ETHERNET IN REDUNDANT NETWORKS

OPERATION OF IEEE802.1AS AND IEEE802.1CB

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AGENDA

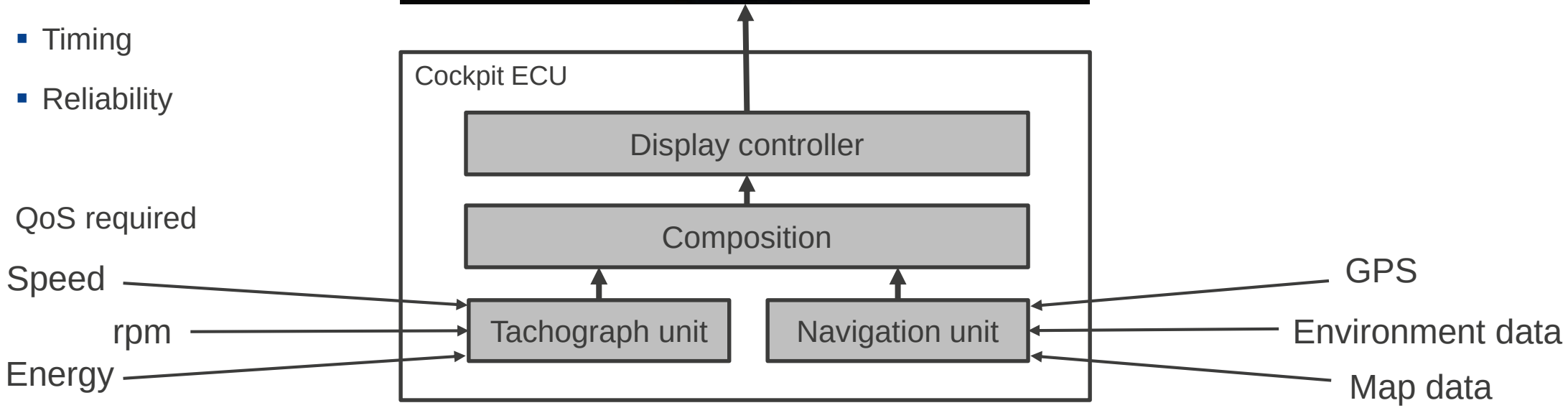
- Automotive Ethernet – The backbone for data communication
- Look inside IEEE 802.1CB
- Look inside IEEE 802.1AS
- Redundant clock synchronization
- Summary

IN VEHICLE NETWORK AND DISPLAY SYSTEMS

There is need for QoS, time synchronization and redundancy

- Network has limitations
  - Bandwidth
  - Synchronization
  - Latency
  - Timing
  - Reliability

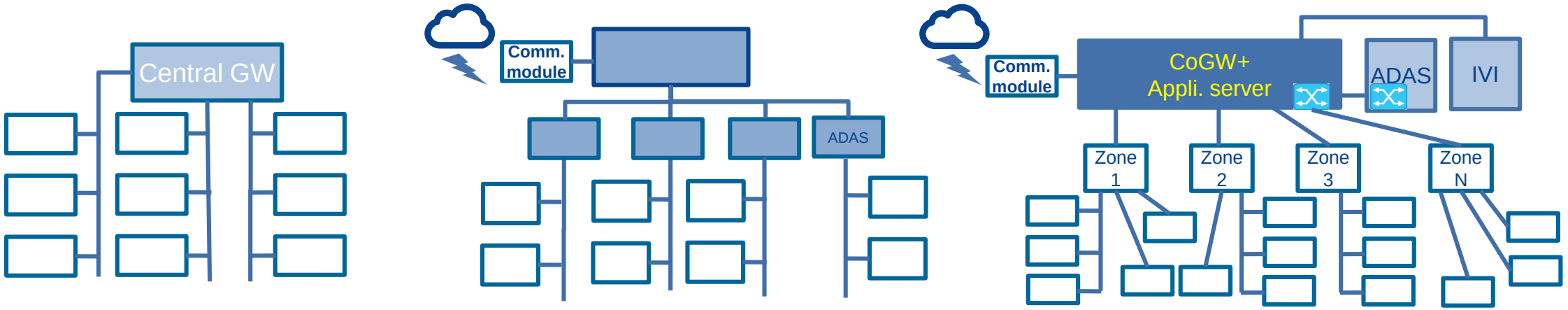
- QoS required



From 18th GENIVI AMM - Wayland-IVI-extension / Waltham Usage in Shared Graphics Environment

