“Interrelation between an Asymmetric Camera Link and IEEE 802.1(DG)”

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Presenter: Kirsten Matheus, BMW Group

Introduction.

ISAAC is addressing the need for an Ethernet PHY that is optimized for the highly asymmetric communication of automotive cameras.

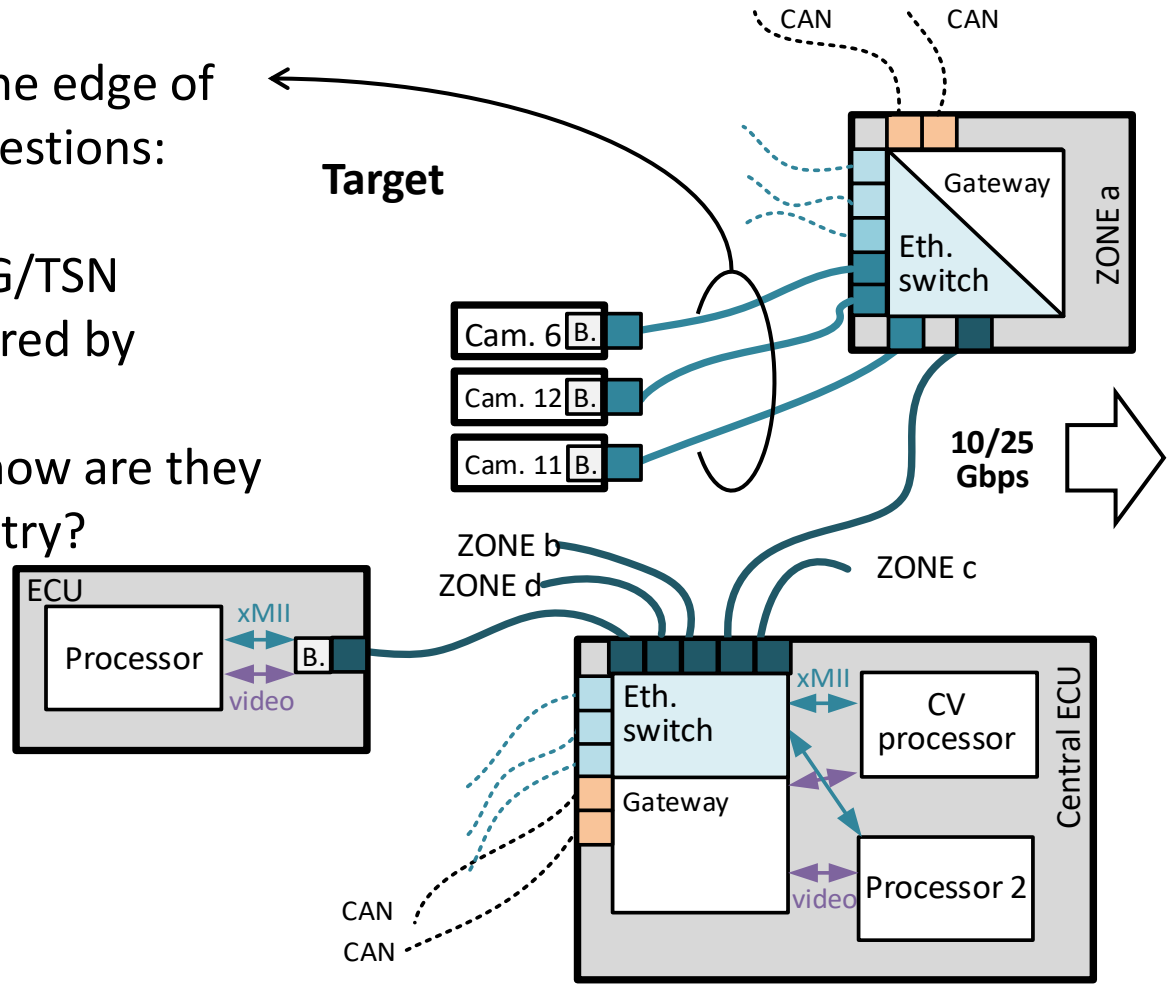
This presentation addresses potential impact and interrelations of such a solution to IEEE 802.1DG/TSN.

Initiative for ISAAC is to realistically enable handling camera data flexibly as Ethernet traffic, esp. in/with zones.

Impact on ISAAC?

Connect end nodes at the edge of the network has two questions:

1. Which of the 802.1DG/TSN functionalities are required by (camera) end nodes?
2. If they are required, how are they affected by the asymmetry?



