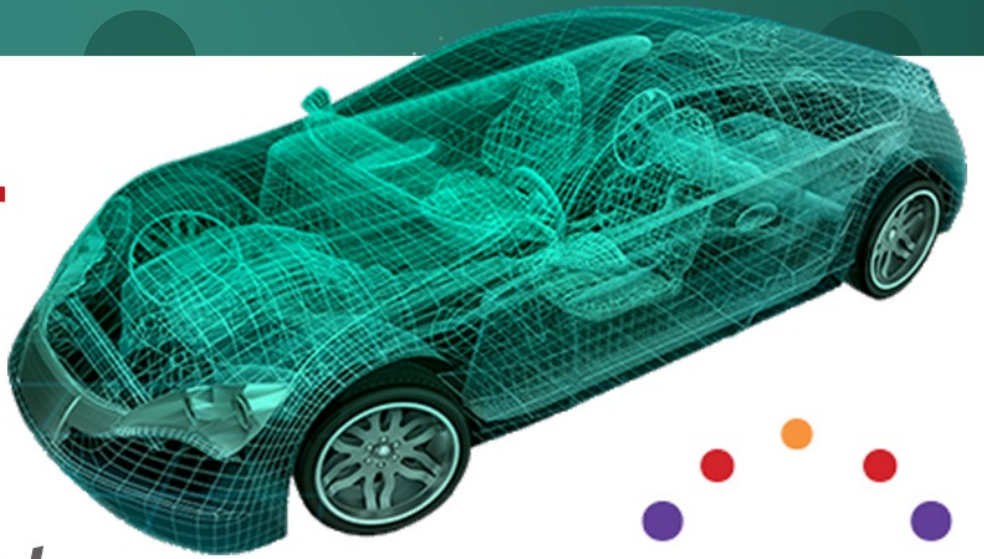
MIPI Automotive Workshop

15 November 2022



Live Virtual Event

mipi alliance

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IF IT'S NOT MIPI, IT'S NOT MOBILE

MIPI Automotive SerDes Solutions:

What Is New in the MASS℠ Connectivity Framework

Ariel Lasry, Qualcomm Inc.
MIPI A-PHY® Working Group Vice Chair

15 November 2022

Agenda

- MASS Overview
- MASS Common End-to-End Model for Sensors and Display
- Camera Service Extensions
- Command and Control Interface Service Extensions
- Display Service Extensions
- Summary

MASS Overview

MIPI Automotive SerDes Solutions (MASS)

A framework for integrating sensors and displays with End-to-End Functional Safety and Security built in

Electronic Control Unit (ECU)

- Advanced driver assistance system (ADAS) based on sensor feeds
- Produces display feeds

Sensors

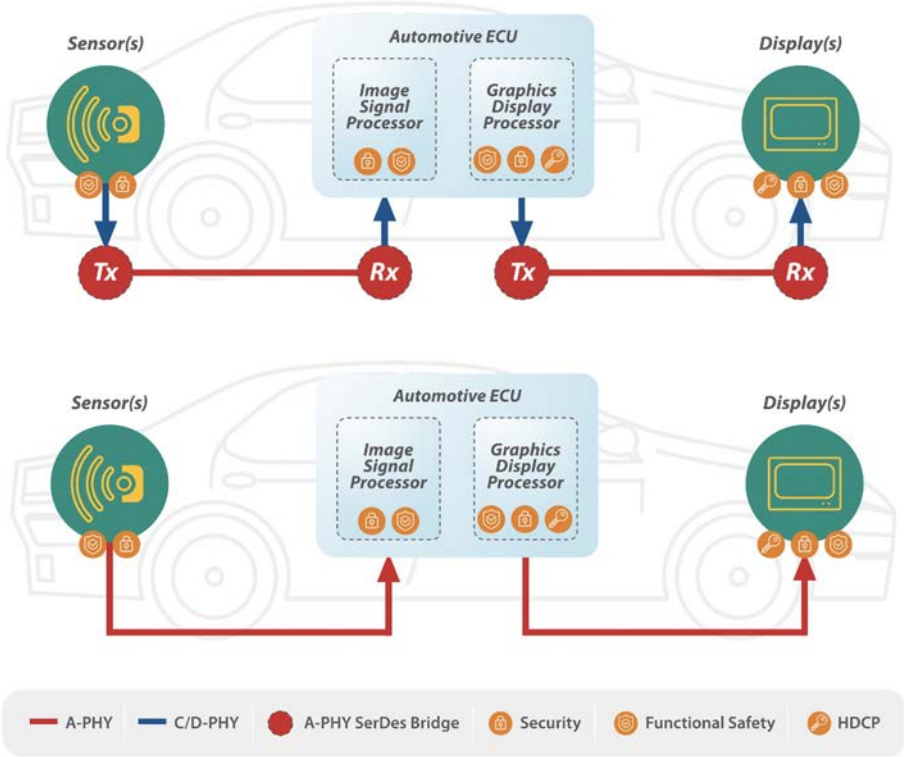
- Camera
- Lidar

Displays

- Dashboard
- Console
- Side-view mirrors
- Entertainment

(Optional) A-PHY bridges

- Translates between short-range MIPI C-PHY / D-PHY & long-range MIPI A-PHY



MASS Guiding Principles

Service Extensions

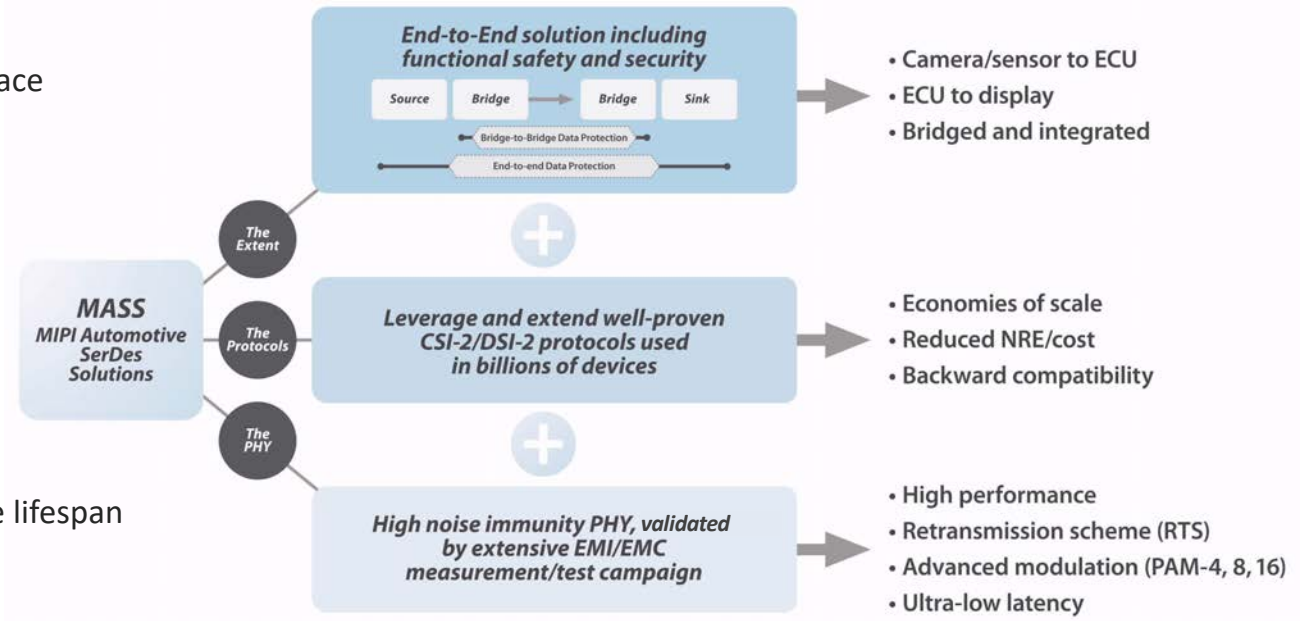
- CSE: Camera Service Extensions
- DSE: Display Service Extensions
- CCISE: Command and Control Interface Service Extensions
- MIPI Security Specification