IN VEHICLE NETWORK
CHANGE IN STRUCTURE

Central Gateway | Domain Controller | In Vehicle Server



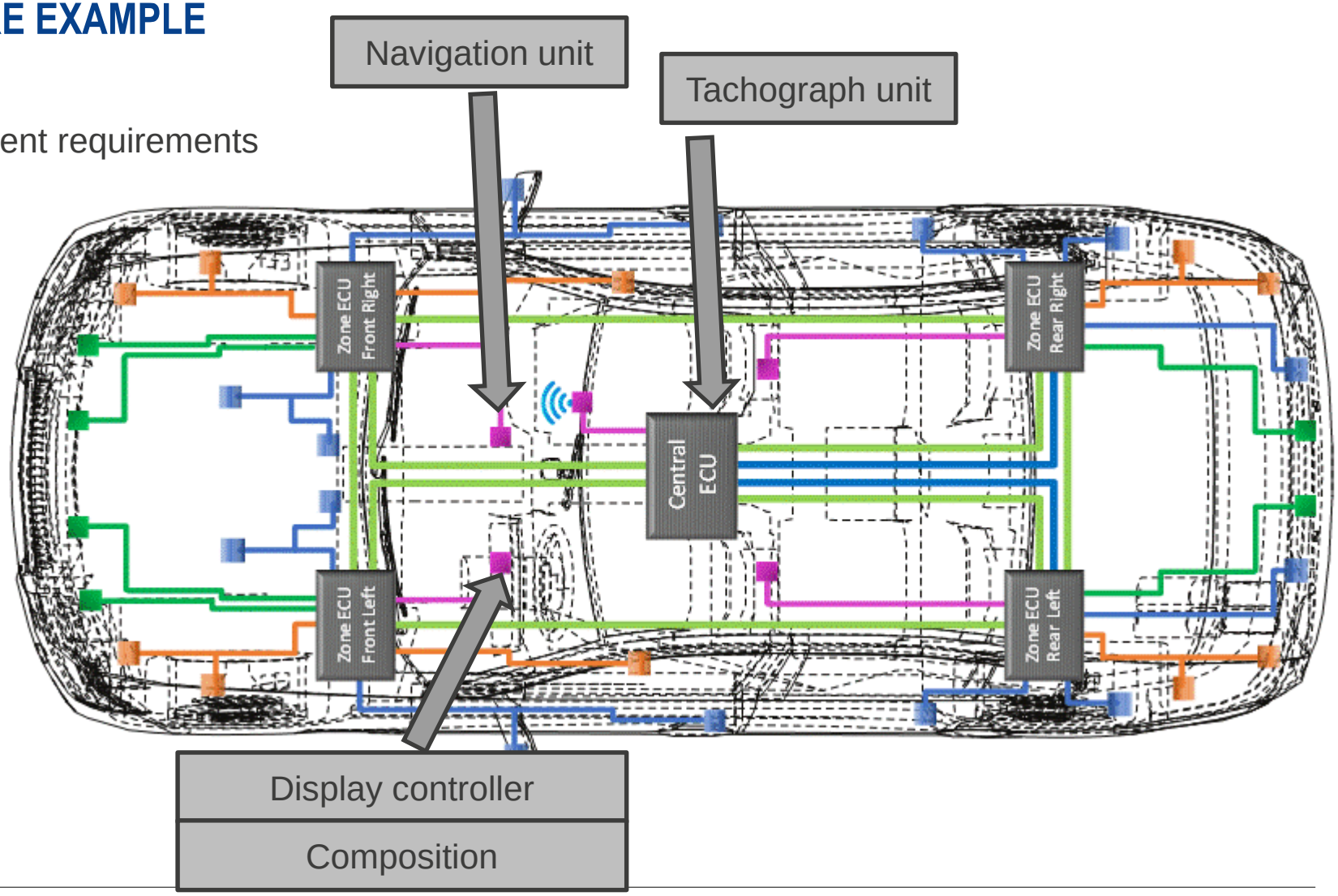
Challenges

- Scalability
- Bandwidth
- Flexibility
- Complexity
- Distributed function
- Ethernet
- Mixed traffic

IN VEHICLE NETWORK
ZONE BASED ARCHITECTURE EXAMPLE

- Diverse applications with different requirements over same network, e.g.
  - Entertainment
  - ADAS
  - Sensor data
  - Control data
- Old and new technology
- Distributed functions

- Ethernet as backbone with features for QoS, time synch and reliability needed



IEEE STANDARDIZATION ACTIVITY
EXTENSIONS TO ACHIEVE QOS

- IEEE 802.1 Audio Video bridging (AVB) task group was started in 2005
  - Use cases in professional audio/ video market
  - Consumer audio/ video market
  - Automotive infotainment

- Over the time AVB capabilities was becoming very interesting also to other groups
  - Industrial
  - Automotive control and sensing
  - Configuration and service management

- Goals
  - Open standard for audio / video transport
  - Precise clock synchronization
  - Bounded latency for different frame classes
  - Traffic shaping to avoid bursts

- Goals:
  - Support all data types (Audio, Video, Sensor, Control)
  - Latency improvements
  - Increase transport reliability
  - Increase network robustness

TIME SENSITIVE NETWORKING
TOOLBOX CONCEPT

Category	Standard
Time Synchronization	IEEE 802.1AS-rev Timing and Synchronization for Time-sensitive applications
Stream Reservation/ Network management	IEEE 802.1Qat Stream Reservation Protocol (AVB)
	IEEE 802.1Qcc SRP enhancements and Performance Improvements
Quality of Service	IEEE 802.1Qav Forwarding and Queueing Enhancements for Time-Sensitive Streams
	IEEE 802.1Qbu + 802.3br Frame preemption
	IEEE 802.1Qcr Asynchronous Traffic Shaping
	IEEE 802.1Qbv Enhancements for Scheduled Traffic (Time aware Shaping)
	IEEE 802.1Qch Cyclic Queuing and Forwarding
Reliability	IEEE 802.1Qca Path Control and Reservation
	IEEE 802.1CB Frame Replication and Elimination for Reliability (FRER)
	IEEE 802.1Qci Per-Stream Filtering and Policing

