AVB + Extensions for Industrial Communication

Siemens AG

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Goals for a Low Latency Stream Class A' used for Industrial Communication

- **Performance Requirements for GE**
  - Typical data size < 300 Bytes / frame
  - Max. hop count ~32 hops
  - **Max latency / hop**
    - Latency <15 µs / hop (~100µs over 7 hops)
    - Latency <5 µs / hop for high performance applications in industry

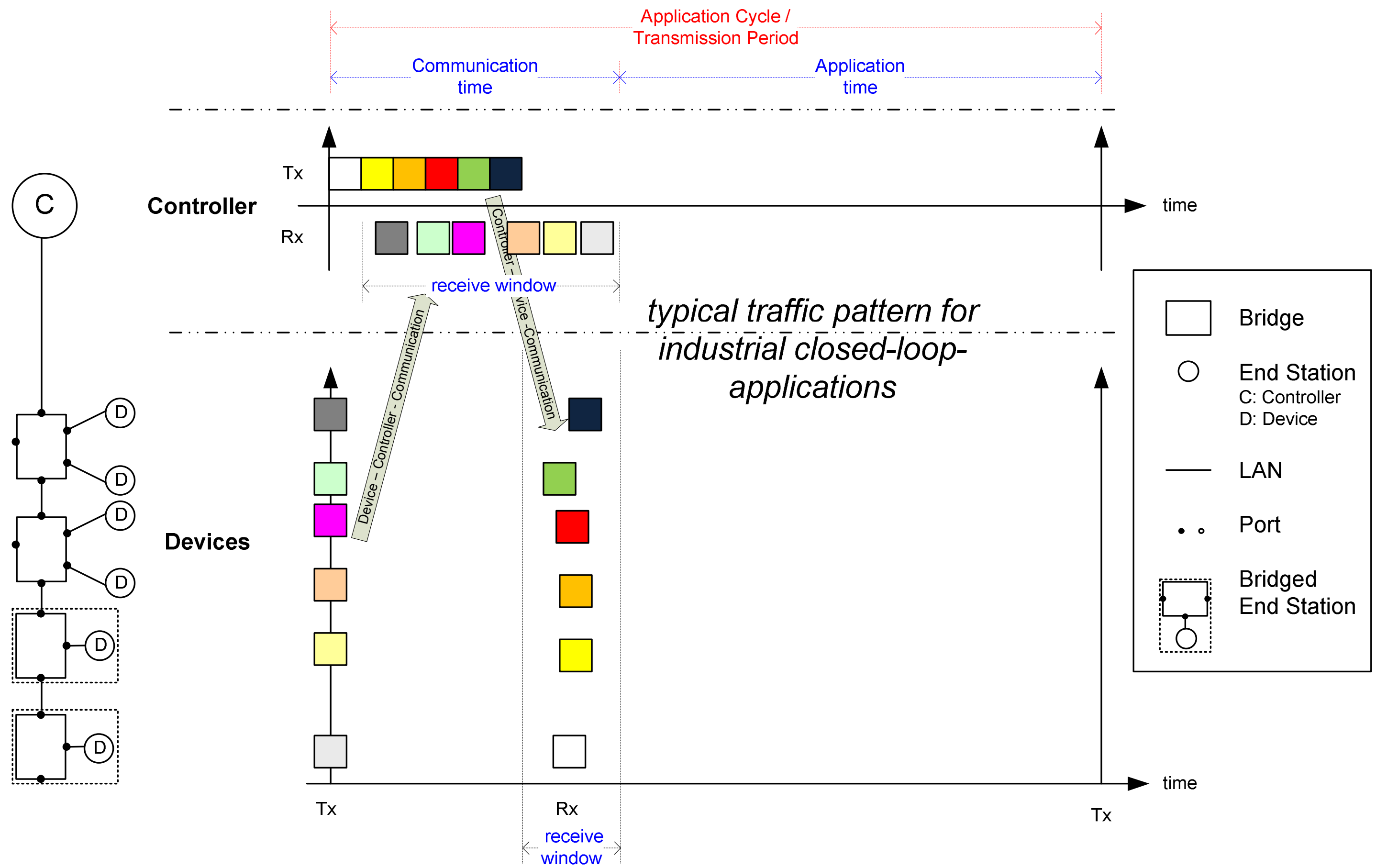
- **Range of typical Transmission Period's**
  - 31,25µs – 1ms

- **Typical topologies**
  - Star
  - Line / ring / comb
  - Combination of star and line
  - Ring with subring

⇒ **Integration of Industrial Communication in *__one__* convergent network**

Why Optimized Latency for Stream Class A' ?

