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Open Issues for a **Layer 2 Solution**

CB information @ Layer 2

IEEE 802.3 Plenary Session – China

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Intention of this Slide Deck

The author would like to focus the future work on CB to the open technical questions.

Some technical aspects were already discussed and (most) of the TSN group members agreed on:

- CB is intended for seamless transmission of TSN streams
- Streams use a unique Stream Destination **MAC** Address
- Redundant Copies use a different VLAN ID
- A Sequence number must be included in every frame

This presentation is about two essential open questions:

- Where to put the Sequence number?
- How big must the Sequence number be?

Agenda

Recap: Basic principle and motivation of CB

- Motivation for CB
- Summary of the CB "history"
- Forwarding of redundant TSN Streams **in L2**

Two essential open questions:

- Right place - Where to put the Sequence number?

  Known protocols with a similar feature (seamless redundancy)
  HSR/PRP/AFDX, Trailer vs. Tag
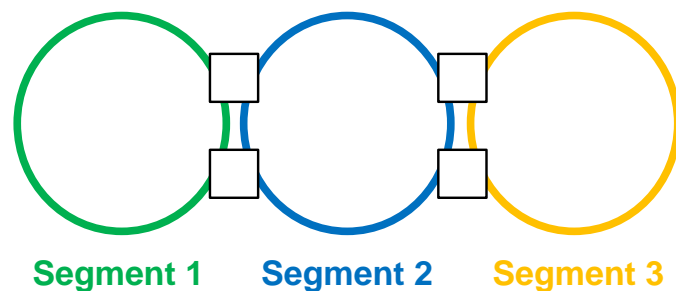
- Right size - How big must the Sequence number be?

Proposal for Redundancy Information

Motivation for CB

Industrial automation + Energy

"Segment protection"

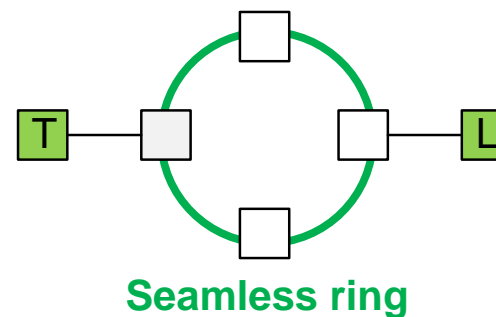Seamless Coupling of multiple rings
1 error per Segment

Segment 1   **Segment 2**   **Segment 3**

Industrial Automation + Automotive

"Seamless Ring"

Simple Devices receive only 1 copy
CB is a "network feature" and
    transparent for the devices

Seamless ring

IEEE

Usable for multiple applications in the LAN
Standardized frame format for the hardware

Summary of the CB "history"

The intention of industry automation and automotive
is still to **get a layer 2 solution.**
http://www.ieee802.org/1/files/public/docs2014/tsn-jochim-L2-3-and-8021CB-0305-v1.pdf

Multiple reasons for this were discussed multiple times in the past:
- Solutions for Layer 2 are existence (but not standardized in IEEE)
- 802 is focused on Layer 2
- AVB introduced Layer 2 mechanisms
- Layer 3 is not used in the intended environment
- focus for time and safety critical applications is Layer 2
- Cost-sensitivity of the solution
- …

Summary of the Layer 2 vs. Layer 3 discussion:
http://www.ieee802.org/1/files/public/docs2013/new-tsn-jochim-seamless-redundancy-discussion-0313-v1.pdf

Recap: Principle operation of CB
Frame Replication and Elimination for Reliability

Basic CB principle:

1. Every frame of a redundant Stream has a sequence number to be able to identify **Duplicates**
2. Duplicates are forwarded in the network on multiple (most-) disjoint paths
3. Duplicates are eliminated at a Duplicate Elimination Point

Talker   **Original**   Path A   Path B   Path ...   **Duplicates**   **Primary**   Listener

TSN network
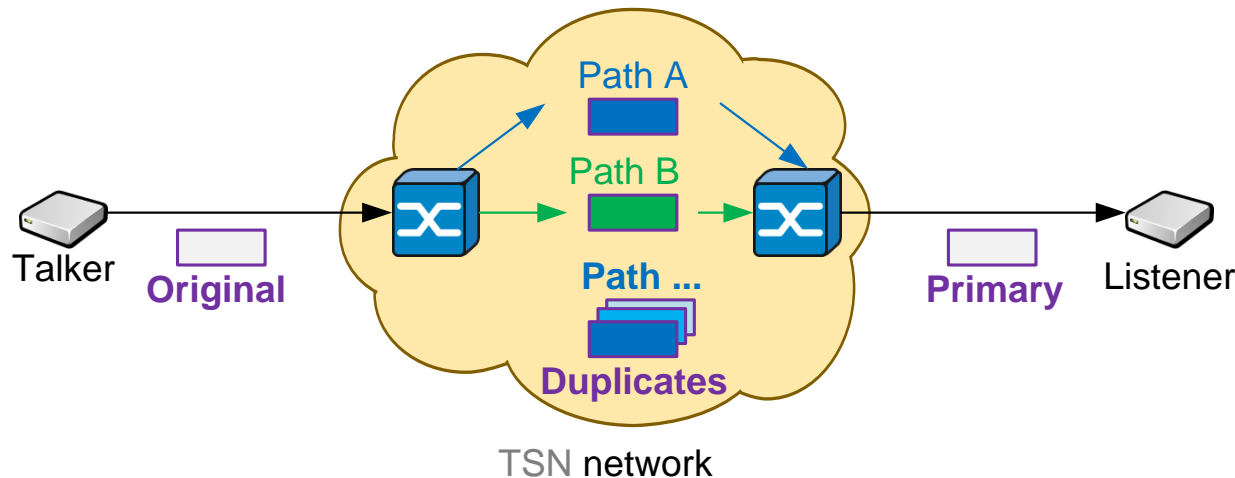
The focus of this presentation is
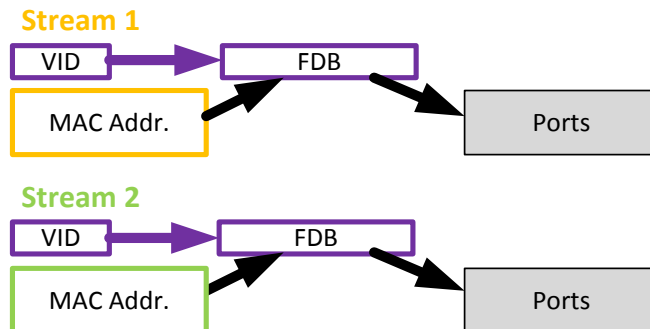the right place and size of the sequence number