Compressed list. For details visit www.ieee802.org

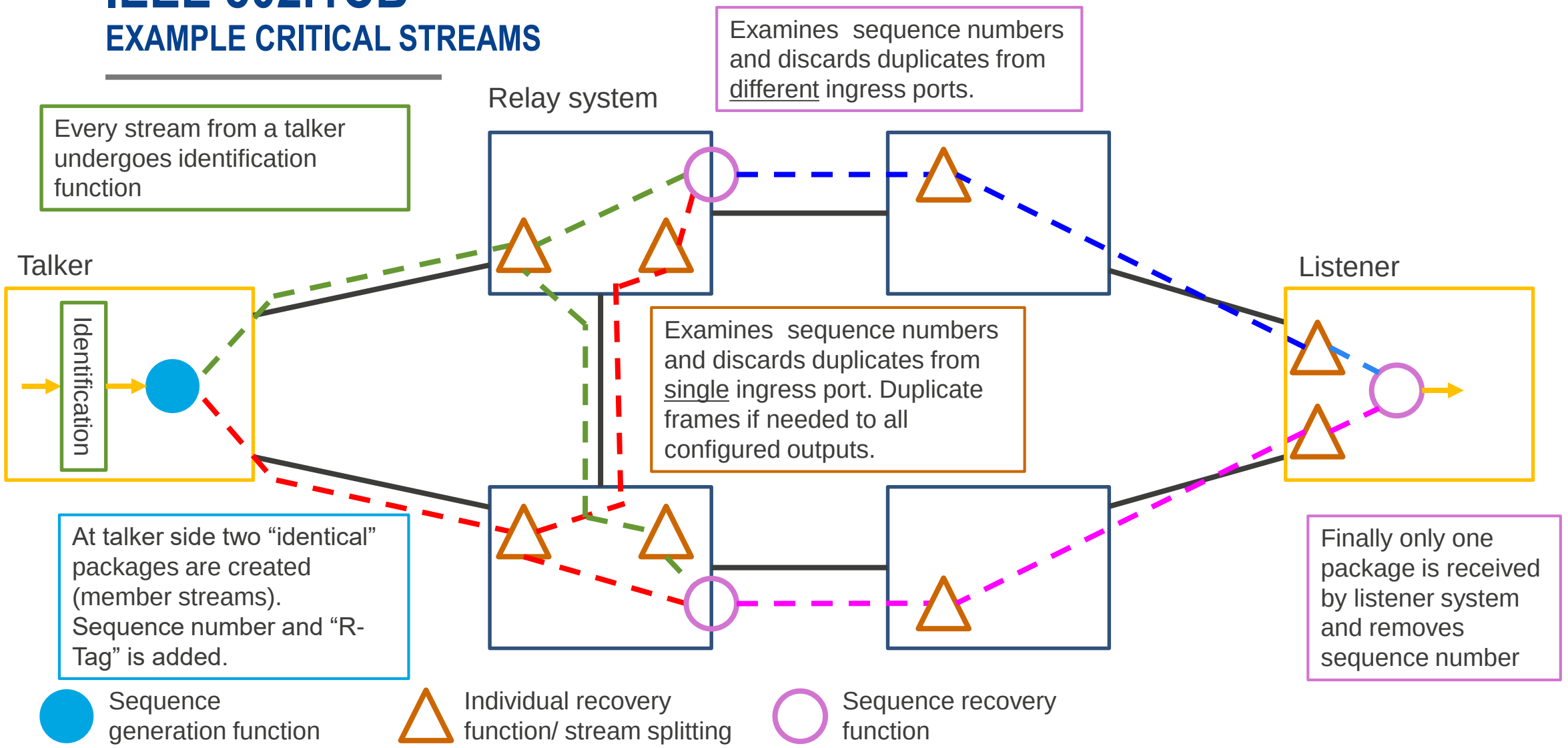
IEEE 802.1CB

IEEE 802.1CB
INTRODUCTION

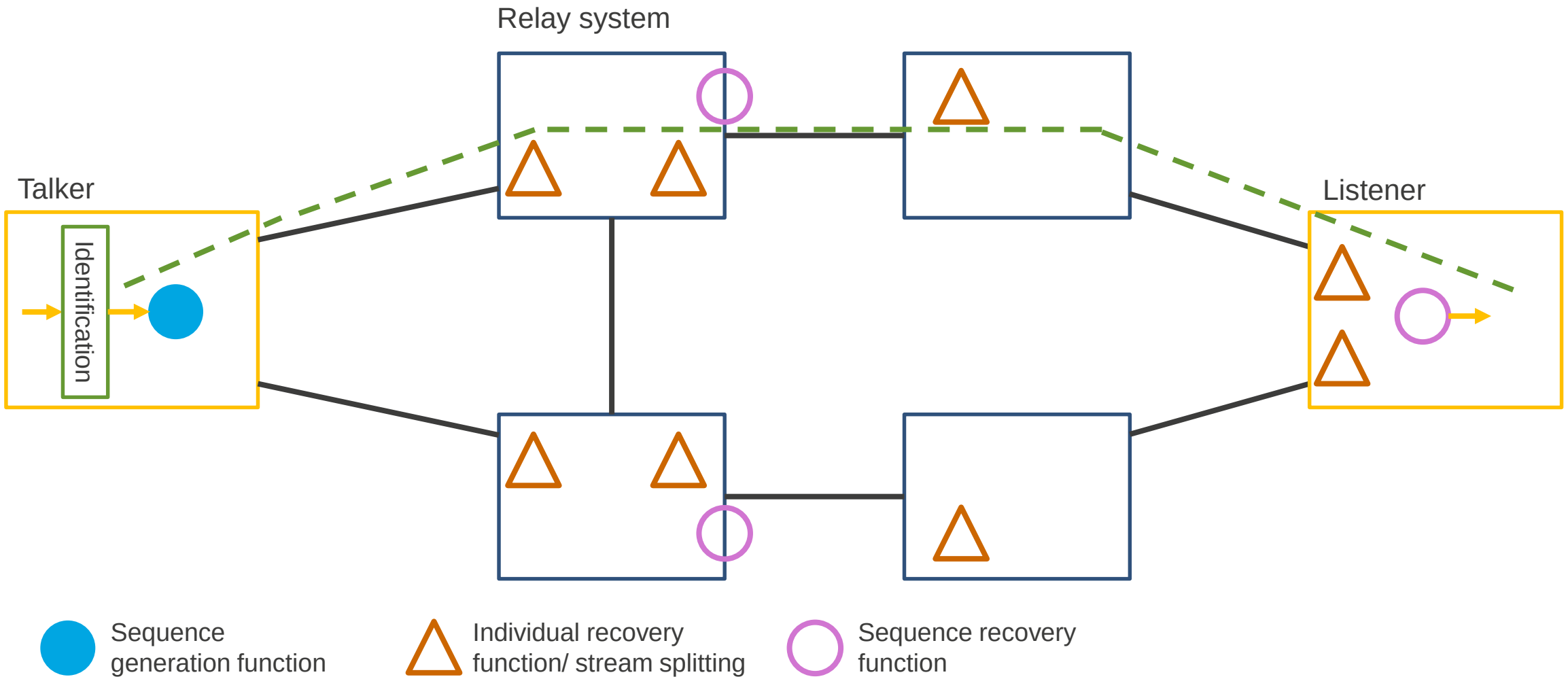
- Critical data must arrive at destination
- Re-transmission would cause not acceptable delay
- My network has limited resources
- Loosing uncritical traffic is acceptable
- Should be transparent for the application layer

- IEEE802.1CB covers following failure models
  - Link loss (e.g. broken cable)
  - Package loss (e.g. CRC error)
  - Stuck transmitter (e.g. software/ hardware failure)