PALs: Protocol Adaptation Layers

- MIPI CSI-2, DSI-2, I3C
- VESA eDP/DP
- Ethernet, I2C, GPIO, SPI, Audio

A-PHY

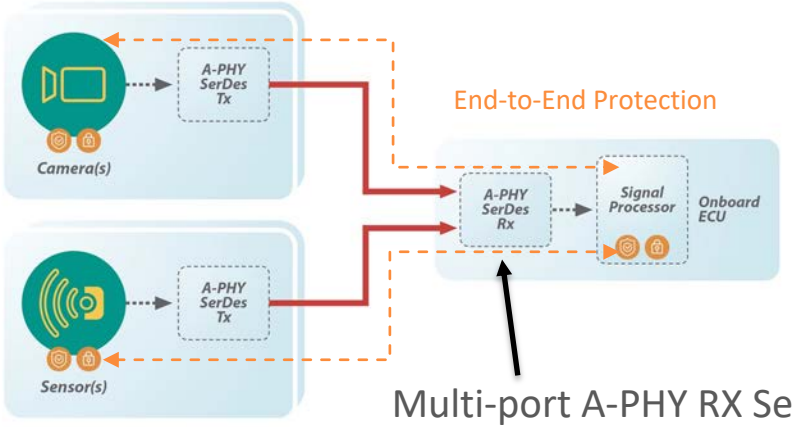
- Robust PHY for Automotive
- MTBF of 1 error over the full vehicle lifespan
- Long-reach PHY (15m)
- Coax, SDP and STQ cables
- Data rates: 2 Gbps – 32 Gbps



MTBF: Meantime Between Failure **SDP:** Shielded Differential Pair **STQ:** Star Quad (shielded dual differential pair)