Forwarding process of TSN Streams

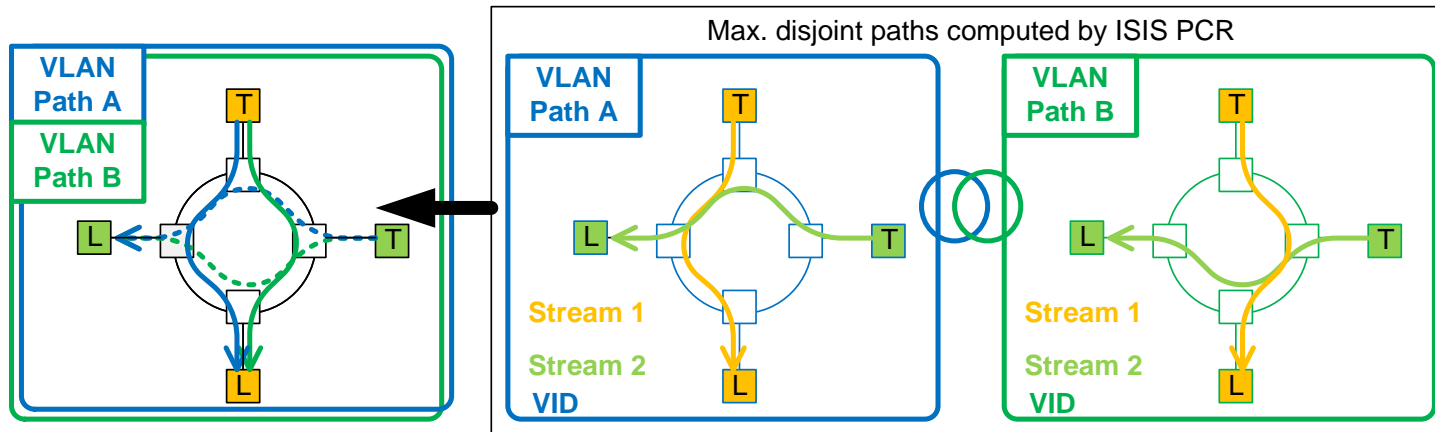The forwarding decision is defined by VLAN + Stream Destination MAC Adr. in the FDB
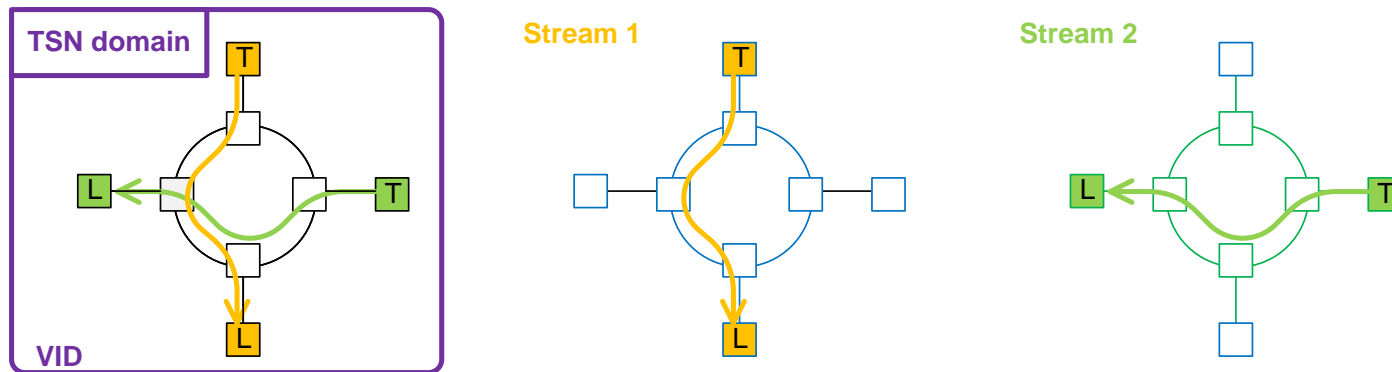
Forwarding path based on active topology defined by RSTP **for TSN VLAN**

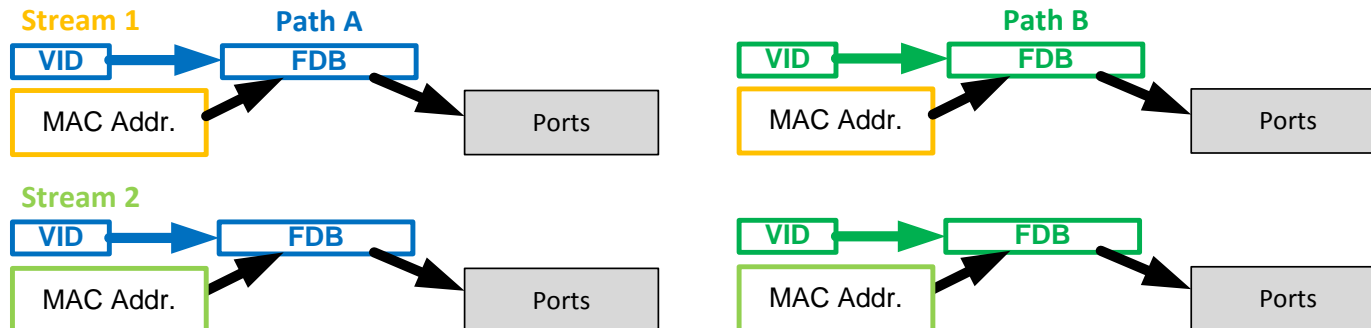VLAN classification defines the Filtering Instance – VID -> VLAN -> FID

Forwarding process of redundant TSN Streams

The forwarding decision is defined by VLAN + Stream Destination MAC Adr. in the FDB