IEEE 802.1CB
EXAMPLE CRITICAL STREAMS



IEEE 802.1CB
EXAMPLE NOT CRITICAL STREAMS

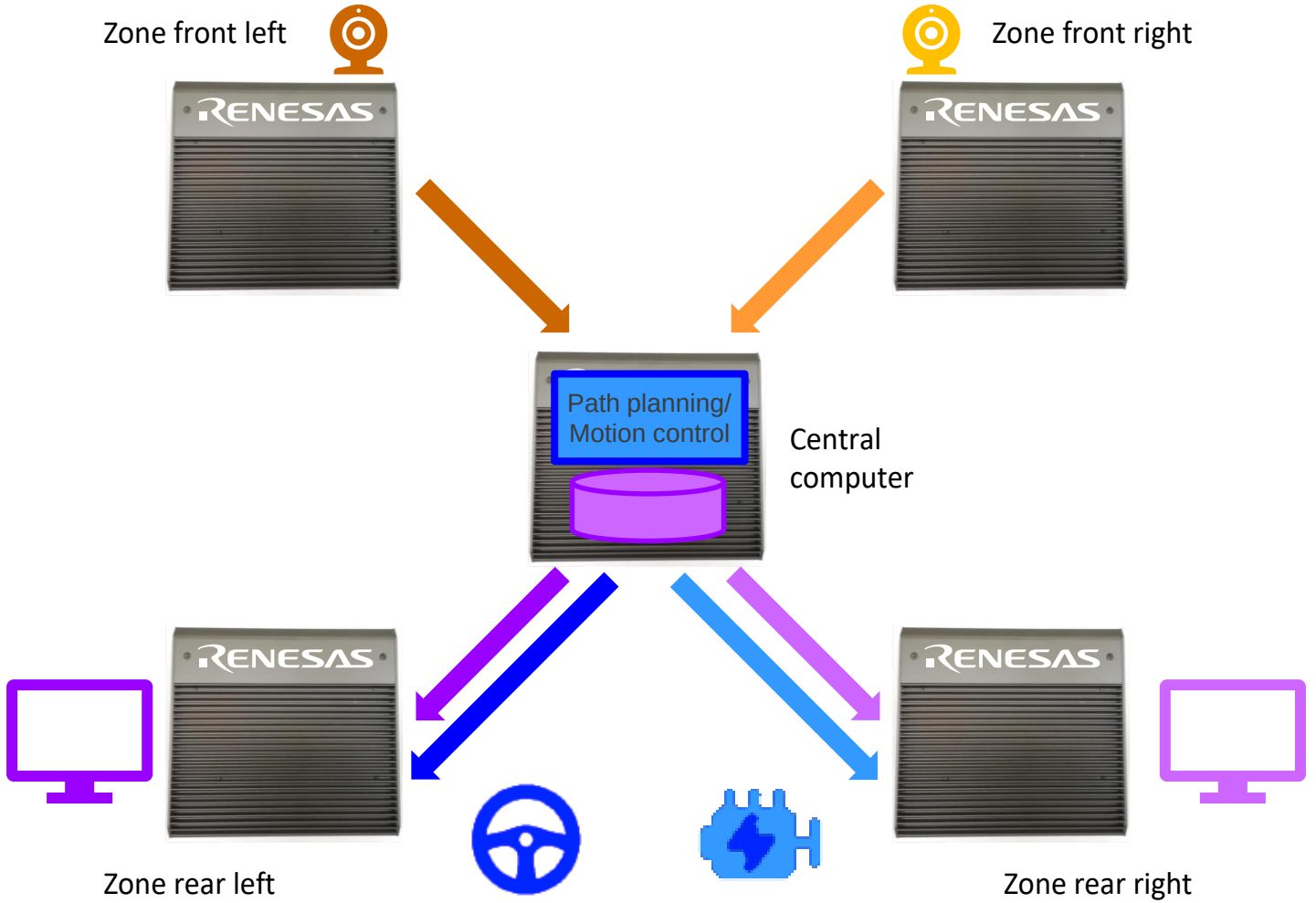


IEEE 802.1CB OPERATION EXAMPLE
SETUP

Camera traffic

Control traffic

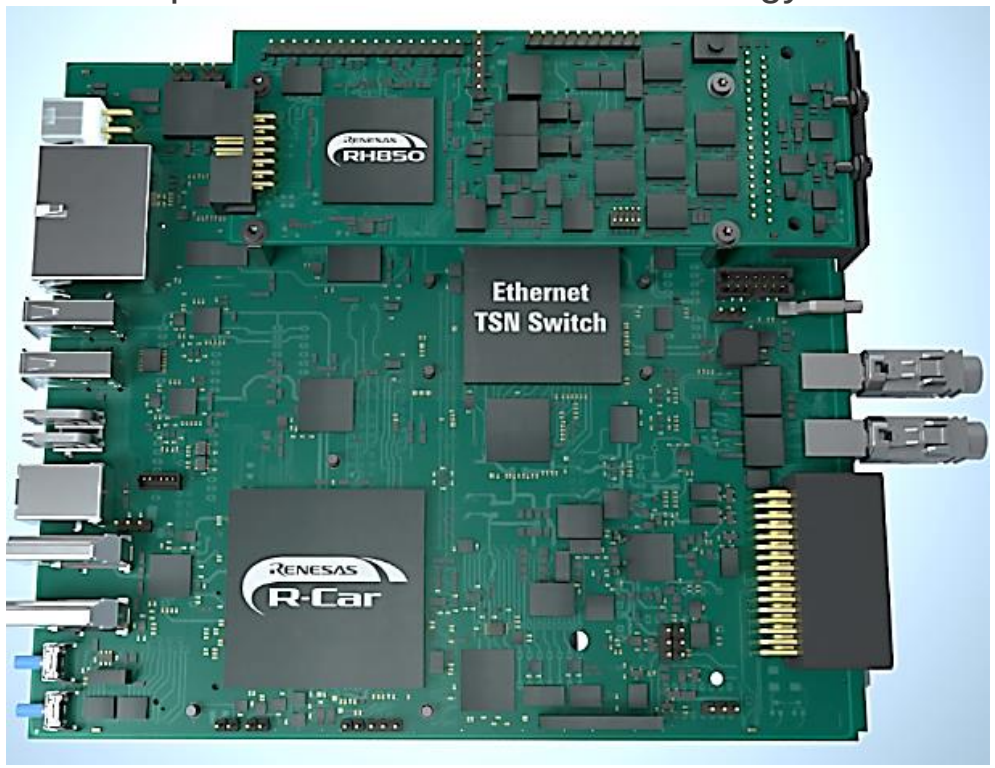
Entertainment video



LOOK INSIDE ECUS

PRE-SILICON DEVELOPMENT KIT VEHICLE COMPUTER 2

- Provide communication gateway solution kit for the next gen. E/E architecture
- Can start quickly of proof of concept (PoC) and prototype development with latest TSN technology



Specification:

- R-Car-H3
- RH850 F1KH-D8 (8M Flash)
- TSN Ethernet Switch (FPGA)
- Connectivity
  - 1Gbps Ethernet (1000Base-TX)
  - 6x100Mbps (5x100Base-T1, 1x100Base-TX)
  - 11x CAN-FD
  - 2x FlexRay / 10x LIN
  - 1x MOST150
  - HDMI
  - 2x USB2.0/ 1x USB3.0
  - 1x WLAN 802.11ac
  - PCI Express