MASS Supported Topologies – Examples

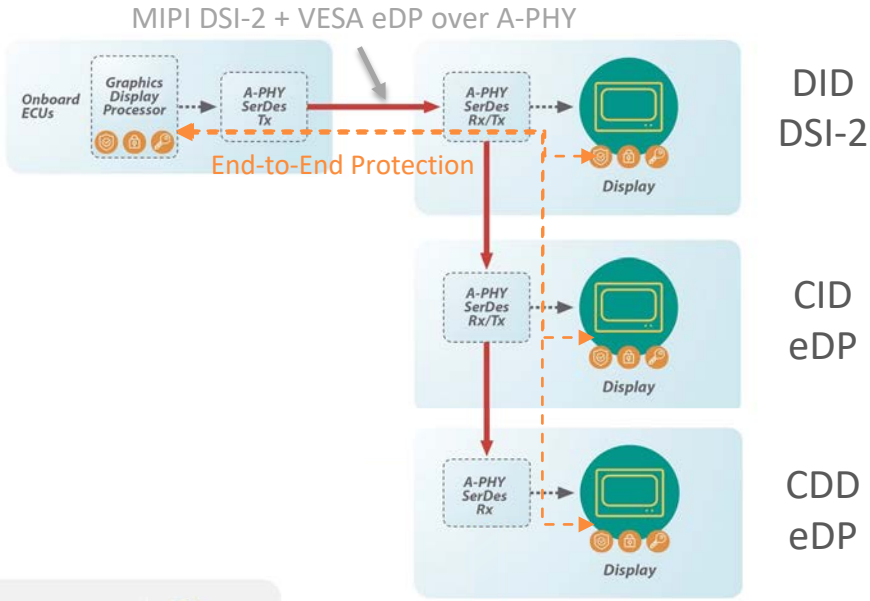
Cameras and Sensors Aggregation



MIPI CSI-2 Sensors

Multi-port A-PHY RX SerDes with CSI-2 Aggregator

Daisy Chaining of Heterogeneous Displays

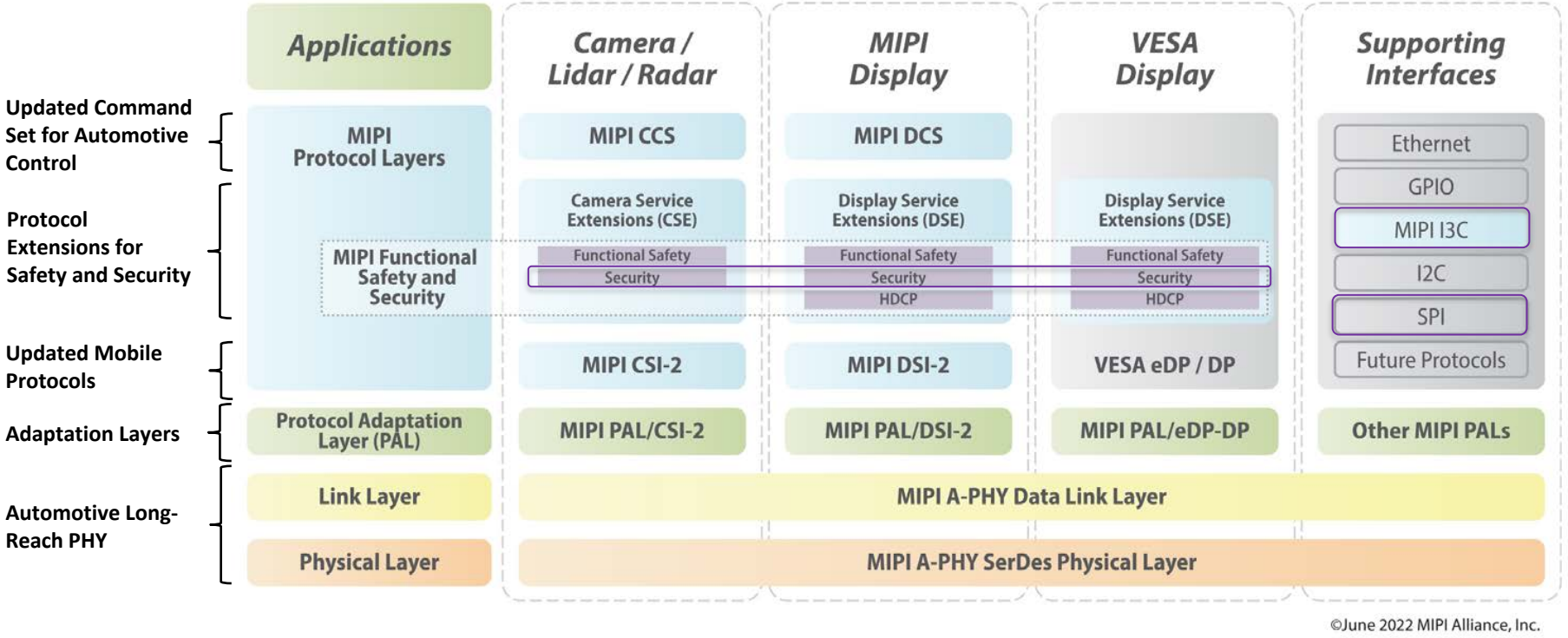


DID: Driver Instrument Display
CID : Central Information Display
CDD: Co-Driver Display

A-PHY | Security | Functional Safety | HDCP

Other common topologies are also supported but not shown

MASS Stack – Framework Nearly Completed



MASS Status

Adopted Specifications

- A-PHY v1.0
- A-PHY v1.1
- PAL/CSI-2 v1.0
- PAL/DSI-2 v1.0
- PAL/eDP/DP v1.0
- PAL/GPIO v1.0
- PAL/I2C v1.0
- PAL/Ethernet v1.0
- CSE v1.0
- DSE v1.0

Under Development

A-PHY v1.1.1	Inclusive Terminology
A-PHY v2.0	Higher data-rate, Security
PoA℠ v1.0	New specification NEW
PAL/SPI v1.0	New specification NEW
PAL/I2C v1.0.1	Inclusive Terminology
PAL/ETH v1.1	Support for frame preemption
PAL/I3C v1.0	New specification NEW
MIPI Security v1.0	New Specification NEW
CCISE v1.0	Command and Control Interface Service Extensions NEW
CSE v2.0	Security, FSED, Timestamping
DSE v1.1	Advanced FuSa, FSED, Timestamping, Audio
DSE v2.0	Security
DCS℠ v2.0	Automotive-related commands

In Adoption Process

- PAL/CSI-2 v1.1
  - timestamping and synchronization

Published Application Notes

- A-PHY Profile 1 and Profile 2

Upcoming Application Notes

- A-PHY RTS and Retraining
- PoA: Power over A-PHY

RTS: Retransmission

FuSa: Functional Safety

FSED: Frame Service Extensions Data

Camera Service Extensions (CSE)

CSE v1.0

- End to End Functional Safety Services
- Message-based Functional Safety protection
- CSI-2 Packets are extended with SEP
- Message Counter and CRC are added per SEP
- Test pattern generation and Error Injection
- ESS-CCI Protocol for End to End Control Plane protection

CSE v2.0

- End to End Security Services: Encryption, Authentication
- FSED Protocol
- Frame-based protection
- SEP per “multiple messages” protection

CCISE v1.0

- Separate specification
- End to End protection of the Control Plane
- Backward compatible to ESS-CCI in CSE v1.0
- Adding Security Services

SEP: Service Extensions Packet
FSED: Frame Service Extensions Data
CRC: Cyclical Redundancy Check
CCISE: Command and Control Interface Service Extensions
ESS-CCI: Enhanced Safety and Security Camera Control Interface

Display Service Extensions (DSE)

DSE v1.0

- End to End Functional Safety Services
- Message-based Functional Safety protection
- SEP support for DSI-2 and VESA eDP/DP
- Message Counter and CRC are added per SEP
- DSI-2 content protection with HDCP IIA

DSE v1.1

- Advanced FuSa features:
  - FuSa protection for ROIs, Compressed Frames
- FSED Protocol
- Frame-based protection
- SEP protection per Frame
- Audio Forwarding Service

DSE v2.0

- End to End Security Services: Encryption, Authentication
- Side band control (TBD)
- End to End protection of the Control Plane

SEP: Service Extensions Packet
FSED: Frame Service Extensions Data
CRC: Cyclical Redundancy Check
HDCP IIA: HDCP Interface Independent Adaptation (by DCP LLC)

MASS End-to-End Protection

Common Model for Sensors and Displays

ISO26262-5 Annex D – Communications Bus


INTERNATIONAL STANDARD

ISO 26262-5

Second edition 2018-12

Road vehicles — Functional safety —

Part 5: Product development at the hardware level

Véhicules routiers — Sécurité fonctionnelle —

Partie 5: Développement du produit au niveau du matériel

Reference number ISO 26262-5:2018(E)

© ISO 2018

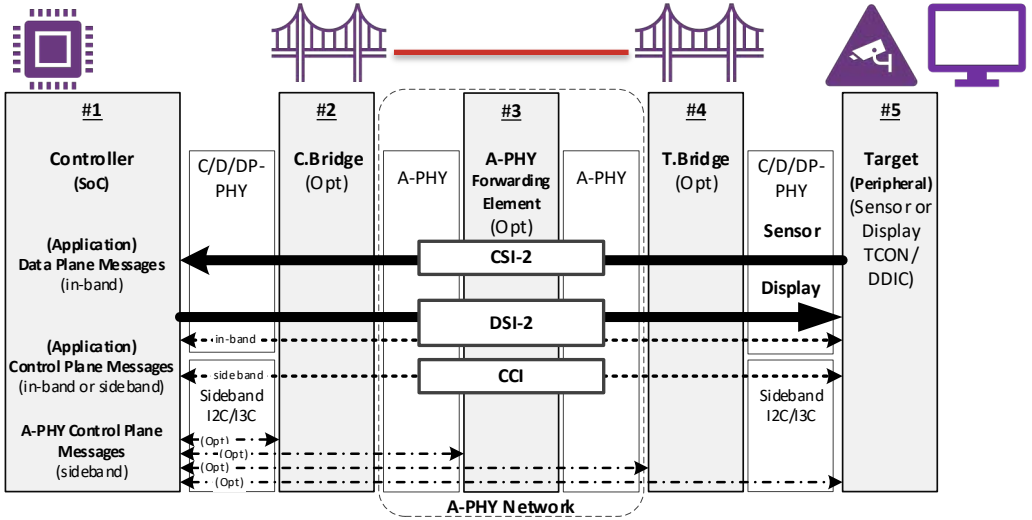
Annex D – Communication bus safety mechanisms:

- One-bit hardware redundancy
- Multi-bit hardware redundancy
- Read back of sent message
- Complete hardware redundancy
- Inspection using test patterns
- Transmission redundancy
- Information redundancy
- Frame counter
- Timeout monitoring
- Combination of information redundancy, frame counter and timeout monitoring

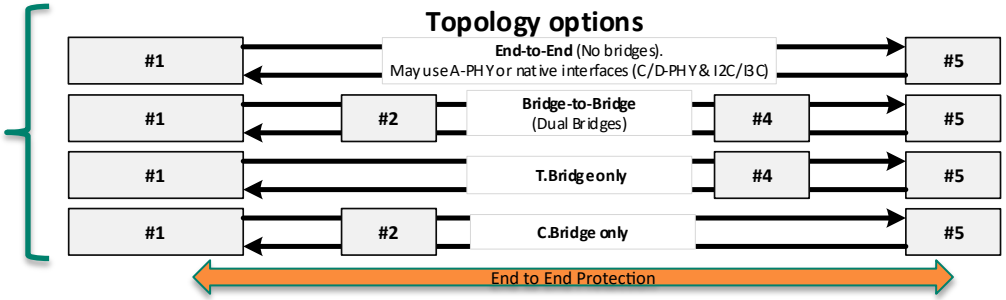
1-5 Model: Reference Topology

End-to-End Functional Safety and Security Protection

- Up to 5 functional **components**
- **Controller** connections to all components that include **Bridges** and **Forwarding Elements**

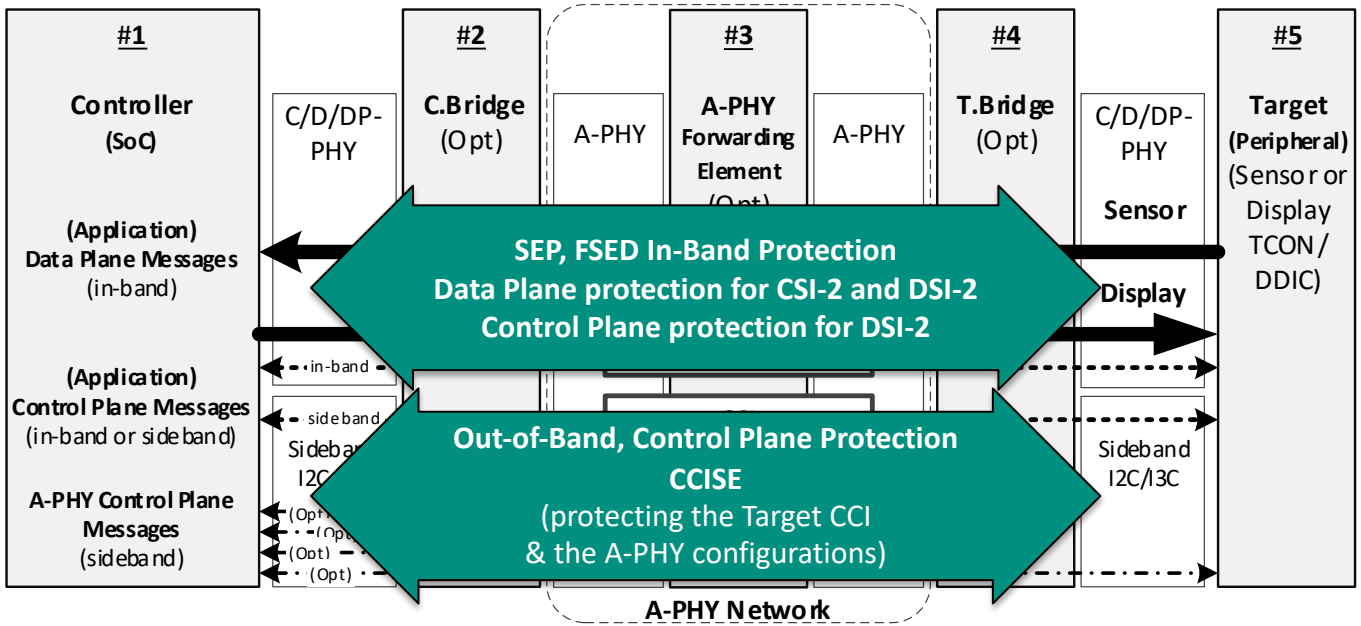


- Any combination of Bridges



3 Data Service Protocols (DSP): SEP, FSED, CCISE

End-to-End Functional Safety and Security Protection



Data Service Protocols (DSP)

SEP: Service Extensions Packet
Granularity: Message-based
Reach: Sensor to Controller, End-to-End (1-5)
Bridge to Bridge (2-4), also (1-4) and (2-5)

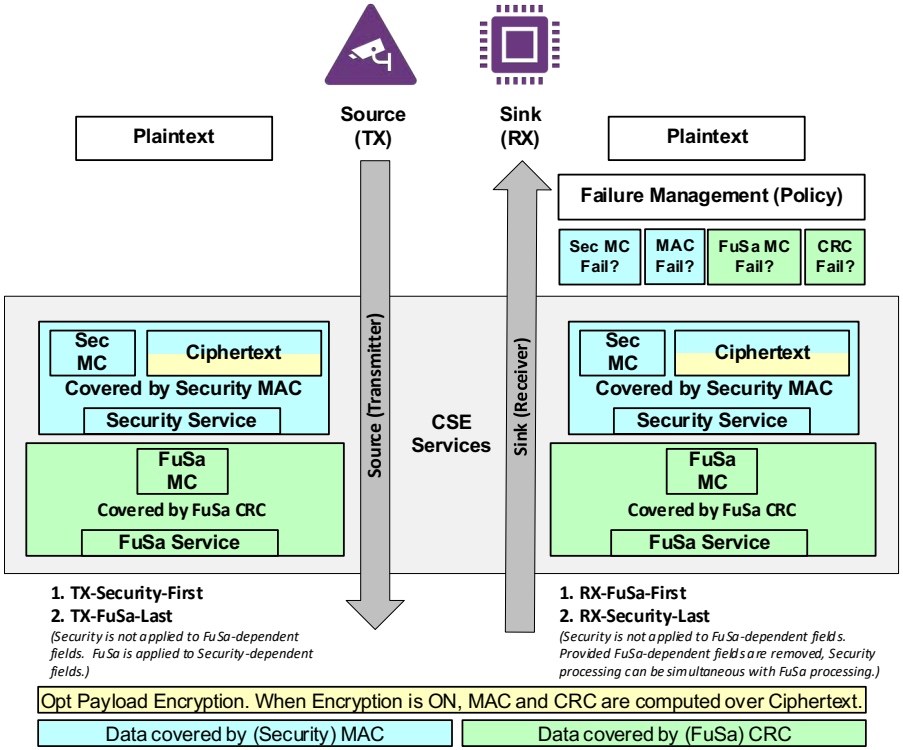
FSED: Frame-Based Service Extensions Data
Granularity: Frame-based
Reach: Sensor to Controller, End-to-End (1-5)