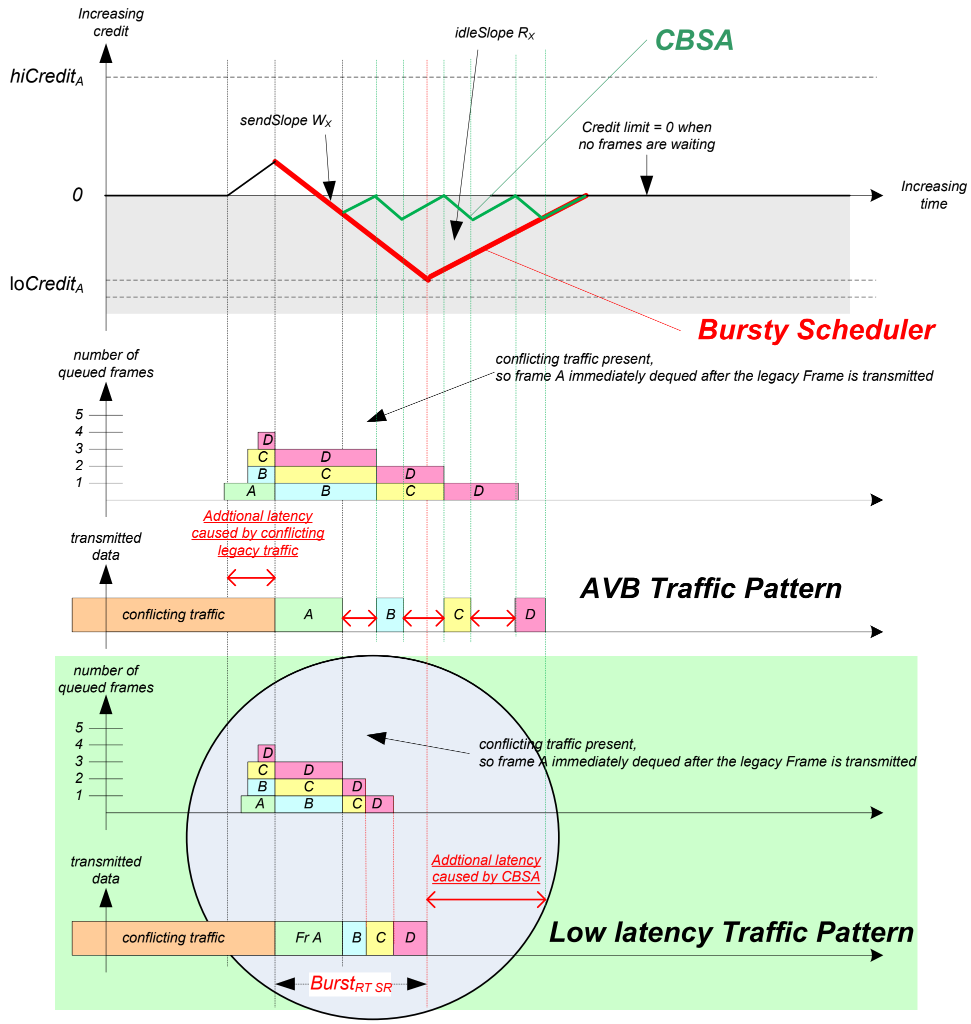
- **Minimize difference between min – max latency -> narrow receive window**
  (Using topology knowledge for stream transmission order by talker [and bridge?])



⇒ **Minimize communication time to get maximum time for application**

Optimized Latency for Stream Class A'