IEEE 802.1CB OPERATION EXAMPLE
RING MODE

Primary camera traffic

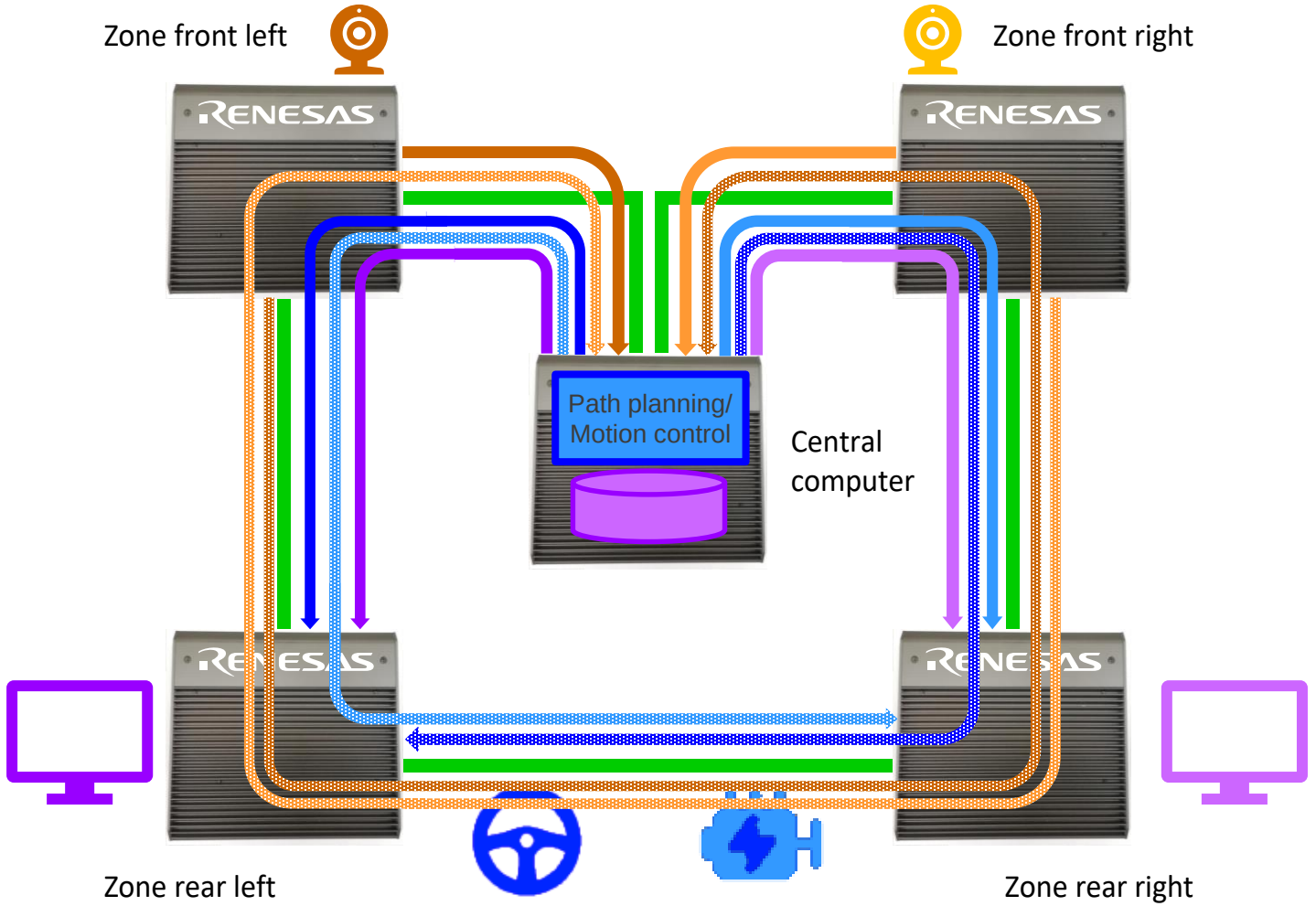
Redundant camera traffic

Primary control traffic

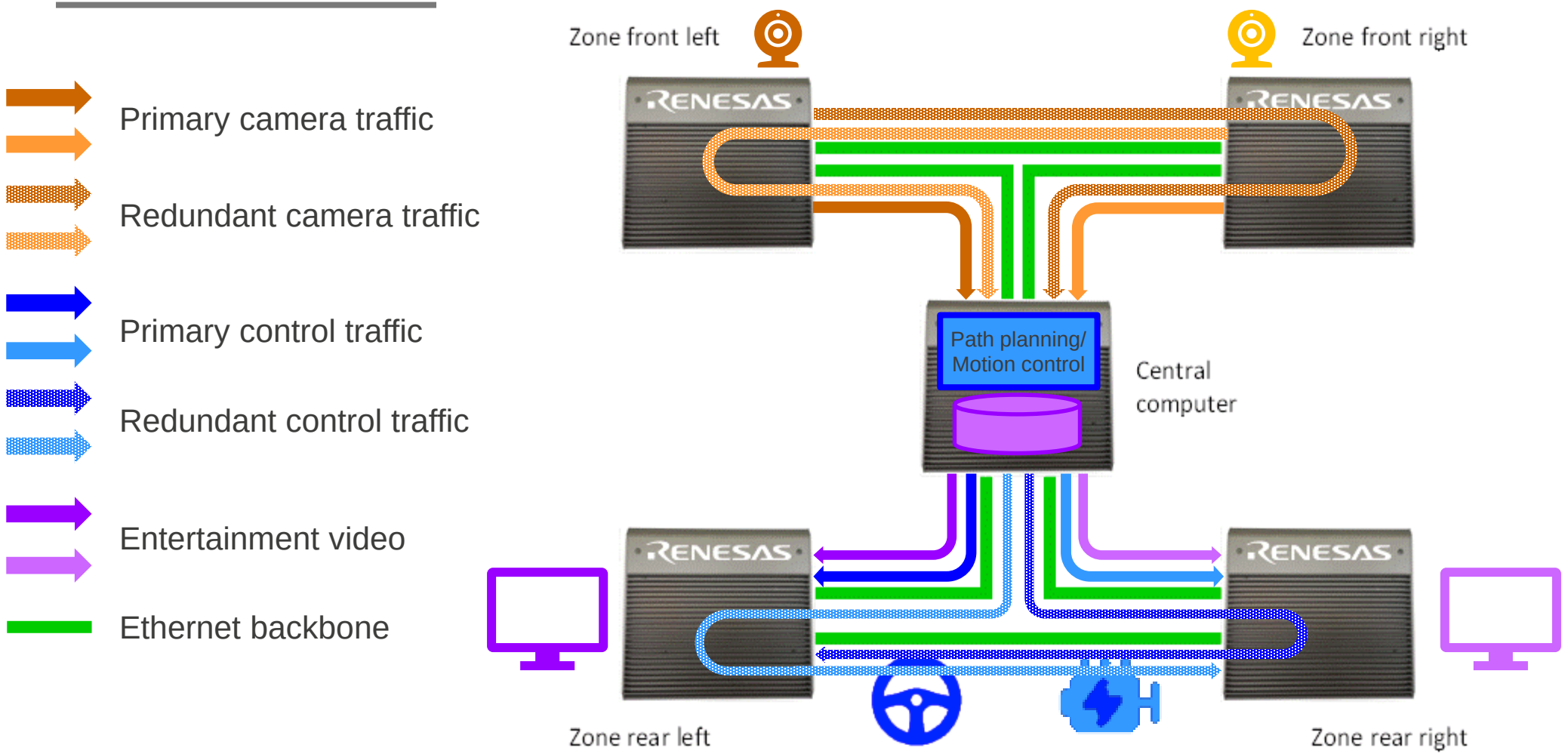
Redundant control traffic

Entertainment video

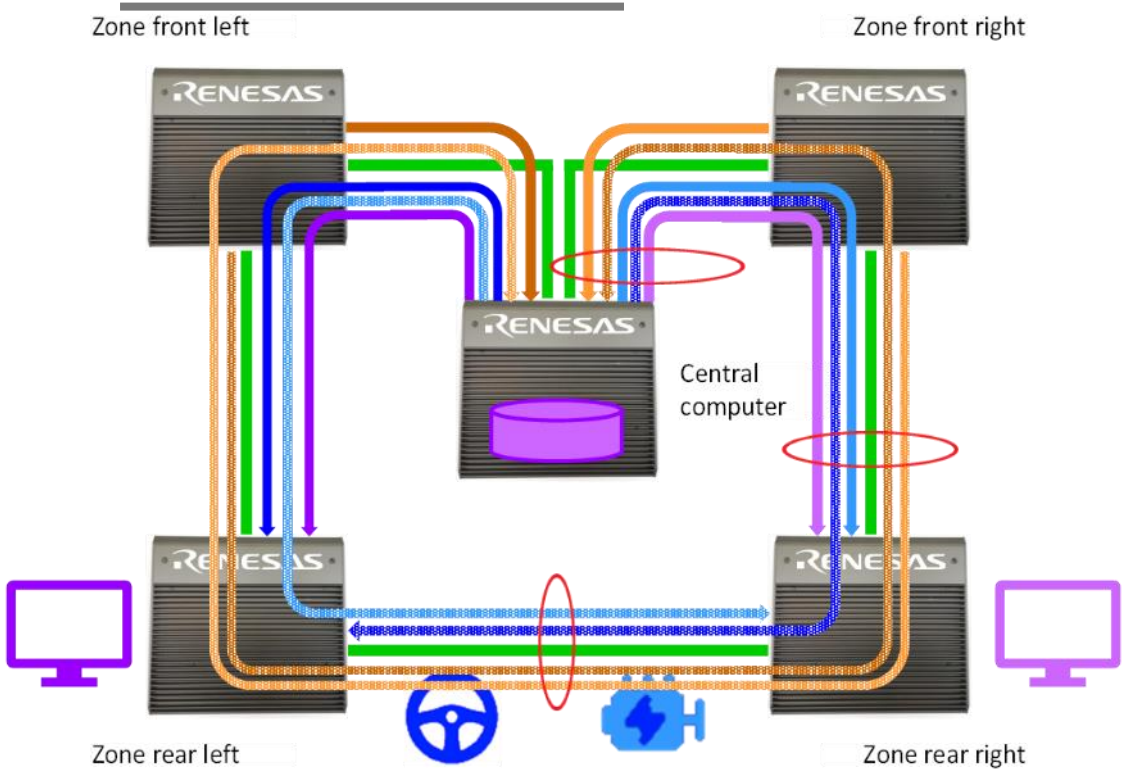
Ethernet backbone

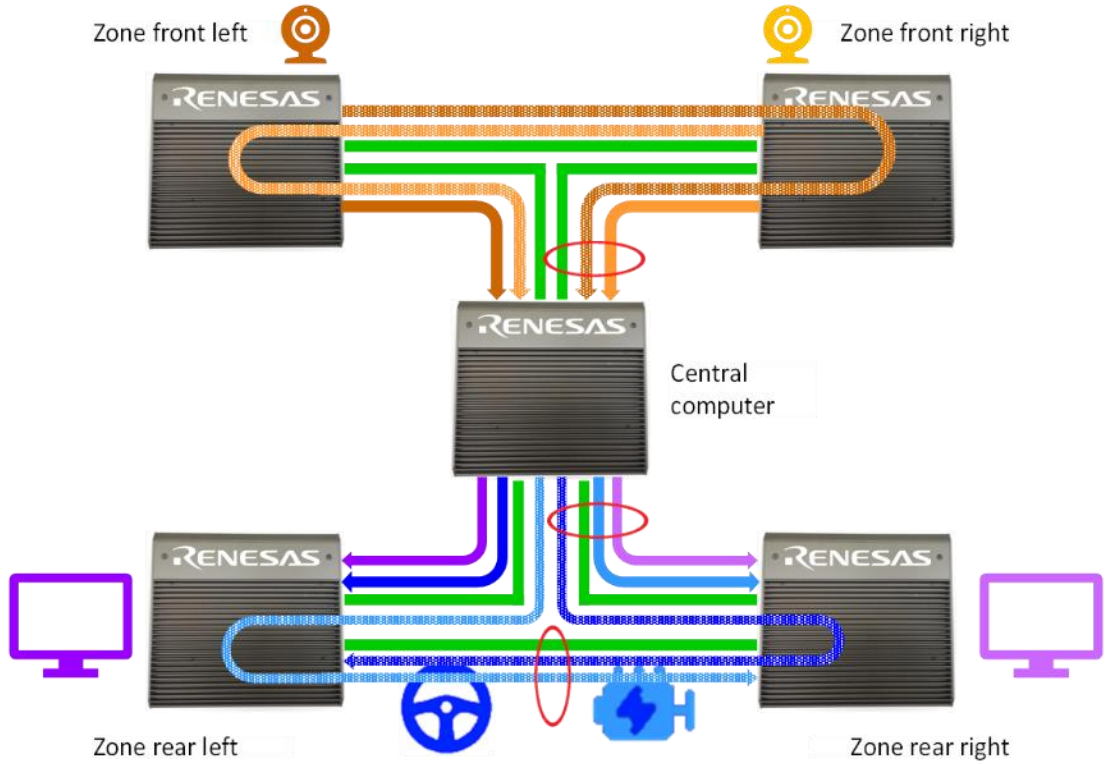


IEEE 802.1CB OPERATION EXAMPLE
MESHED MODE



IEEE 802.1CB OPERATION EXAMPLE
ARCHITECTURE COMPARISON





New challenges