CCISE: CCI Service Extensions
Granularity: I^2C Transaction (Start to Stop)
Reach: Controller to all Targets, End-to-End (1-5)
End-to-End (1-2), (1-3), (1-4)

SEP and FSED for Sensors

Camera Service Extensions (CSE)

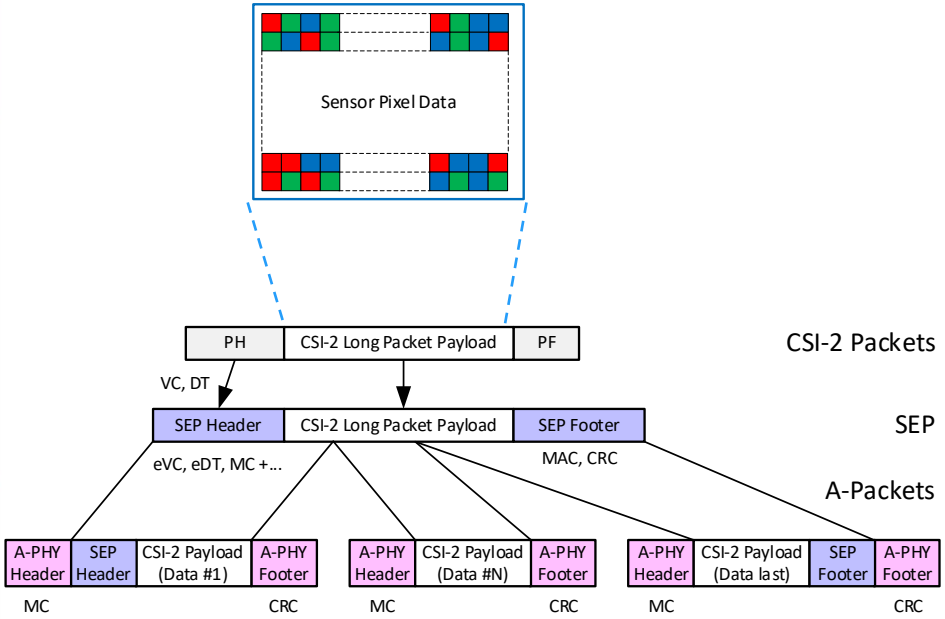
MIPI Camera Service Extensions (CSE) Layering



MAC: Message Authentication Code
CRC: Cyclical Redundancy Check
MC: Message Counter
FuSa: Functional Safety

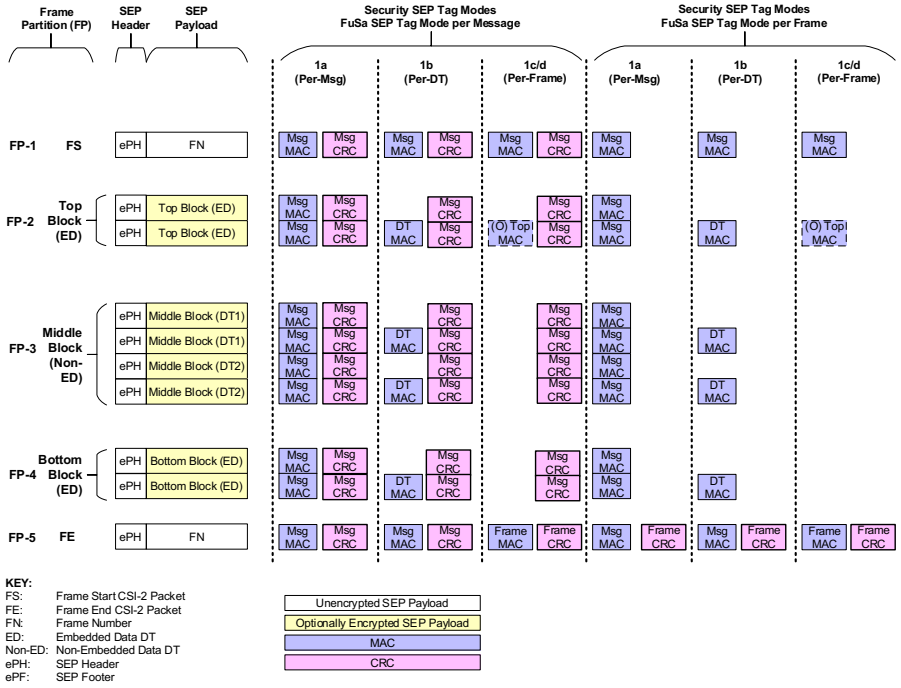
- Data Service Protocols (DSP) provide Security and Functional Safety Services for protecting CSI-2 and CCI traffic in the following order:
  - TX Security first
  - TX FuSa last
- The receiver performs the operations in reverse order
- This layering applies to all 3 DSPs: FSED, SEP and CCISE
- Failure management policy is defined by the system

Service Extension Packet (SEP) over A-PHY



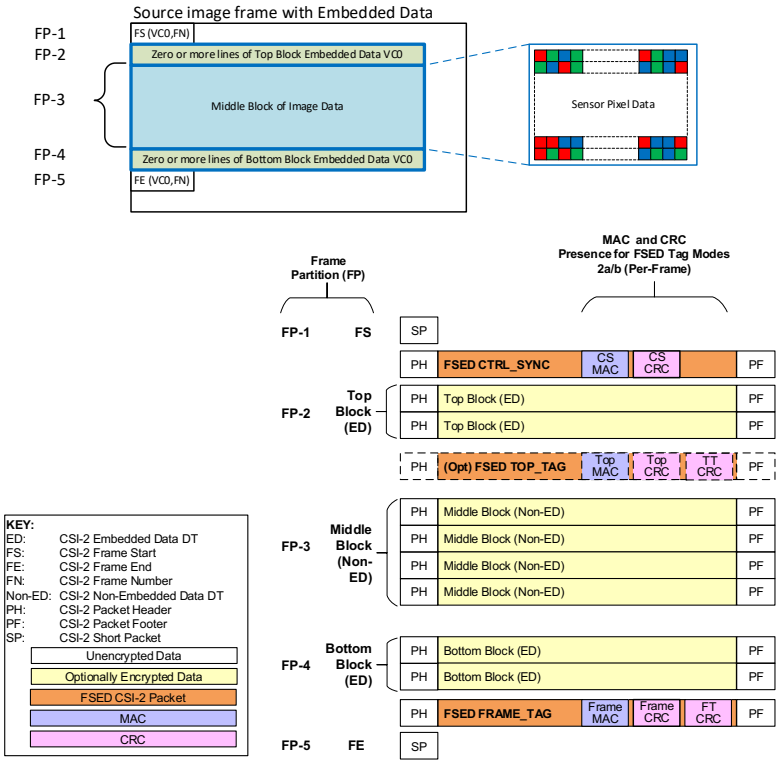
- CSI-2 Packets are extended with SEP
- SEP is protected end-to-end on application protocol level with
  - FuSa Message Counter in SEP Header
  - Security Message Counter in SEP Header
  - MAC in SEP Footer
  - CRC-32 with Hamming Distance ≥ 3 in SEP Footer
- SEP Header contains extended CSI-2 PH information
  - eVC: extended Virtual Channel
  - eDT: extended Data Type
  - Source ID: identifying the sensor
  - Other fields (timesamp, Row ID, Column ID etc.)
- SEP are chunked to multiple A-Packets when transported over A-PHY. Each A-Packet is protected with a Message Counter and CRC-32