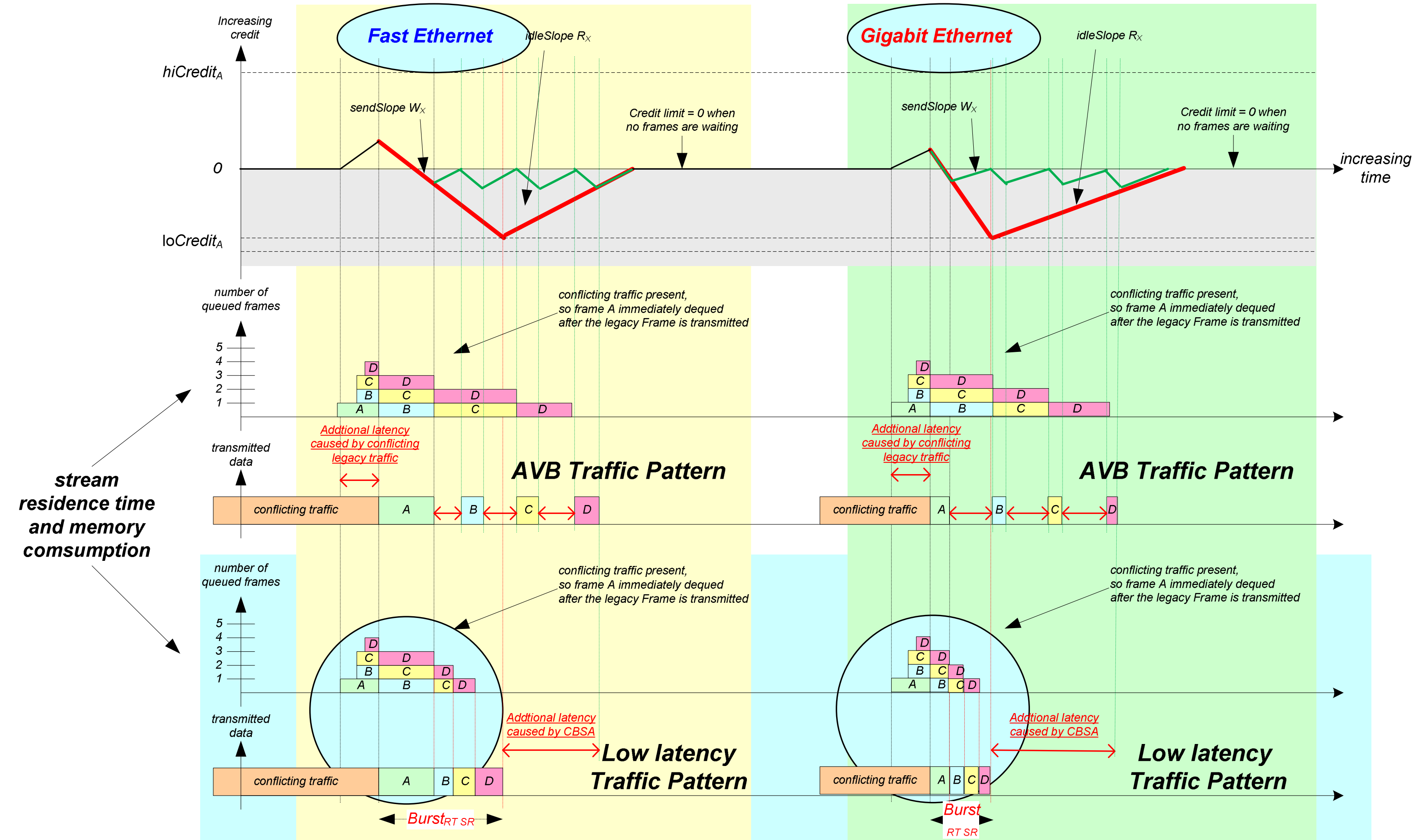
- **Shaping for Stream Class A'**



⇒ **Allow bursts with max. burst size for Stream Class A' to minimize latency**

Optimized Latency for Stream Class A'

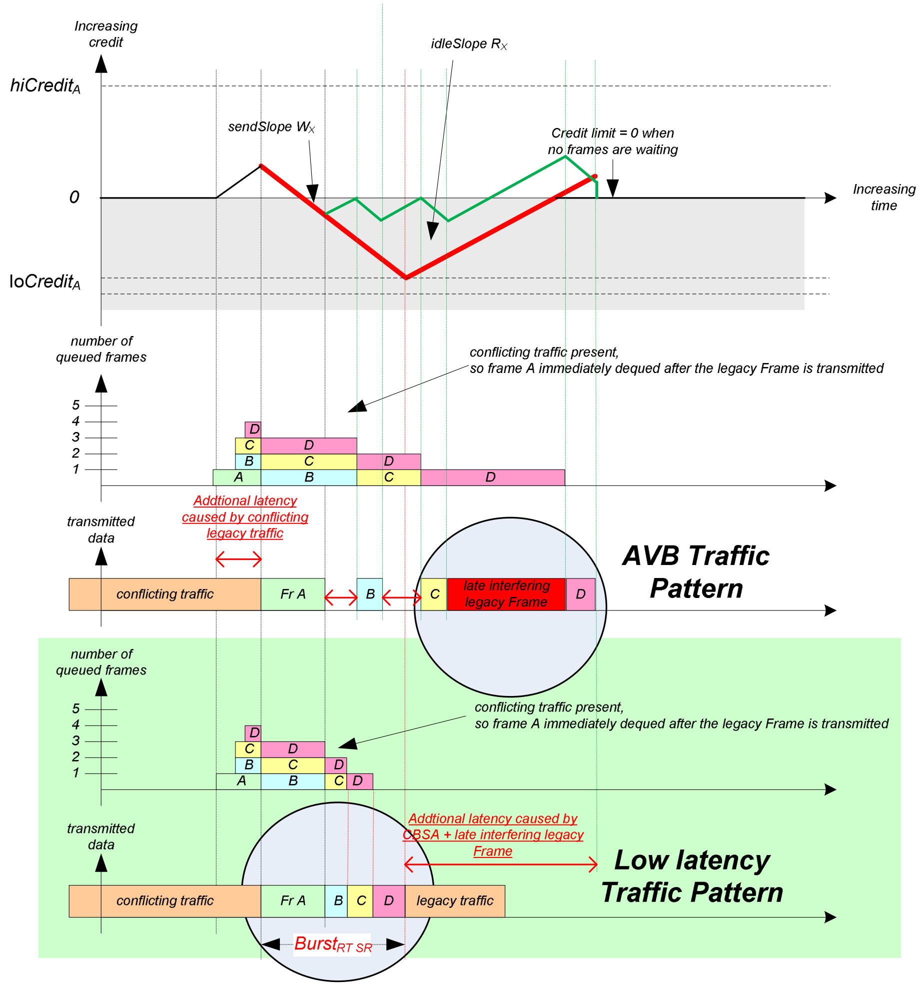
- **Get advantage on latency from higher link speed (FE <-> GE)**