- Jitter
- Topology
- Latency
- Bandwidth
- Port count

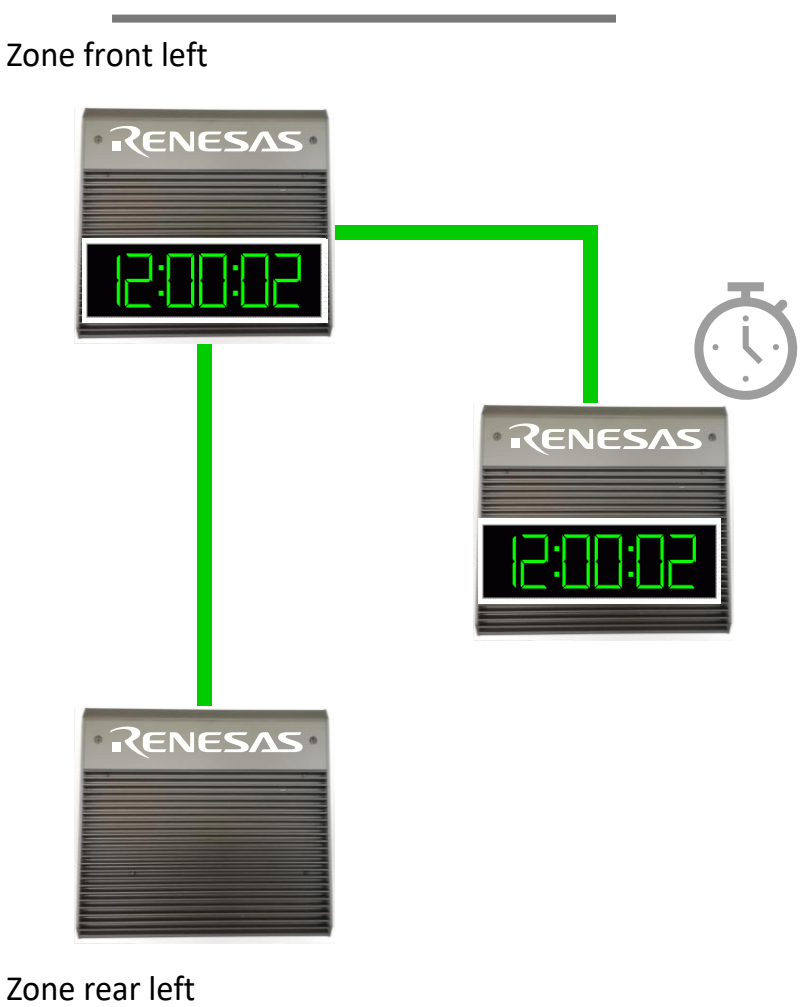
IEEE 802.1AS

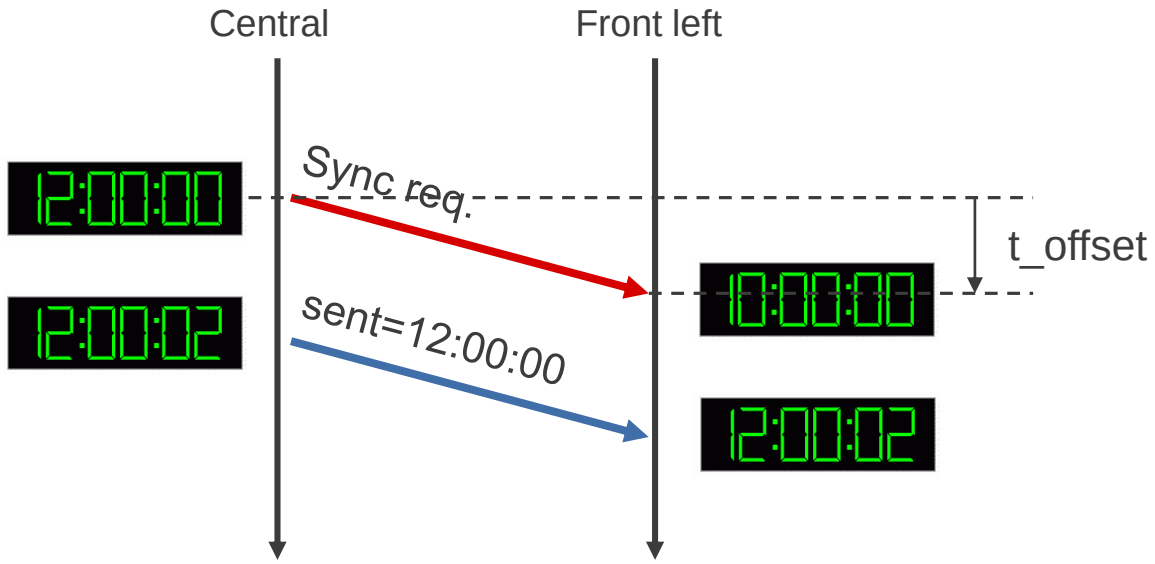
802.1AS – TIMING AND SYNCHRONIZATION
PURPOSE OF STANDARD

- Purpose: provide network with accurate, reliable, simple-to-use time
  - Original target: Audio/ video synchronization
- IEEE 802.1AS is a profile of IEEE1588v2 (subset with automotive specific extensions)
  - One or more Grand Masters (GM) provide time