Disjoint Forwarding paths defined by ISIS PCR in **VLAN A and VLAN B**
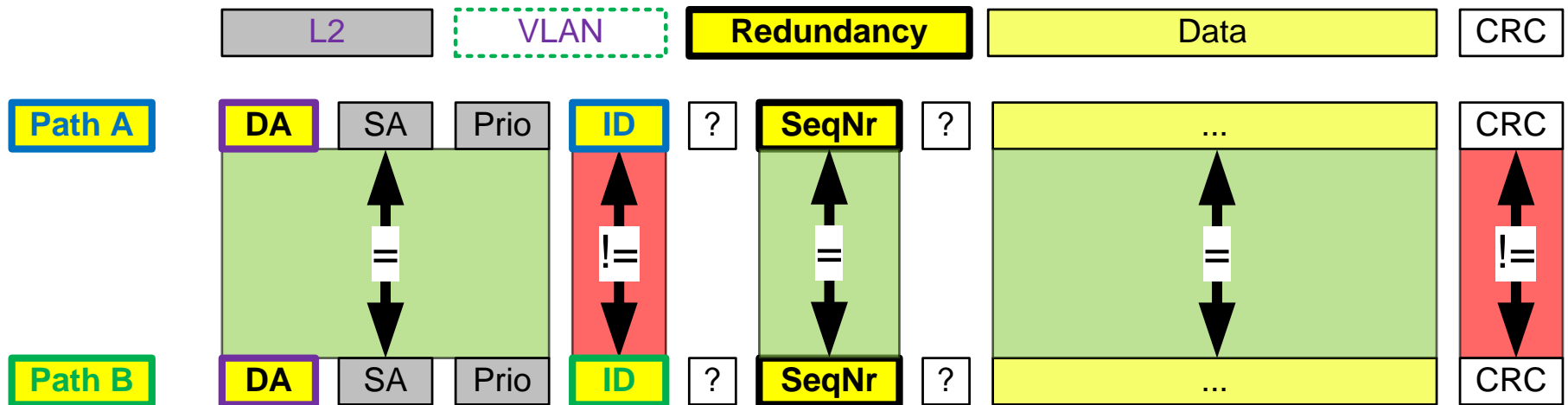
VLAN classification defines the Filtering Instance (VID -> "VLAN" -> FID)

CB Information for Duplicate Elimination

CB combines the Stream DA (identify the stream)
and the Sequence number (SeqNr – identify the duplicate)
to identify duplicates for duplicate Elimination

Agenda

Recap: Basic principle and motivation of CB

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- Forwarding of redundant TSN Streams **in L2**

Two essential open questions:

- Right place - Where to put the Sequence number?

  Known protocols with a similar feature (seamless redundancy)
  HSR/PRP/AFDX, Trailer vs. Tag

- Right size - How big must the Sequence number be?

Proposal for Redundancy Information

The right place for the sequence number?

Multiple places for the CB sequence number are possible:
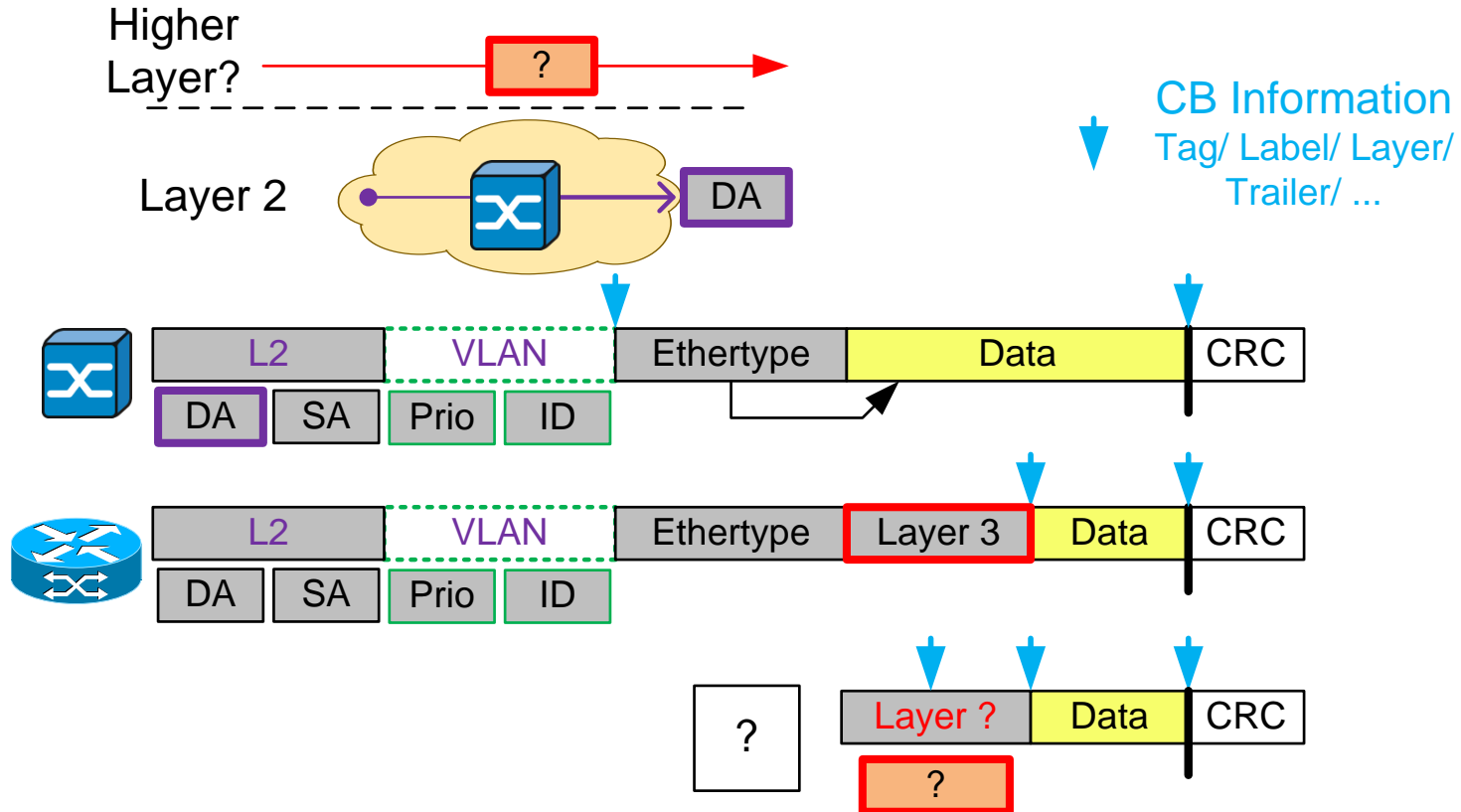
Main Goal: no layer violation for Layer 2 solution

IEEE bridging model uses **TAGs** to identify the next "protocol" / function in the frame

IEC 62439-2 HSR Forwarding

Basic principle:

- redundant ring without recovery times
- Open for usage from all protocols
  Applications with fixed DA e.g. ARP