CSE SEP Tag Modes



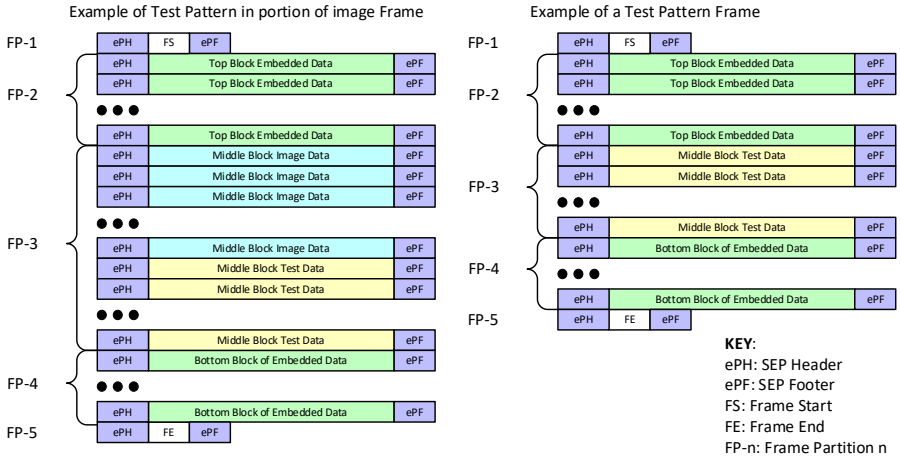
- Two Tag Modes for FuSa
  - Per Message
  - Per Frame
- Three Tag Modes for Security
  - Per Message
  - Per Data Type
  - Per Frame
- Provides a trade-off between Tag overhead and error detection latency
- Optional TOP Tag for early error detection in TOP Embedded Data when using a single Tag per Frame
- CSE v1.0 supports only Per Message CRC
- CSE v2.0 introduces Per DT and Per Frame Tag Modes

Frame-Based Service Extensions Data (FSED) in CSE



- FSED protects End-to-End CSI-2 Frames at application protocol level
- PHY agnostic using “legacy” CSI-2 packets
- Adds FSED Messages to “regular” CSI-2 Frames
  - FSED CTRL_SYNC provides Frame information and security configuration
  - Optional FSED TOP_TAG protecting the Top Block
  - FSED FRAME_TAG protecting the full CSI-2 Frame
- FSED Messages transported as CSI-2 Embedded Data

Built-In Self Tests (BIST) and Diagnostics



- Increasing diagnostic level with
  - Test pattern generation
  - Faults injection
- Tests can be applied
  - During initialization
  - Runtime
  - Every N frames
- CSE specifies 5 standards patterns. Sensor vendors can add own specific patterns
- Further diagnostics with A-PHY BIST
  - BIST A-Packets generation
  - BIST A-Packets monitoring

Command and Control Interface Service Extensions (CCISE)

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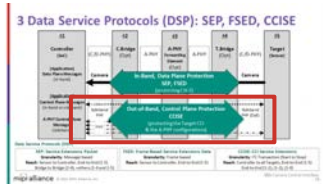
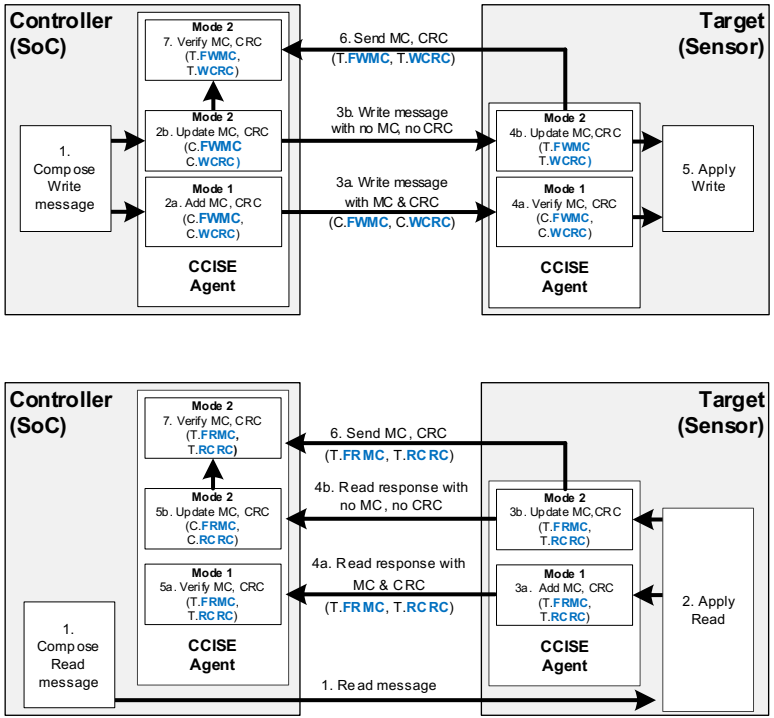
Control Plane Protection with CCISE



- Command and Control Interface **Service Extensions** (CCISE) add Functional Safety and Security services to CCI (I2C)
- CCISE supports control of
  - Camera Control Interface CCI (I2C)
  - A-PHY bridges and forwarding elements
  - Any other device controlled via I2C (or virtual I2C with PAL/I2C)
- CCI (I2C) Messages are extended with Tags
  - Functional Safety Tags: Message Counter, CRC
  - Security Tags: Message Counter, MAC
  - Separate Tags for Read and Write Messages
- Two CCISE verification modes
  - **Mode 1**: **Per-Transaction**. Tags are transmitted with the Messages and can be **verified immediately by the Target** or the Controller
  - **Mode 2**: **Per-Frame**. Tags are not transmitted with the Messages. Tags are calculated over an entire CSI-2 Frame, both at the Controller and at the Target. Tags are sent from the Target to the Controller
    - Within CSI-2 Embedded Data or
    - Controller read access to the Tags

    Tags are verified by the Controller. Mode 2 is motivated by the speed limit of I2C interface.