  - Clock tree reconfigures automatically if GM is lost
  - Best Master Clock Algorithm (BMCA) is used to select to select the Grand Master

- Operation:
  - Grand master is the master to its slave device
  - that slave device is a master to its slave, and so on…
  - Continues synchronization on time and rate

802.1AS – TIMING AND SYNCHRONIZATION
OPERATION





t_offset = send – t_rx_sync

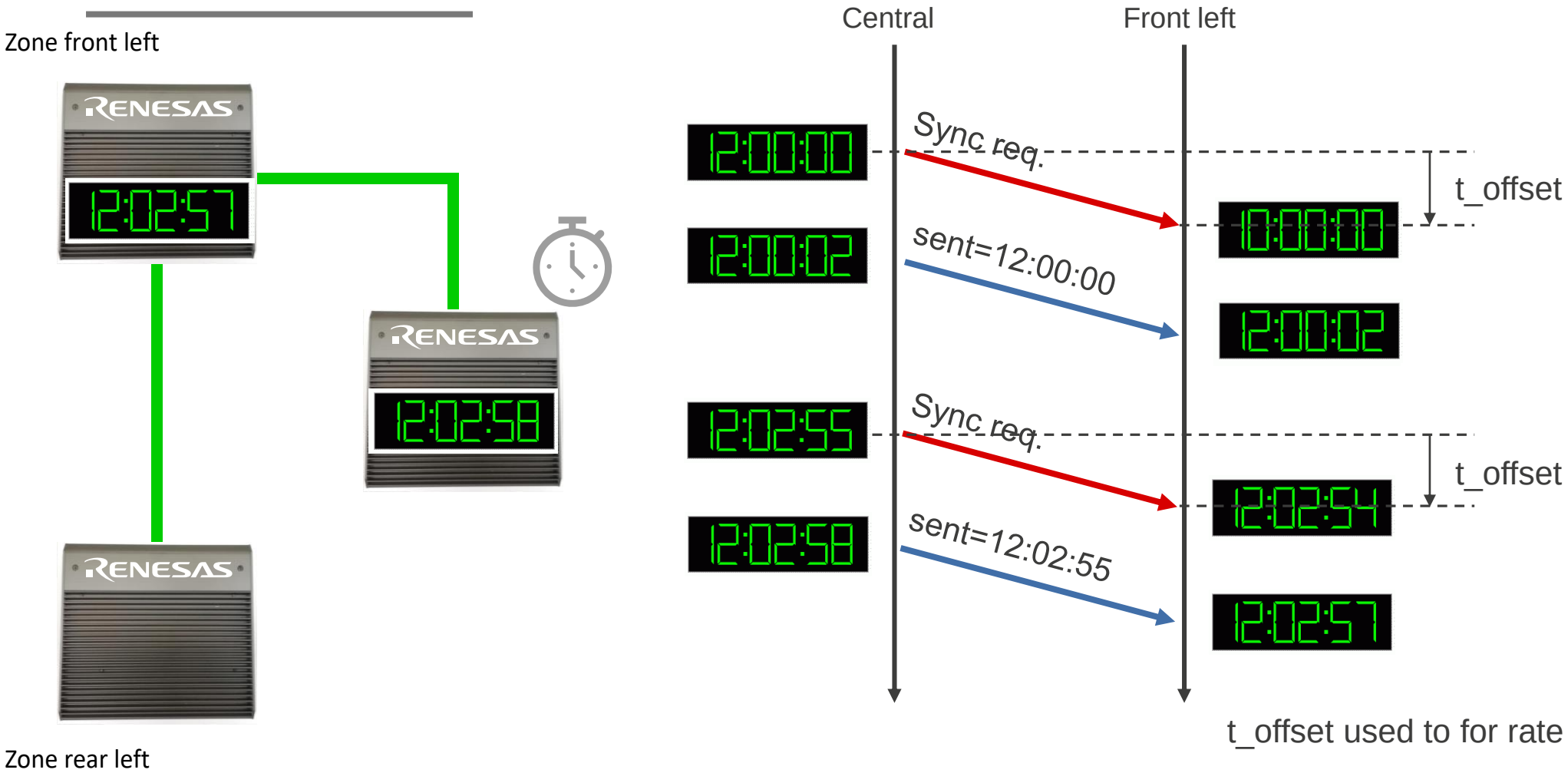
t_offset = 12:00:00 - 10:00:00 = 02:00:00