Like a hub (flooding bridge) with duplicate filtering mechanism, flooding limited by using a non – IEEE FDB for the ring ports
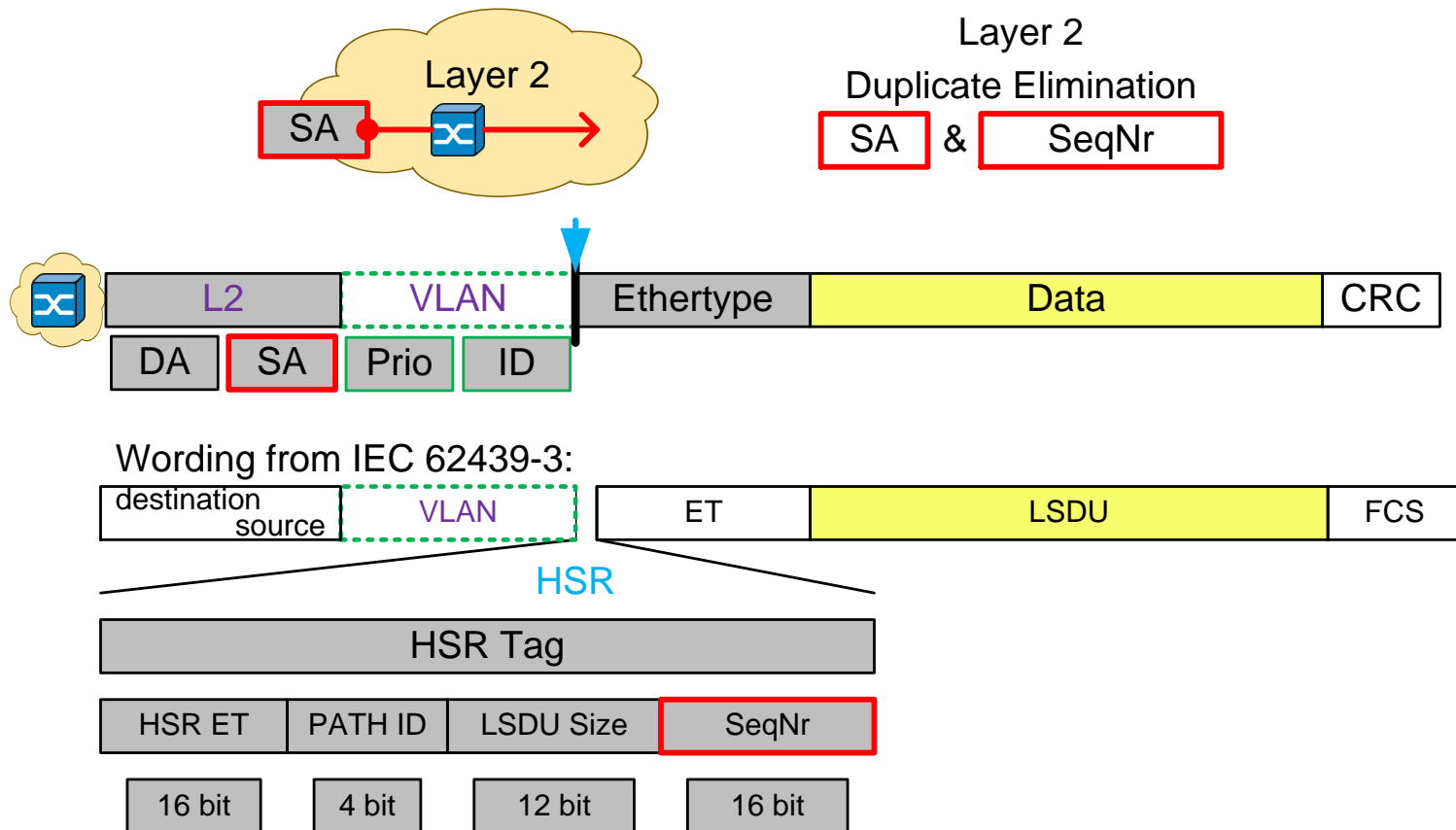
Forwarding is similar like water in a moad

HSR Ring

HUB
(Flooding Bridge)

HSR network

water in a moat
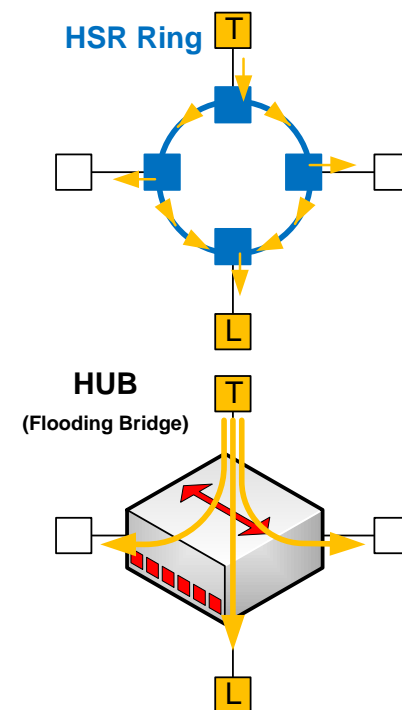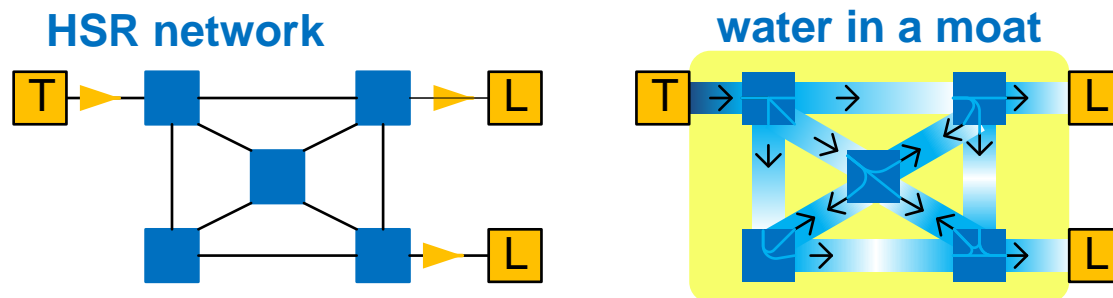
IEC 62439-2 HSR Tag

HSR defines a new "Layer 2" Tag.