⇒ **Reduce Memory consumption for Stream Class A' in bridges**

Optimized Latency for Stream Class A’

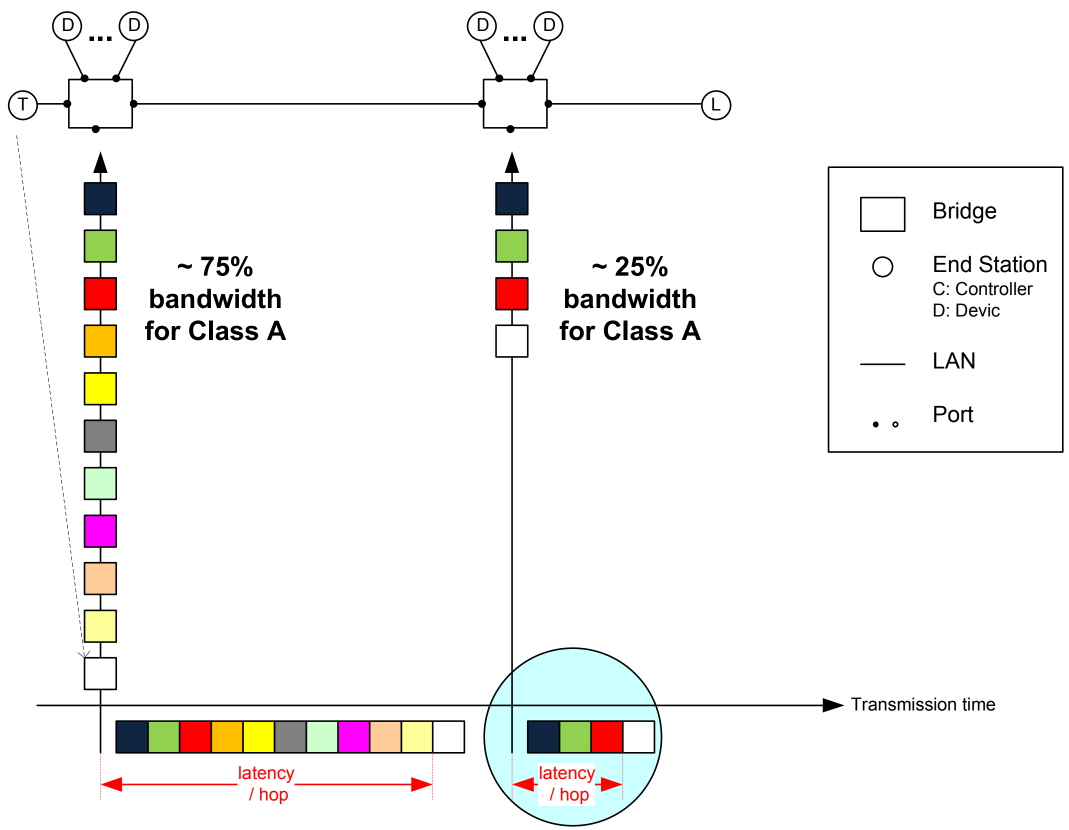
- **Avoiding of late interfering / collisions with legacy traffic caused by CBSA**



