundancy (i.e. yet existing 802.1Q applications are not affected – they don't use static redundancy)
  - Fail-operational applications using the mechanism *can* handle out-of-order delivery in case of a failed path easily on listener side and …
  - … the failure *can* be handled and the applications can stay operational! With only one active path at a time, this wouldn't be possible at all!

Example: Industrial Control



- The key message of this slide is to show that the out of order arrivals are not critical for industrial control applications.
- The diagram above shows various alternative arrival orders for the same set of messages.
- Independently of the original arrival order, all messages will be available in a buffer for further processing by the application at the end of the transmission phase. (See diagram on the right)



- *Concern expressed:*

  Frames replicate themselves exponentially in misconfigured networks

Looping frames

- Replication and duplicate detection are based on stream reservations on loop-free paths.
- This project only provides mechanisms to replicate and eliminate frames, the path control is out of scope of this project.
- It is intended to use mechanisms provided by ISIS-SPB-PCR to set up paths using VIDs which are explicitly not rerouted after a failure.

Backup Slides

One solution per problem

- ITU G.8032 /Y1344 defines a protocol to manage a single ring or multiple ring architectures with the following parameters:
  - Loop prevention through disabling and activating redundant links on demand (revertive and non-revertive operation)
  - Clearing bridge FDB‘s after a switchover process
  - Defined *reconfiguration* times (<= 50 ms in small rings, > 50 ms in large rings)
  - Defines methods to combine G.8032 with G.8031

- ITU G.8032 /Y1344 is not in scope due to reconfiguration time

One solution per problem

- ITU G.8031/Y1342 defines 1:1 and 1+1 redundancy scenarios for end-to-end communication, possibly over G.8032 rings
  - 1:1 mode defines dual end-to-end paths. One path is active and one is passive. The active path is used simultaneously in both directions and in a fault scenario, communication is *switched over* from the active path to the previously passive path
  - 1+1 mode defines dual end-to-end paths where both paths are used simultaneously, either unidirectional or bidirectional. Frames are replicated at the source entity and travel both paths, but at the sink entity, only frames from the working transport entity are forwarded. In case of a fault, a *switchover is still necessary*
- G.8031/Y1342 reduces switchover / reconfiguration times and minimizes the number of necessary switchovers, but does not eliminate them. Therefore, it is not in scope.