Layer 2 forwarding is used (but Layer 3 information is shifted!)
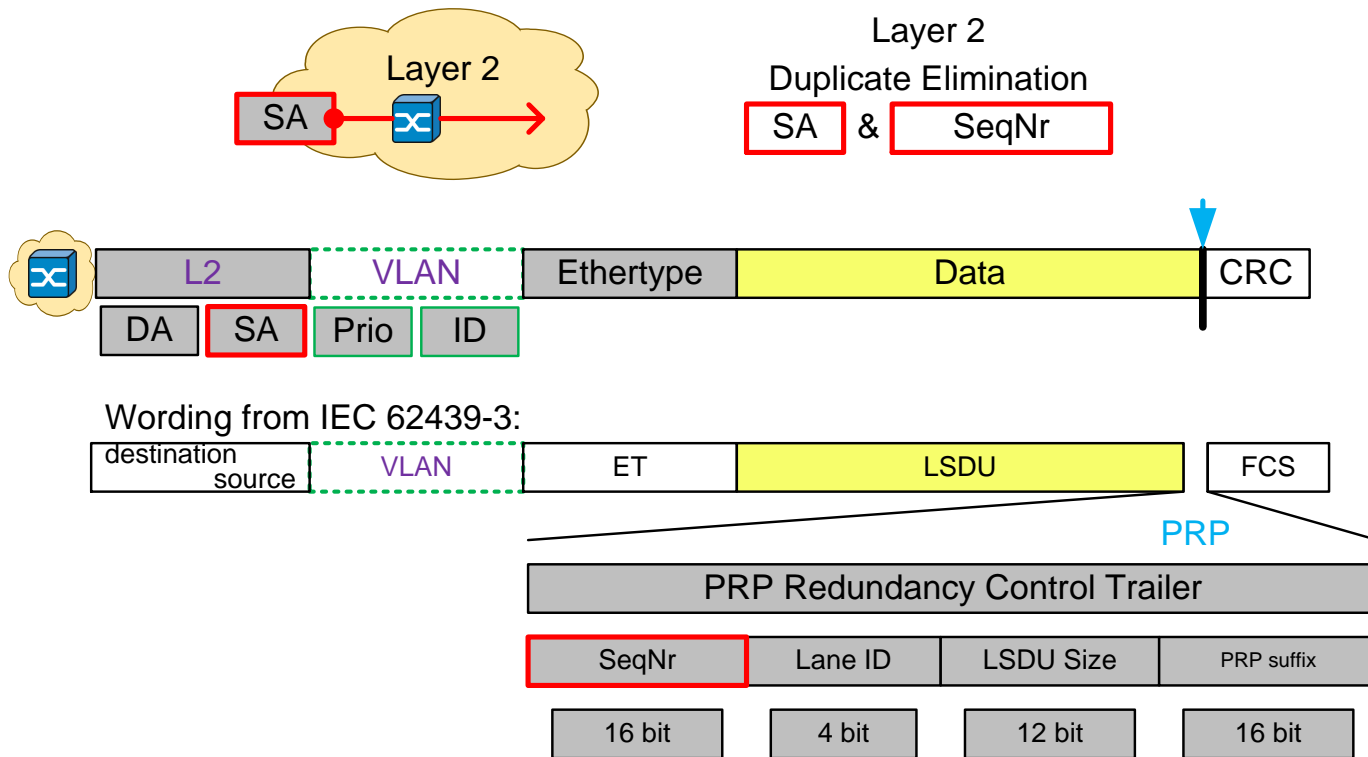
IEC 62439-2 PRP Forwarding

Basic principle:

- duplicate networks without recovery times
- should work without change of applications (transparent)
- **physically** separated IEEE networks required

Forwarding of the trailer like application data
Trailer to prevent the change of other
protocols / applications

LAN A   LAN B
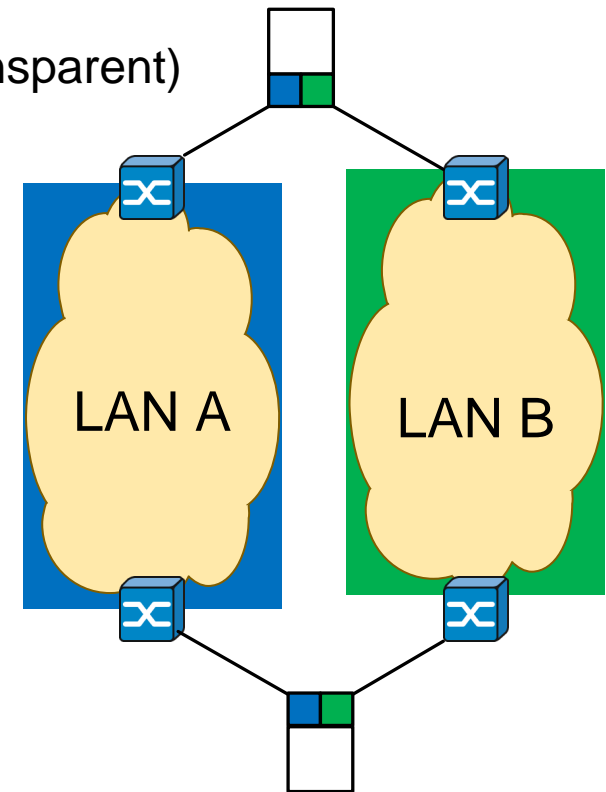
IEC 62439-2 PRP Trailer

PRP identifies duplicates using the source address!
TSN Streams use a destination address per Stream
LSDU size to ensure that a trailer is in the frame

Layer 2

SA

Layer 2
Duplicate Elimination

SA & SeqNr

L2	VLAN	Ethertype	Data	CRC

DA	SA	Prio	ID

Wording from IEC 62439-3:

destination source	VLAN	ET	LSDU	FCS

PRP

PRP Redundancy Control Trailer

SeqNr	Lane ID	LSDU Size	PRP suffix
16 bit	4 bit	12 bit	16 bit

AFDX – ARNIC 664 part 7

Each frame uses a 1 byte Sequence Number, which is positioned just before the FCS of the frame. + Plausibility check (+1 and +2 accepted!)
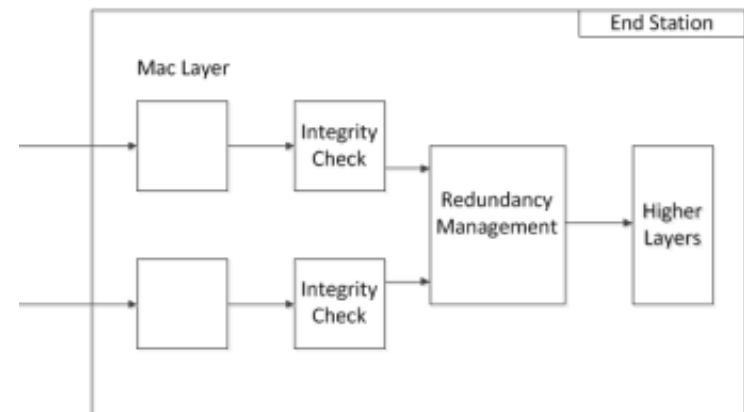
   1-255 Sequence +