⇒ **Scheduler which allow a certain burst size for Stream Class A’**

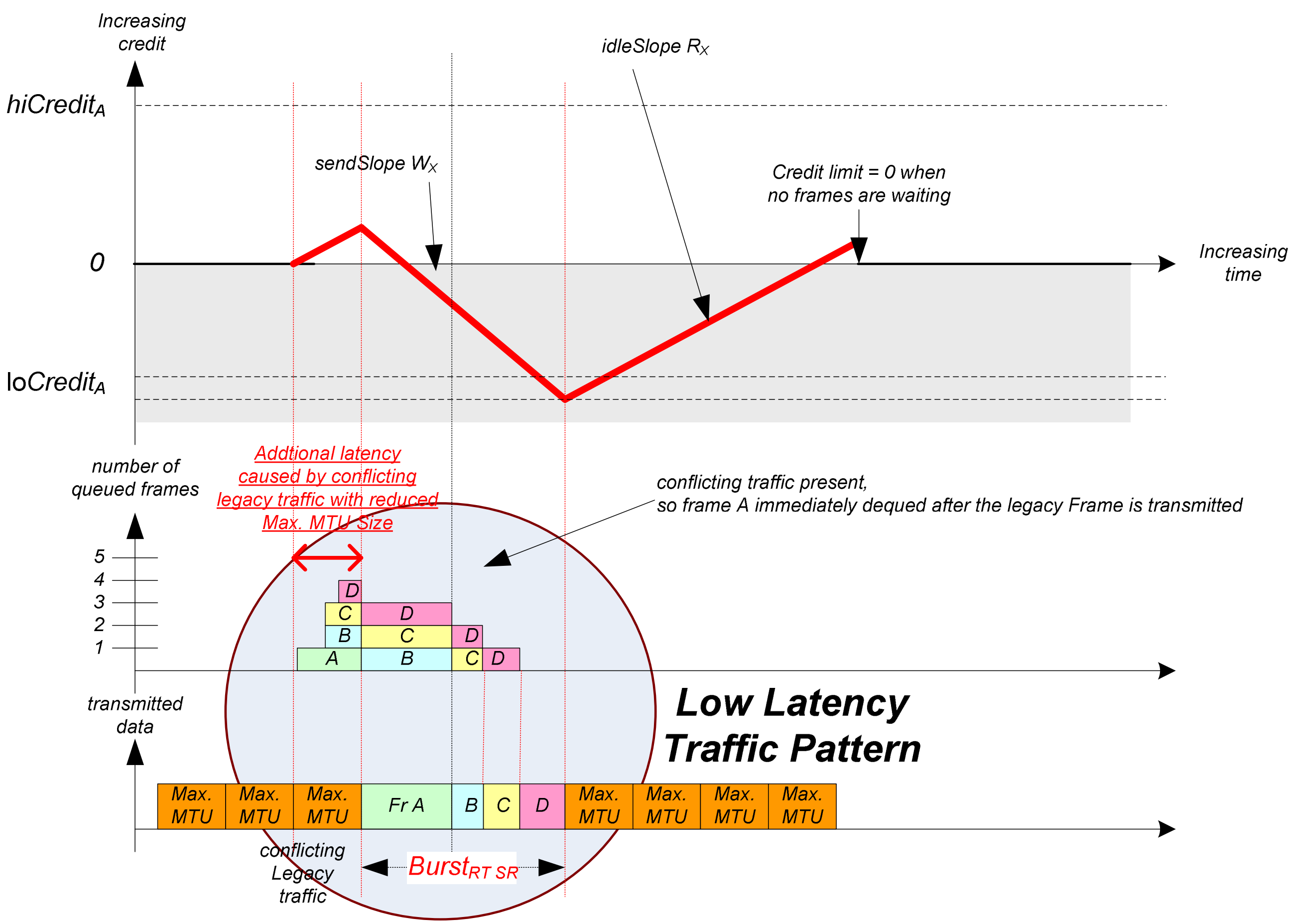
Optimized Latency for Stream Class A’

- **Avoiding of interfering Streams** (less impact with CBSA)
  - **Limit max. bandwidth for Stream Class A’ i.e. ~25%**
  - **Support multiple stream classes**
    (i.e. Stream Class A’ for closed-loop-applications 125µs application cycle and Stream Class B for control systems with 10ms application cycle in parallel)



Optimized Latency for Stream Class A'

