Latency and Linkup Time
Contribution to 802.3dm Task Force

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Introduction

- It is imperative to control both linkup and latency time in Ethernet for automotive sensor applications

- In this presentation, we share linkup, latency, and jitter time requirements that we have seen for the automotive sensor applications

- Specific linkup time limits are proposed as a reference for the work in the Task Force

- Specific latency limits are proposed as a reference for the work in the Task Force
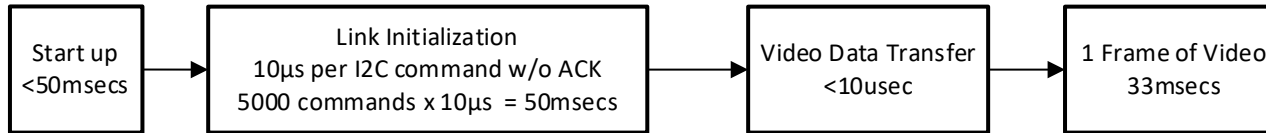
Linkup Time Requirements

- The 802.3dm development should consider the industry requirements for fast linkup and be competitive with the existing nonstandard solutions

- Limiting the linkup time is essential to allow immediate initialization of sensors to meet strict latency requirements and avoid consuming processing cycles to accelerate the additional delay accumulation

- For automotive camera applications, the linkup time should be no more than …
  - No more than 50ms from power-on until the link is up (communication can start flowing)
  - Assuming 10ms for Power and Crystal to stabilize, the startup sequence should be limited to 40ms
  - Sentry mode applications require quickly transmitting data from a sensor's deep sleep state. The ability to fast retrain (warm start) the communication link to <3ms.
    - These requirements go beyond EEE and TC-10

Latency and Initialization Time are Related

- Initialization is mandated by regulations, and user experience demands better.
  - Meeting government regulations does not meet customer expectations and is consider a "D-" user experience – barely passing system.
  - The NHTSA has established rules regarding rearview camera systems under FMVSS No.111 which focuses on rear visibility
    - The regulations mandate that rearview camera systems must be operational within 2 seconds of the vehicle being placed in reverse
    - Although the standard specifically applies to rearview cameras, it highlights the importance of quick initialization across the various camera systems in vehicles
- Current ADAS sensors can require 1000s to 10000 of initialization commands – Startup time multiplies latency 1000-10000 fold!

Link Latency Budget Calculation

- Additional latency will accumulate quickly.
- Customers expect 1st frame in <300msecs
  - As more sensors are added customer expects quicker initialization
- Example Total Link Budget Impact

| Start up <50msecs | → | Link Initialization 10µs per I2C command w/o ACK 5000 commands x 10µs = 50msecs | → | Video Data Transfer <10usec | → | 1 Frame of Video 33msecs |

Total Budget to achieve 1st Frame of data = 133.01msecs

Increasing link budget time impacts overall processing cycle timing budget

Latency Requirements

- Latency and Jitter are important to avoid long initializations of sensors and frame synchronization with other ADAS sensors

- For automotive sensor applications, latency should not exceed
  - There is a 10us hard limit related to functional safety (from switch to camera)
    - This includes a GPIO trigger event or a single I2C command
  - There is a less than 1.0us latency limit from the sensor to switch
  - There is a 1-2us limit on GPIO trigger events from the switch to sensor
  - There is a less than 1.0us latency limit on the video channel from sensor to switch