    0   Reset – Trigger!

Virtual Links are similar to Streams

   Periodic transmission: BAG (bandwidth allocation Gap) =~ Period
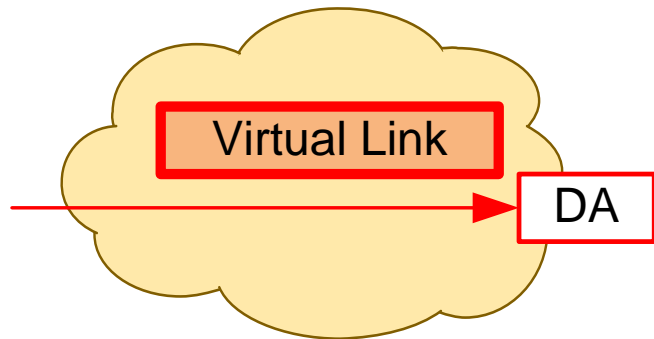
   Maximal Frame size: L_{max} =~ max. Frame size

Source Address used to identify Network A/B
Destination Address with 16-bit VL identifier
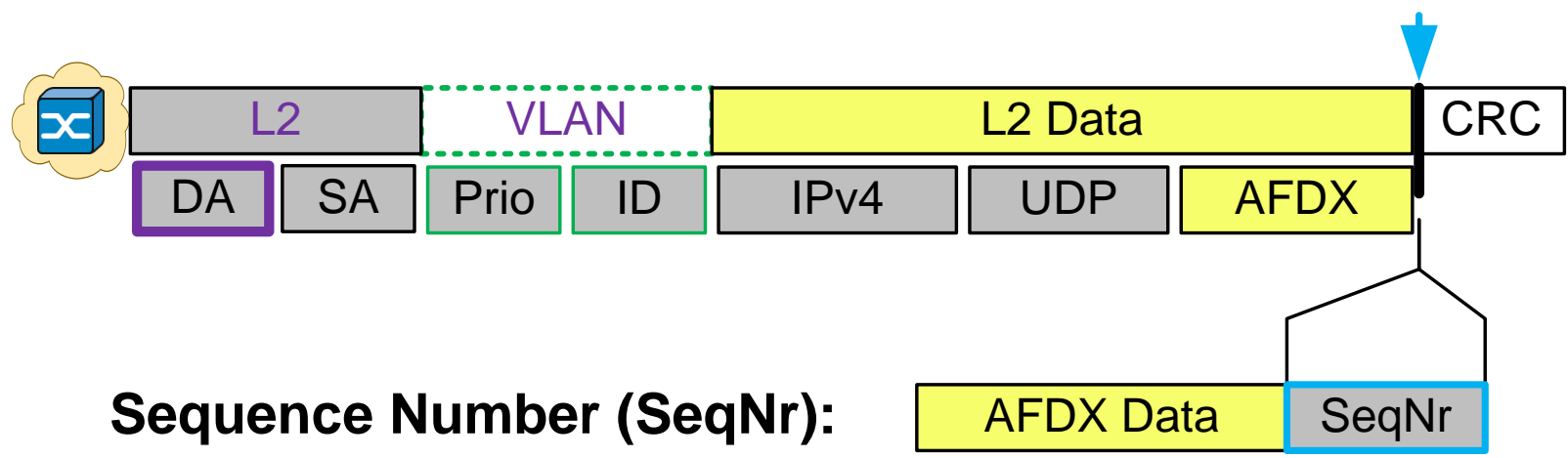
2 physically separated networks (like PRP)

AFDX – ARNIC 664 part 7

Lmax ⟷ Tspec Max. Frame size

BAG ⟷ Frames/Class-Intervall

AFDX Trailer

L2	VLAN	L2 Data	CRC
DA	SA	Prio	ID	IPv4	UDP	AFDX	

AFDX Data	SeqNr

Sequence Number (SeqNr):

0   RESET

1-255   duplicate elimination

http://application-notes.digchip.com/056/56-39808.pdf
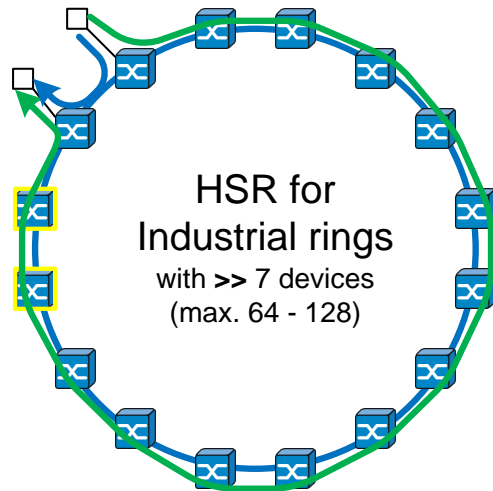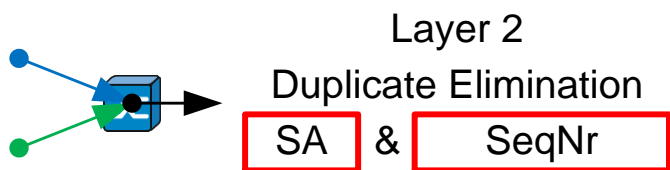
PRP vs. HSR

HSR defines a Tag, PRP uses a trailer to transport the sequence number.