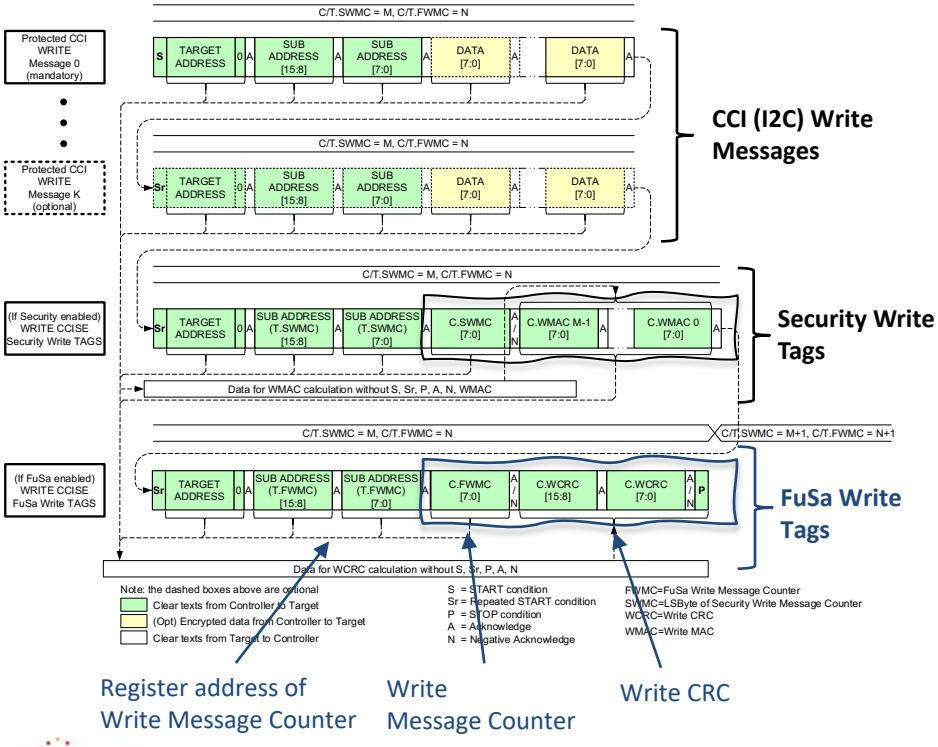
CCISE Functional Safety Protection Flow



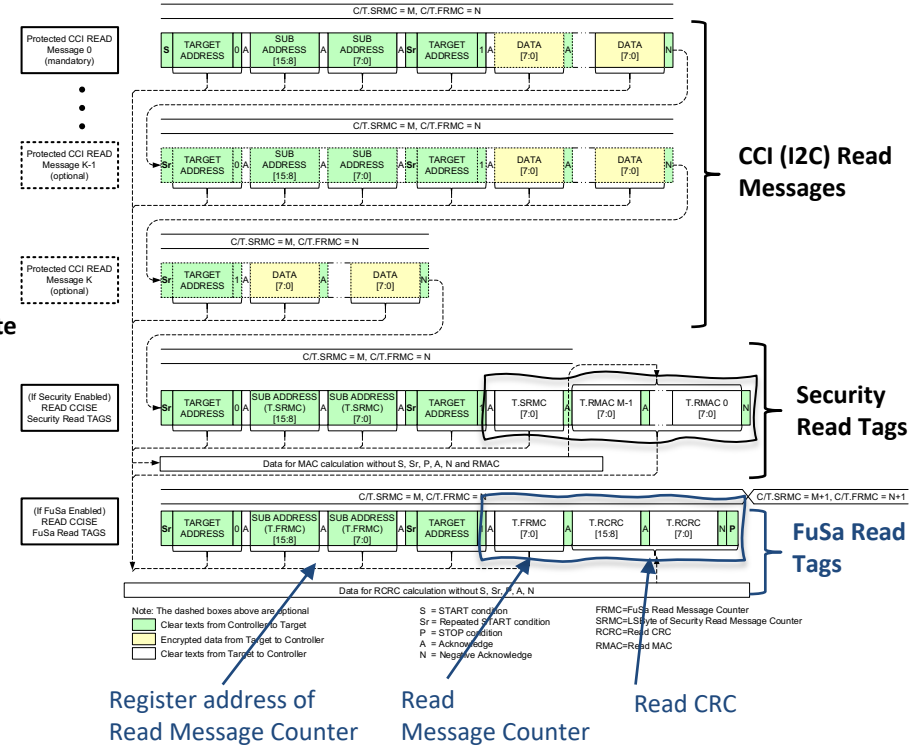
CCISE Mode 1

Tags are added as Footer to CCI (I2C) Read/Write Transactions

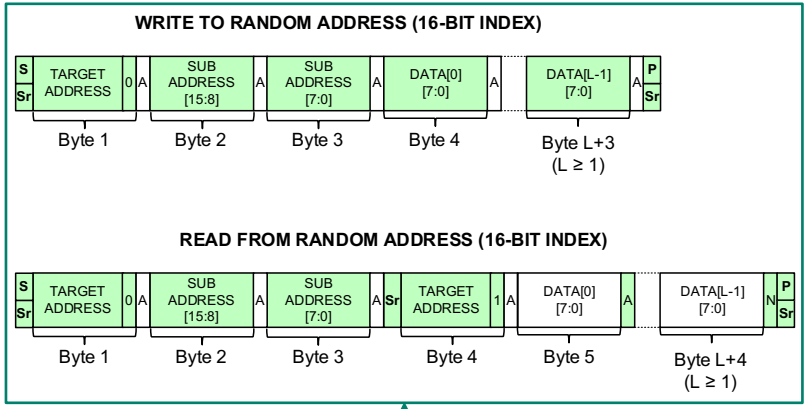
WRITE Transaction



READ Transaction



CCISE Mode 2



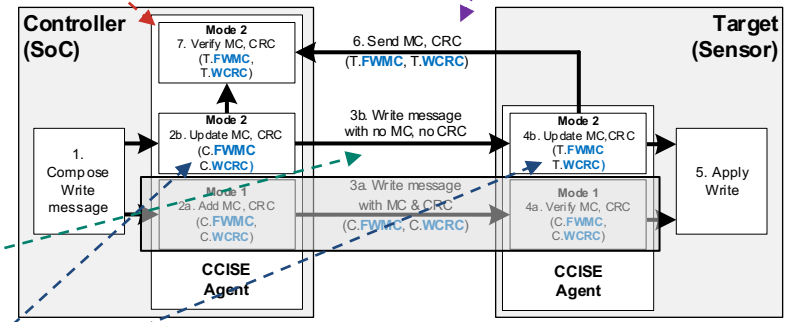
Exactly same transactions on the line as in CCI (I2C)

- No Tags on the wire
- No overhead

Controller verifies Tags

Accumulated Tags are sent from the Sensor to the Controller at the end of the CSI-2 Frame

- As CSI-2 Embedded Data or
- Controller reads Tags registers



Both Controller and Target calculate independently the Functional Safety Tags accumulated over the CSI-2 Frame