- Competing SERDES technology can already achieve these latency requirements

Latency and Jitter Application Diagram

- ADAS High Precision applications involving fast moving objects require highly accurate distance and velocity measurements, a trigger latency of <1-2usecs is ideal
  - This requires precision synchronization for accurate distance calculations 1 Horizontal Line of accuracy between sensors.
  - PTP can be used to schedule events and provide additional latency on the GPIO trigger if a link can not achieve <1-2usecs
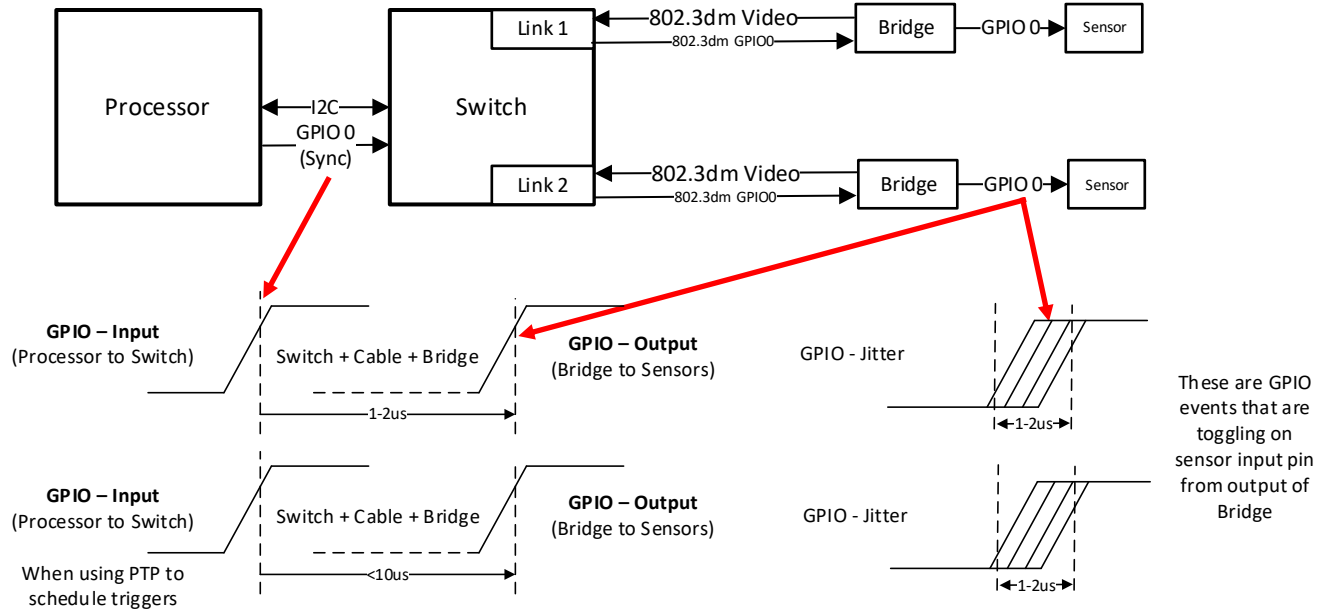
Latency Requirements

- Low Latency Video data is critical for ADAS applications.
- PCS to PCS block should not exceed 1usec for 10Gbps
- Customers are accustomed to solutions that meet these requirements
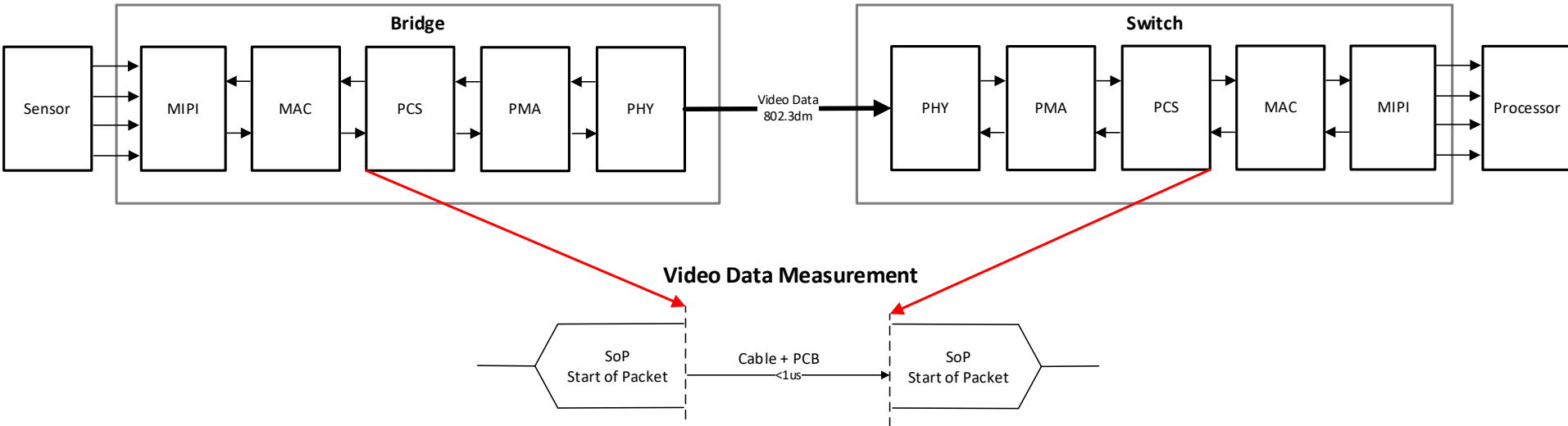
Summary

- It is essential to limit both latency and linkup time for automotive sensor Ethernet links to meet customer and application requirements

- It is proposed to limit the latency to 10us worst case in the switch to camera direction and 1us worst case in the camera to switch direction.

- It is proposed to restrict the linkup time to <50ms on initial/cold link up and to provide for <3ms on the warm link up.