- **Reduce max. MTU size of legacy traffic**

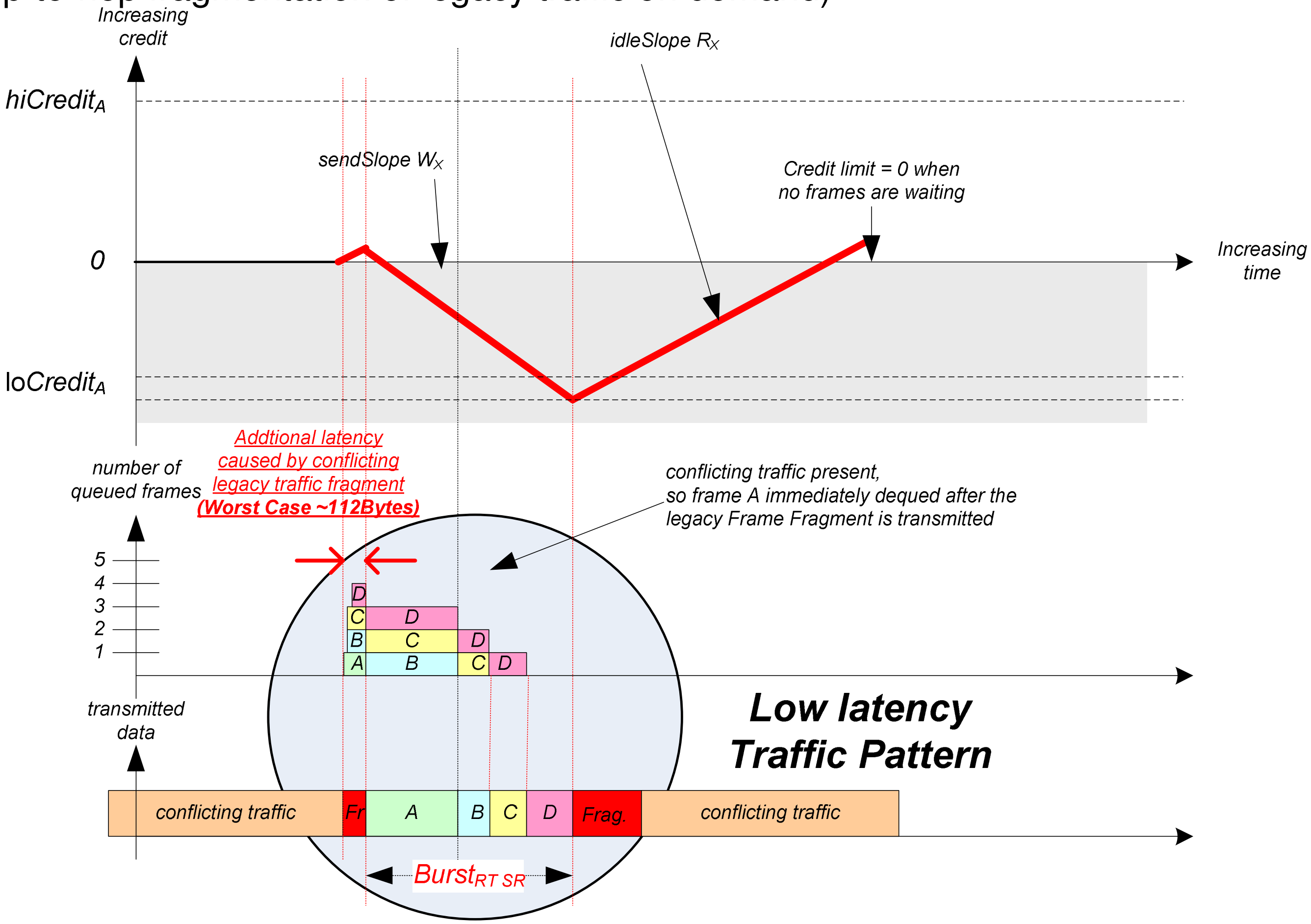


⇒ **Reduce impact of large / giant interfering legacy traffic to max. MTU size but much more overhead by reduction of max. MTU Size**

Optimized Latency for Stream Class A’

- **Avoiding interfering legacy traffic by fragmentation of legacy traffic**

  (hop-to-hop fragmentation of legacy traffic on demand)



⇒ **Reduce impact on latency of large / giant interfering legacy traffic by fragmentation**

(guaranteed addition latency of ~1µs in worst case for a 112 Byte fragment by GE)

Optimized Latency for Stream Class A'

- **Comparison reduced max. MTU Size to hop-to-hop legacy traffic fragmentation on demand**

	Reduce max. MTU Size (E2E Fragmentation)	Interfereing legacy Traffic Fragmentation (H2H Fragmentation)
Introduction / Support	Within a SRP domain each End Station and borderline has to support the same max. MTU size	Link specific Negotiation with i.e. LLDP
Fragmentsize	Must be configured	No configuration necessary (Min. fragment size ~112 Bytes)
Efficiency	Fragmentation for all legacy frames larger max. MTU Size => a lot of overhead for legacy traffic	Fragmentation of legacy traffic only if interfering with streams => less overhead
Additional delay/hop for Streams	Max. MTU Size	Min. Frag Size 112 Bytes in worst case
Implementation effort	Higher implementation effort in the end station but also in bridges with borderline functionality (VPN?)	Higher implementation effort in bridges. End Stations are not affected.
Compatible	Not each implementation can handle reduction of MTU size	Backward compatible to existing implementations

Ideas of hop-to-hop Fragmentation of Legacy Traffic on Demand

- Fragmentation of legacy traffic on demand only when conflict with stream traffic to minimize additional overhead
- Fragmentation and reassembling is a port property and port specific (not network specific) -> makes it easier to introduce fragmentation
- Fragmentation and reassembling of only one legacy frame at one time per port to simplify implementation
- LLDP protocol may be used to negotiate fragmentation on link
- Stream traffic can overtake legacy traffic