Part of the core in-vehicle Ethernet network. Will use 802.1DG/TSN functions

a) 802.1AS
b) Priorities, VLANs
c) Traffic shaping, esp. ATS
d) 802.1Qci ✓
e) MACsec
f) Service orientation
g) …

1. It is expected that only a part of the 802.1DG/TSN functions are needed in (satellite) camera end nodes:

	Function	Applicable to camera end-node?	Comments
a)	802.1AS	Yes (sync is important)	**More next slides**
b)	Priorities, VLANs	Yes	Part of the packet header, independent of speed or asymmetry
c)	Traffic shaping	Not really	**More next slides**
d)	802.1Qci	No	Implemented in switch, co-existence with ATS, see 1.DG
e)	MACsec	Yes (important reason to use Ethernet)	Part of packet, independent of asymmetry and speed (as camera link is P2P and not multidrop), affects data rate
f)	Service orientation	Depends on implementation	**More next slides**
g)	Else?	Multiple hops? Control of power over from zone?	**More next slides**

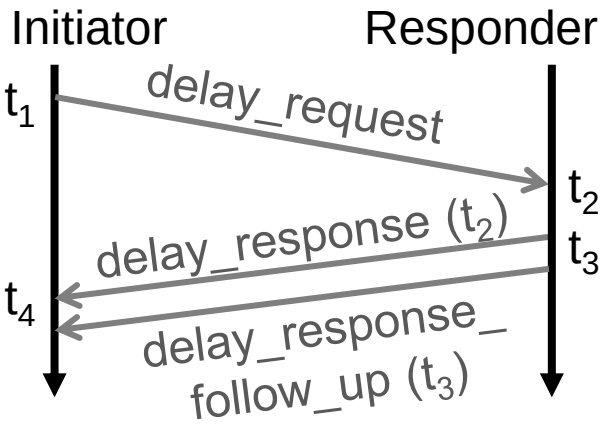
2. Variants of asymmetric communication considered in this presentation:

Type	Symmetric-capable PHY with EEE	Frequency Division Duplex (FDD)	Time Division Duplex (TDD)
Explanation	IEEE 802.3ch/cy-like PHY using EEE to save power esp. in the low data rate direction.	High transmit frequency/data rate in one direction, low in the other, but simultaneous.	High transmit frequency in both directions but alternating short and long transmission times.
General impact on latency*)	Some added latency owing to EEE signaling. Latency/power saving trade-off highly depends on possibility to control upstream traffic.	Continuous transmission down- and upstream. However, same size up-stream packet needs longer than down stream packet.	Some added latency up-stream. Only short (likely negligible) gaps down-stream. Longer gaps/wait in up-stream. Impact depends on exact system.
Example*): approx. 10Gbps/100Mbps	Sleep and wake-up signaling causes some latency.	Upstream packet takes 100 times longer on channel than downstream packet.	Wait of upstream packet depends on defined slot lengths.

*) PMA/PCS processing impact (bit-mapping, FEC, interleaving …) etc. not included, details require extra presentation

2.a) IEEE 802.1AS in cameras.

- Cameras will need to be part of the overall timing concept inside cars, which includes synchronization and timestamps.
- The logic exchange of synch packets as such is independent of PHY.
- Important: Timestamping needs to happen, when the data is really sent (in case this differs from when the MAC forwards it).
- pDelay measurement/calculation assumes that pDelay is the same in both directions. As this relates to the speed of transmission in copper, this should not be affected.



$$pDelay = \frac{(t4-t1)-(t3-t2)}{2}$$

2.c) Traffic shaping in cameras.

- Cameras will contribute the highest data rates in the network/zones.
- Typically, however raw camera (sensor) data is inherently shaped
  - rolling shutter (no buffer, but continuous data generation and forwarding, packet sent when full, blanking/packaging/TDD DS gaps are likely not relevant, i.e. duplexing scheme has no impact)
  - global shutter (frame taken all at once, requires frame buffer in imager, shaping needed if link speed significantly higher than sensor speed, can be done in imager)
- Should a camera unintentionally send more data than planned, the switch can use 802.1Qci (for Qci coexistence with ATS inside the switch, see .1DG)

2.f) Service orientation in cameras.

- How is it integrated in the system?
  - Everything via 1722?
  - SRP?
  - Service Discovery?
  - Service subscription to camera stream?

Goal is the implementation without software stack (e.g. E2IP).
Should not be impacted by asymmetry and duplexing method

- Typically, cameras are controlled via an I2C interface. Might use smart control, or duplication of I2C interface. The discussion of latency boundaries for these interfaces are of interest, but this again requires a separate presentation on latency. Relation to IEEE802.1DG questionable.

2.g) Else?

- **Multiple hops:** The duplexing/energy saving methods might cause additional latencies on the edge link. In case of multiple hops, this needs to be taken into consideration for the overall latency planning (potentially fewer overall hops).

- **Start-up:** Cameras require fast start-up plus often “large” data transfer to the camera during start-up.
- **Power over/wake-up:** Both are important, including the consideration of daisy chaining/control from the zone.

} Important items, but interrelation with TSN?

Summary and Conclusion.

- The following relevant 802.1DG/TSN items are unaffected:
  - MACsec, VLANs, priorities impact the packet but are independent of asymmetries.
  - Sensor data is typically inherently shaped (esp. in case of rolling shutter imagers).
  - 1AS, 1722, SRP, Service Discovery etc. logic signaling happens on higher layers.
- In respect to 802.1DG/TSN implementers might consider:
  - Timestamping needs to happen when data is actually sent!
  - Global shutter data might need to be shaped inside the camera/imager if link speed differs significantly from sensor speed.
  - Overall latency in case of multiple hops (as always).
- Recommend the following CSD compatibility statement:
  - As a PHY amendment to IEEE Std. 802.3, the proposed project will remain in conformance with IEEE Std. 802, IEEE Std. 802.1AC, and IEEE Std. 802.1Q.