- HSR is optimized for single **HSR** networks (rings)
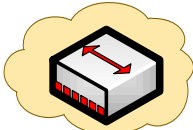- PRP can work in arbitrary physical separated "IEEE" networks (typ. red. Stars)

HSR for
Industrial rings
with **>>** 7 devices
(max. 64 - 128)

PRP for redundant
networks
Support of higher layer
protocols for forwarding

Bridged
Endstation
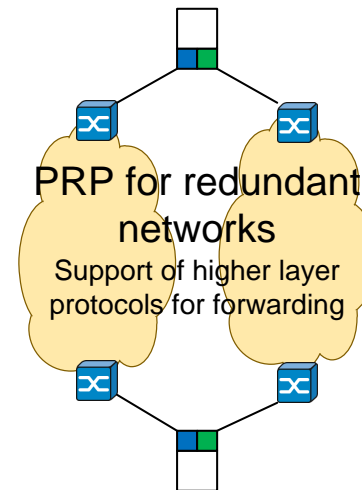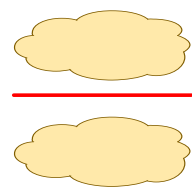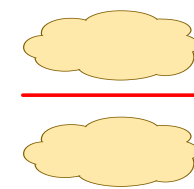
forwarding in the L2 network (ring) => Tag

Layer 2
Duplicate Elimination

| SA | & | SeqNr |

forwarding in unknown network => Trailer

HSR, PRP and AFDX redundancy compared

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	HSR	PRP	AFDX	*CB*
Path ID	Tag	Trailer	Trailer	*Tag*
SeqNr	16-bit SA	16-bit SA	8-bit **Virtual Link**	24 bit **Stream**
Additional	Size of Data	Size of Data	Plausibility Check 0 = Reset	*All?*
Serialization	-	-	+	+
networks				VLANs
scope	Industry / Energy		aerospace	IEEE

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Two essential open questions:
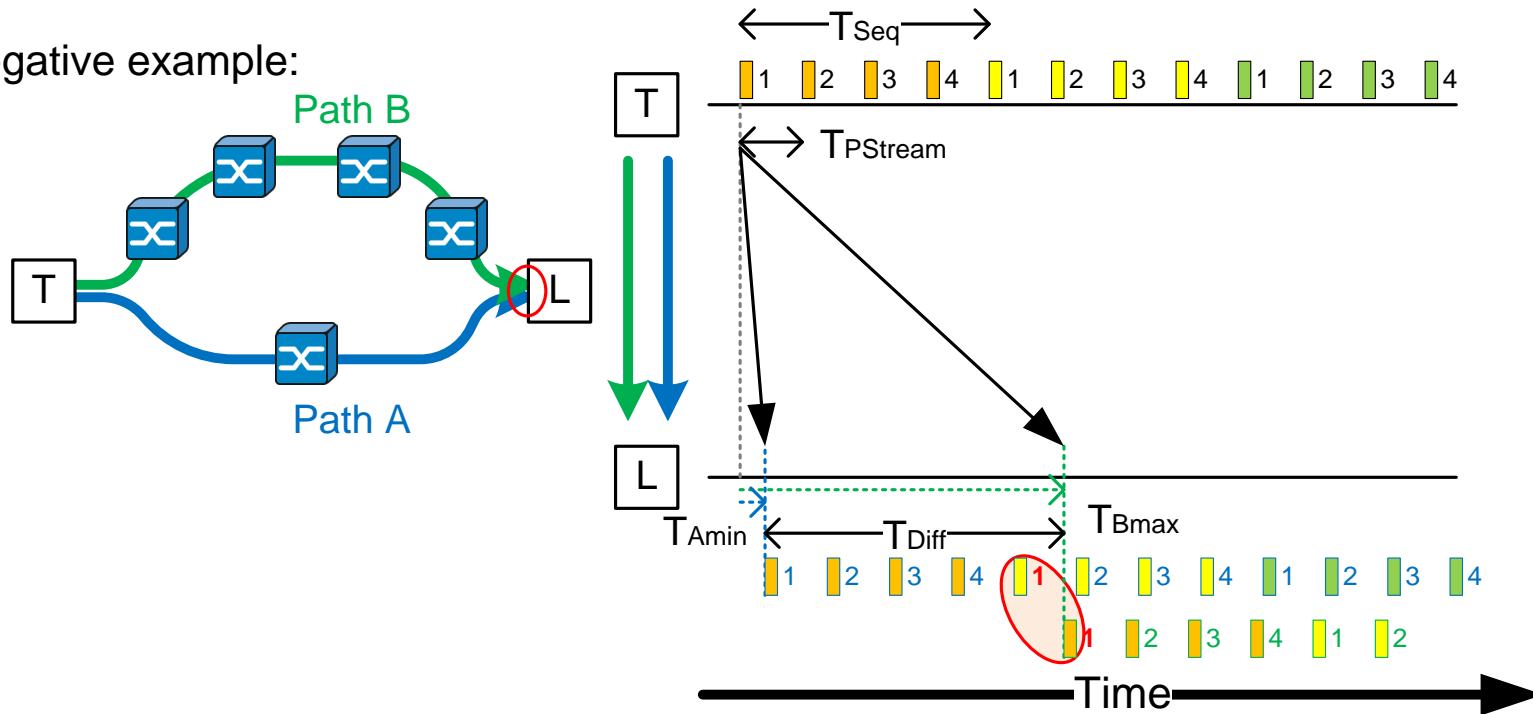- Right place - Where to put the Sequence number?

  Known protocols with a similar feature (seamless redundancy)

  HSR/PRP/AFDX, Trailer vs. Tag
- Right size - How big must the Sequence number be?

Proposal for Redundancy Information

The right size of the Sequence number?

Ensure that the sequence number belongs to the same information

Negative example:

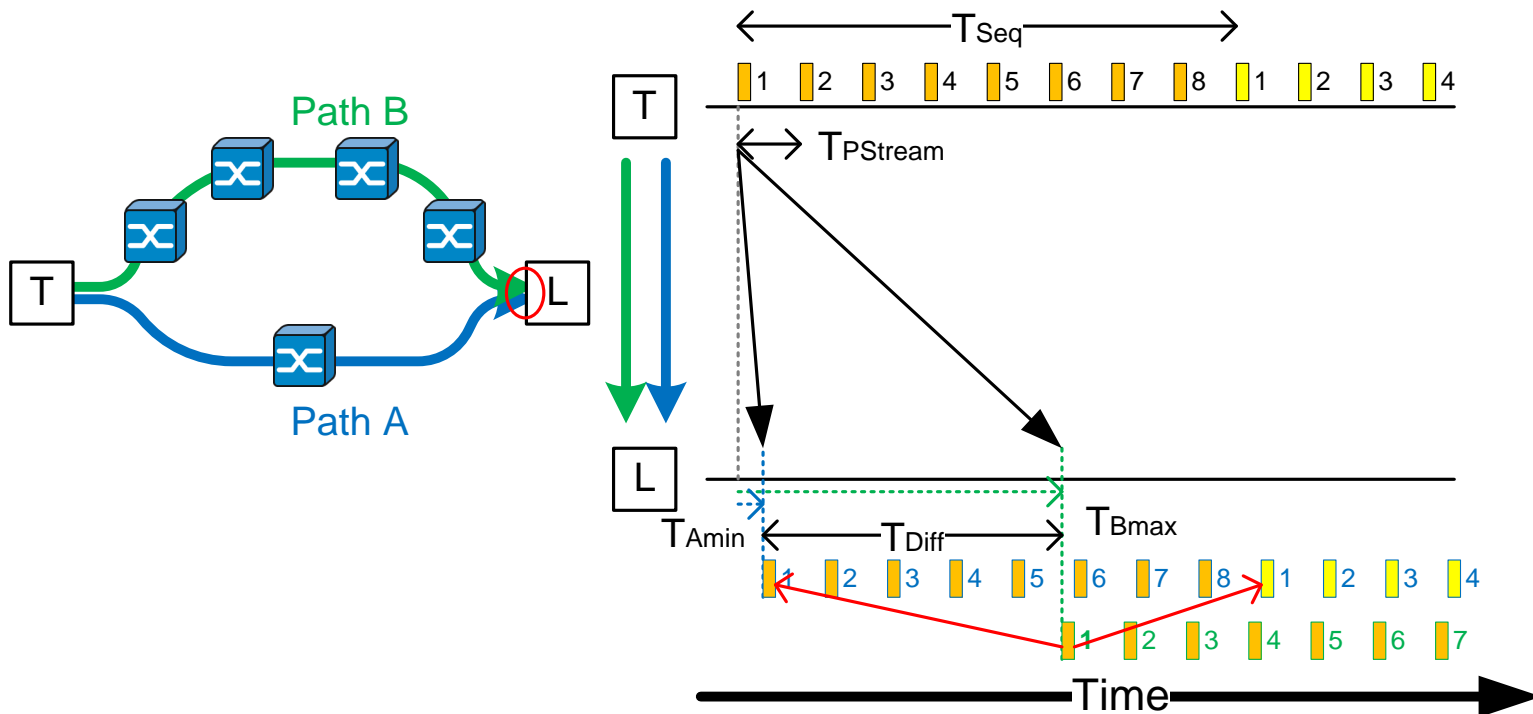T_{Seq}:   Needed time until the Sequence number restarts / overflows

T_{Diff}:   Maximal difference between both paths

T_{xmin}:   Minimal path delay on path X

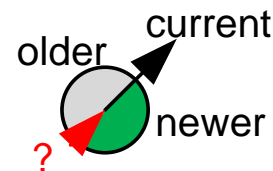T_{xmax}:   Maximal path delay on path X

The right size of the Sequence number?

Ensure that the sequence number belongs to the same information
and identify the right sequence of the information

Acceptance – Window for newest information
Assumption: Sequence Number * 2 + 1:

The right size of the Sequence number for TSN Streams?

Assumptions from the AVB definition:

- Max. AVB transmission rate must be supported
  (16-bit number for frames per Transmission period)

- Max. delay difference between Path A and B must be supported (AVB: T_{Diff}: 50 ms)
 (T_{Xmax} = 50 ms for Class B (A = 2ms) - T_{Xmin} = ~0 for worst case)

This leads to the minimum size:

Class B: 16 bit (Tspec) + 8 (50ms/250µs = 200 => 8 bit - 256 = 2^8)
  -> Combined 24 bit
  with simple Assumption: SeqNr *2+1: **25 bit**

Assumptions for CB Streams?

What are the assumptions for CB?

- **Latency Difference** on Stream transmission paths?
  Maximal Difference between two paths is important

- Stream Transmission period for CB Streams (TPStream) ?
  A Class A stream can nearly send every 1.9 ns a frame (considering the Tspec definition)
  This is nearly ~6 Tb/s with max. size frames – ~250 Gb/s with shortest frames

- How big must the "Gap" between new and old information be?
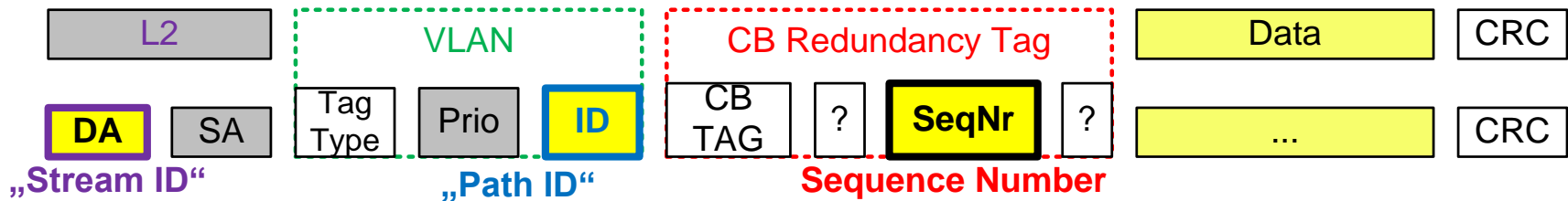 Acceptance of new information
  Discard of old information

  old

  new

  ?
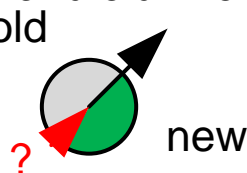
This assumptions influence the size of the Sequence number

Right place - Where to put the Sequence number?
As a common practice in IEEE: **Use a TAG**

| L2 | | VLAN | | | CB Redundancy Tag | | | | Data | CRC |
| DA | SA | Tag Type | Prio | **ID** | CB TAG | ? | **SeqNr** | ? | ... | CRC |

„Stream ID"   „Path ID"   **Sequence Number**

New Tag Type for the CB tag needed:

81-00 -> Customer VLAN Tag

88-a8   Service / Backbone VLAN Tag

88-e7   Backbone Service Instance Tag

TDB   CB Redundancy Tag
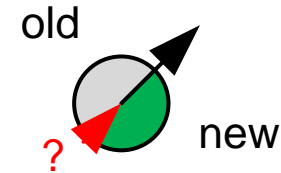
Right size - How big must the Sequence number be?

- Depending on the **assumptions** of CB flows / streams:

    Stream Transmission period

    Maximum Latency difference

old

new

?

Main Goal of 802.1 CB is to get a Layer 2 for seamless redundancy.

But, what is important for the Compatibility with other protocols?

- Stream Transmission Period & Maximum Latency Difference

The right assumptions for CB ensure the compatibility / usability!

Thank you for your attention!

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