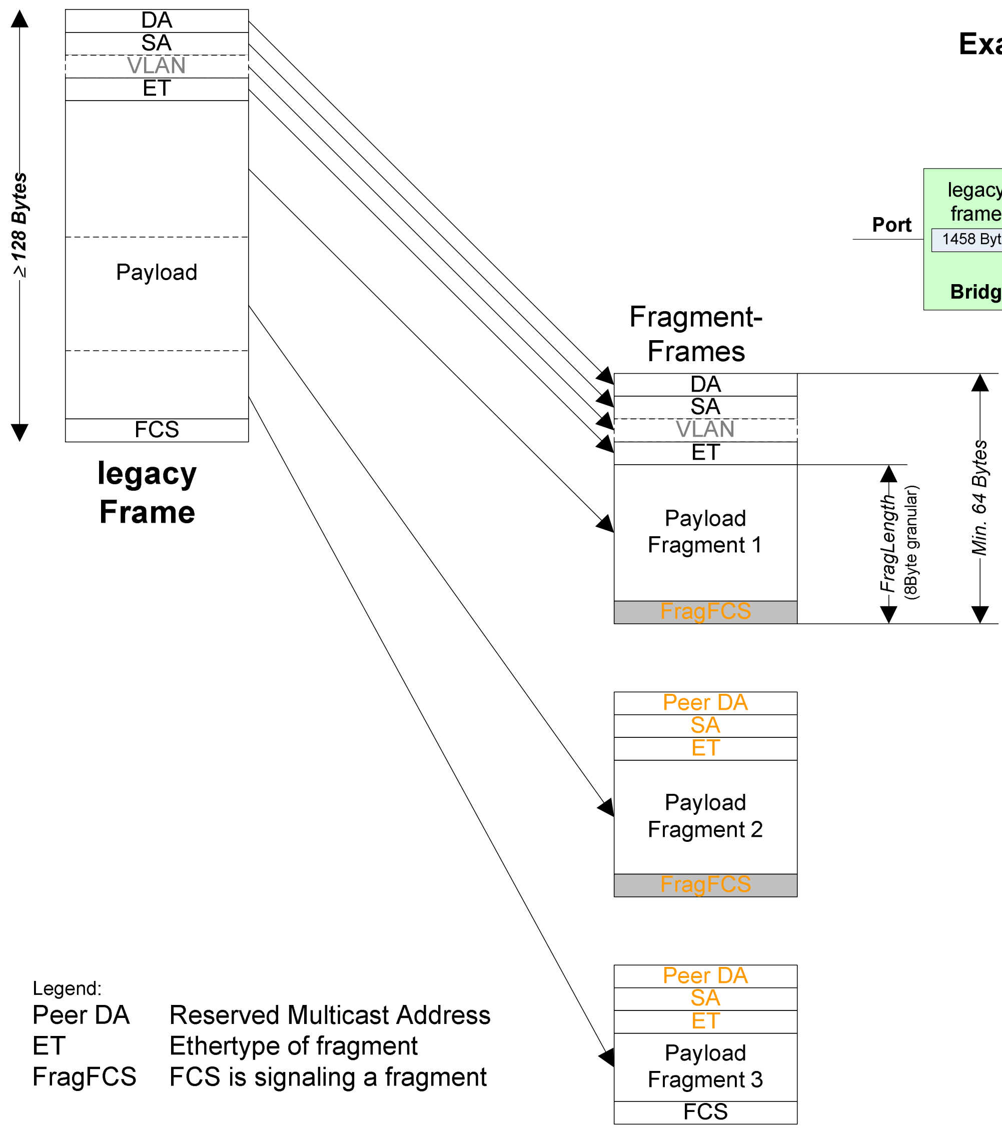
Proposal for next steps:

⇒ **Setup team of expert to specify architecture for fragmentation**

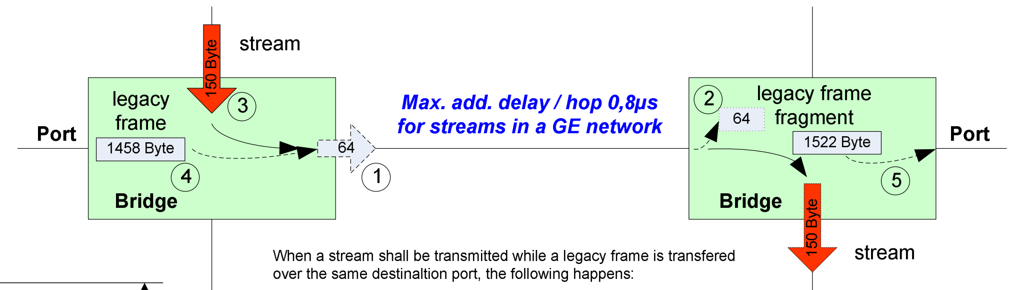
⇒ **Draft for hop-to-hop fragmentation of legacy traffic on demand**

⇒ **Validate architecture with network simulation**

Proposal for hop-to-hop Fragmentation of Legacy Traffic on Demand



Example for hop-to-hop fragmentation for a legacy frame



When a stream shall be transmitted while a legacy frame is transfered over the same destinaltion port, the following happens:

1. Fragmentation of legacy frame on the bridge, which is transmitting the legacy frame

2. The bridge, which is receiving the legacy frame has to store the fragment of the legacy frame

3. The stream will be transmitted and overtake the legacy frame

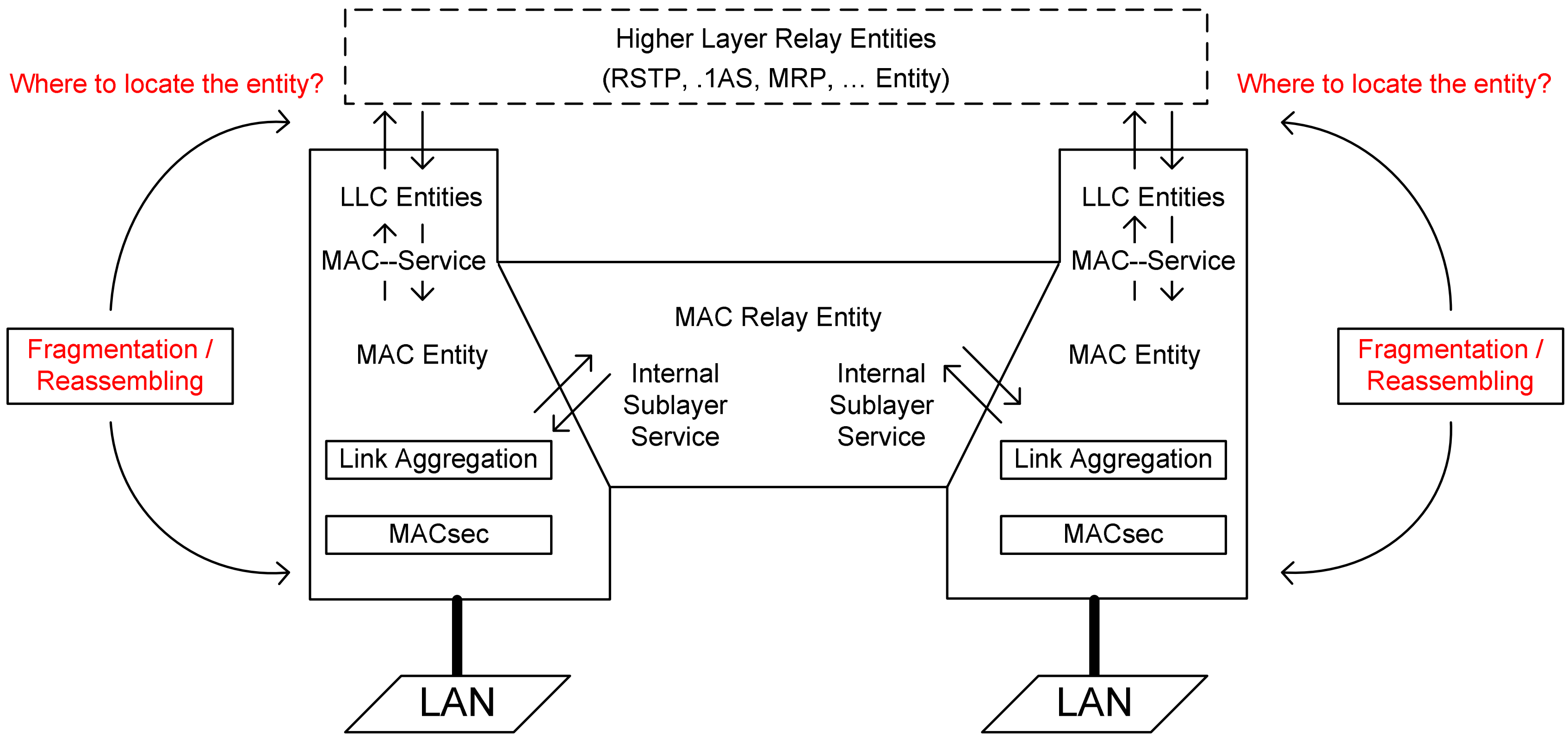
4. When the stream transmission is completed the rest of the legacy frame will be sent

5. After reassambling the legacy frame on the receive port the legacy frame will be transfered to the destination port

Legend:

Peer DA	Reserved Multicast Address
ET	Ethertype of fragment
FragFCS	FCS is signaling a fragment

Proposal of Processing hop-to-hop Fragmentation



Ideas for Stream Class A'

- Stream Class A' get highest priority when credit is available and a Class A' is in the transmit queue
- The residence time for Stream Class A' should be as short as possible
- Minimize memory consumption in bridges for Stream Class A'
- Basic assumption for Stream Class A' is bandwidth reservation with MSRP
- The scheduler for Stream Class A' makes use of negative credit to transmit burst, but in average it restricts the bandwidth
- Short bursts for Streams Class A' shall be allowed
- The Scheduler for Stream Class A' has also to guarantee bandwidth for lower traffic classes

Proposal for next steps:

⇒ **Team to specify Class A' traffic class**

⇒ **Draft for Stream Class A' scheduler**

⇒ **Validate specification for Stream Class A' by network simulation**

MSRP Extensions for Industrial Communication

- **Support for low latency Stream Class A'**
  - Transmission period's (31,25µs – 1ms)
  - Memory consumption
  - Latency calculation

- **Stream Preemption**
  - The communication between controller and device is typical preconfigured and planned
  - The communication between controller and devices is based on Streams
  - A industrial network has to give a guarantee to establish controller – device communication independent of other kind of communication in the network and independent of startup sequence

  ⇒ **MSRP has to support Ranking (i.e. 4)**

  ⇒ **High ranking Streams must be able to preempt lower ranking Streams**

- **Predictable recovery time by network reconfiguration**
  - Guaranteed fast recovery time
  - Recovery time calculation

- **Media redundancy for fault tolerance**
  - No loss of RT Streams caused by RSTP (or similar mechanism) during network reconfiguration
  - Alternate path reservation based on VLAN or other mechanism (e.g. routing)
  - Seamless Redundancy (http://www.ieee802.org/1/files/public/docs2010/at-kleineberg-goetz-AVB-redundancy-1110.pdf

END

Thank you for your attention!