- Write Message Counter (FWMC), Write CRC (WCRC)
- Read Message Counter (FRMC), Read CRC (RCRC)

Display Service Extensions (DSE)

Features for v1.1

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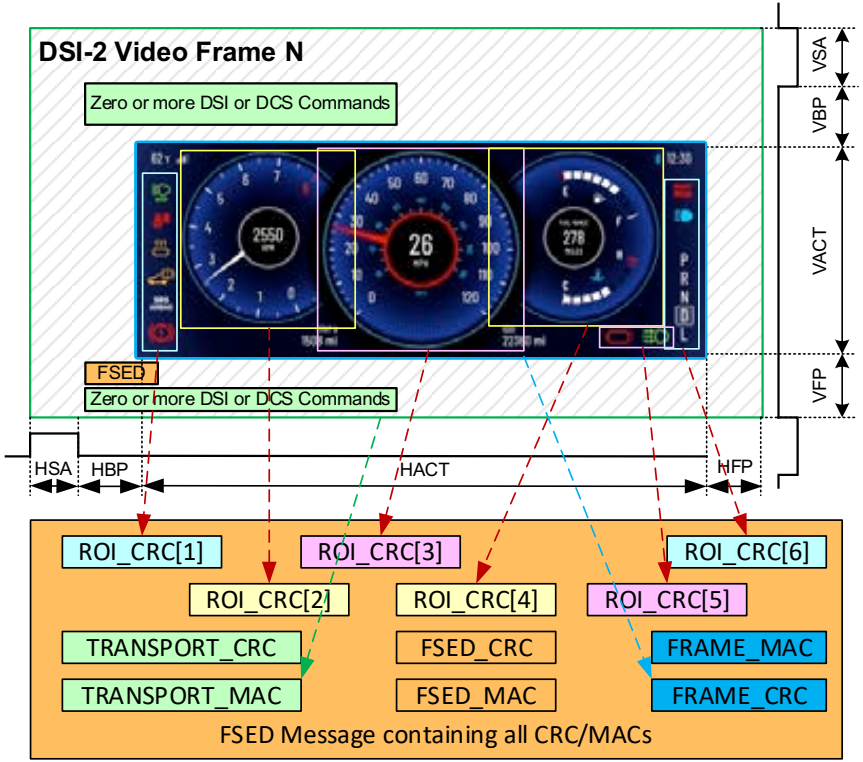
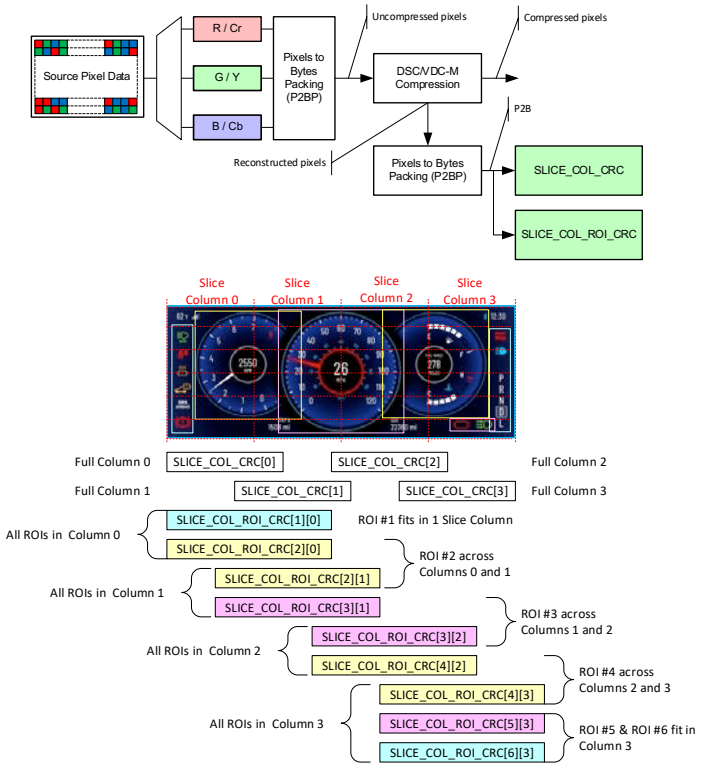
FSED in Display Service Extensions (DSE)



- One FSED Message per DSI-2 Video Frame
- Contains FuSa & Security extension data
  - Frame number
  - CRCs
  - MACs
- FRAME CRC/MAC for Active Video Area
- TRANSPORT CRC/MAC for “meta data” (display commands and control)
- Region of Interest (ROI)
  - Up to 16 ROIs – ROIs can overlap
  - 1 CRC per ROI
- Note: Security support from DSE v2.0 only

FSED: Frame Service Extensions Data

FuSa Support for Compression in DSE



- Visually lossless compresssion with VESA DSC and VDC-M
- CRCs are calculated over the “reconstructed“ pixels
  - Matching between TX and RX
  - Compression engine is covered by the CRC
- Compression engine runs over slices. To ease the implementation, DSE defines Slice Columns
- Each Slice Column has its own CRC
- For ROI, CRCs are calculated over the Slice Columns
- All CRCs are sent in the FSED Message at the end of the DSI-2 Video Frame
- DSE aligning with VESA on CRC calculations

Summary

- MASS leverages and extends well-proven protocols (e.g., CSI-2, DSI-2, eDP)
- MASS provides a standardized framework enabling end-to-end functional safety and security protection at the application protocol level
  - Data plane with SEP and FSED
  - Control plane with CCISE
- Flexibility with message-based and frame-based protections to enable system integrator trade-offs
- Advanced self-testing and error injection features for a higher functional safety diagnosis level
- A-PHY and MASS are architected for seamless integration into sensors, providing an optimal robust and resilient solution for automotive safety applications

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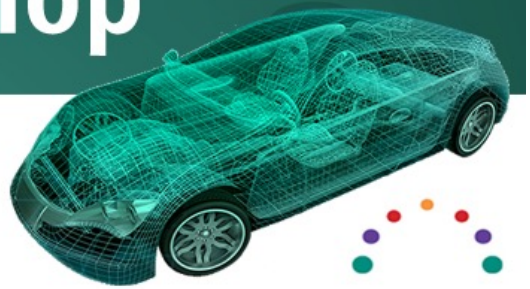

Q&A

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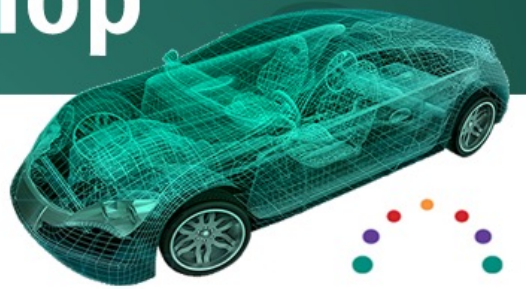

THANK YOU

Check back at http://www.mipi.org/2022-automotive-workshop
to view recordings of any sessions you missed