t_local = t_local + t_offset

t_local = 10:00:02 + 02:00:00 = 12:00:02

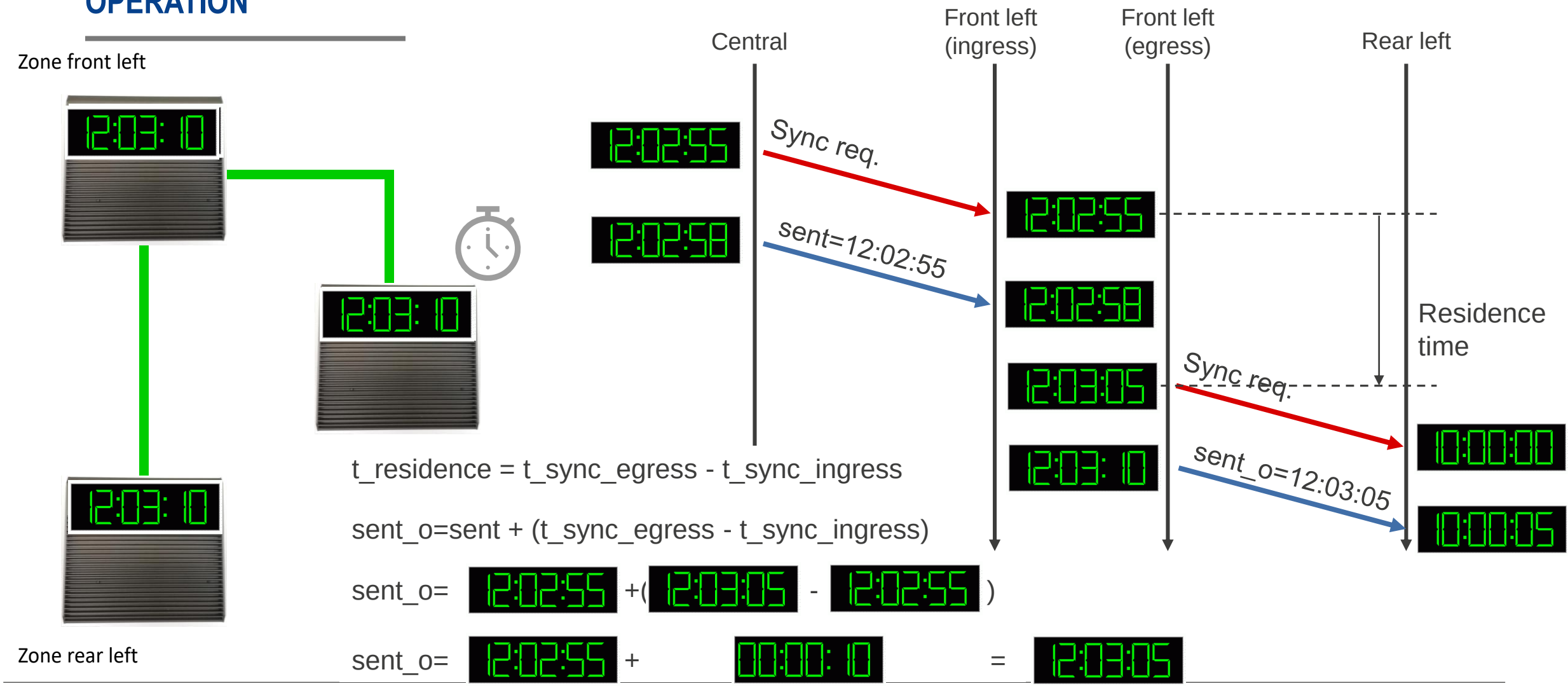
802.1AS – TIMING AND SYNCHRONIZATION

OPERATION



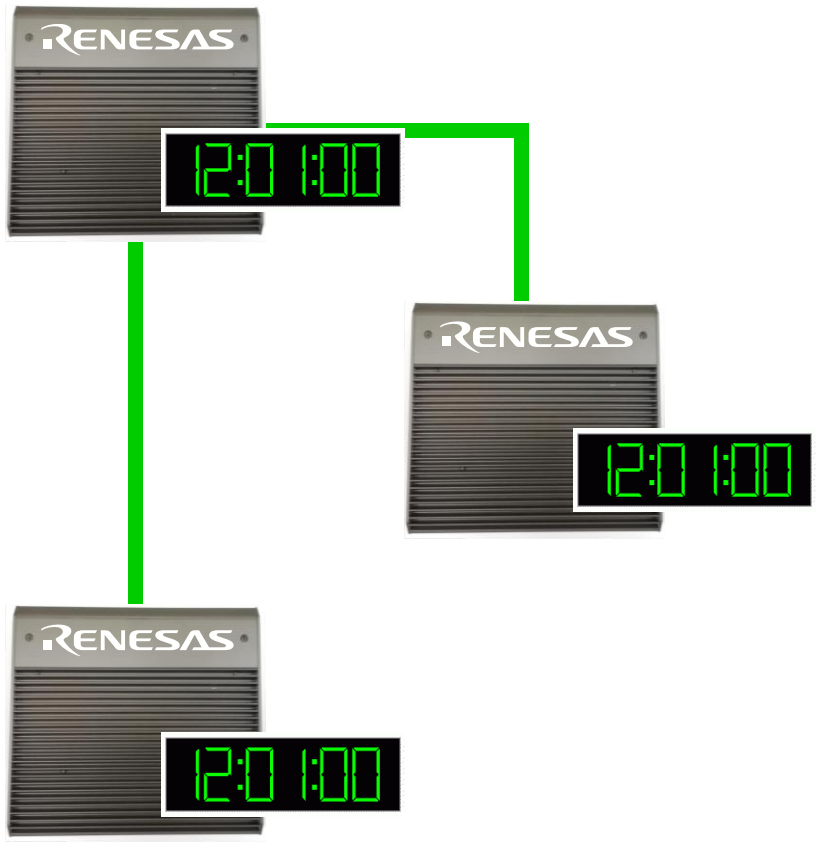
802.1AS – TIMING AND SYNCHRONIZATION

OPERATION



802.1AS – TIMING AND SYNCHRONIZATION
FURTHER FEATURES

Zone front left



Zone rear left

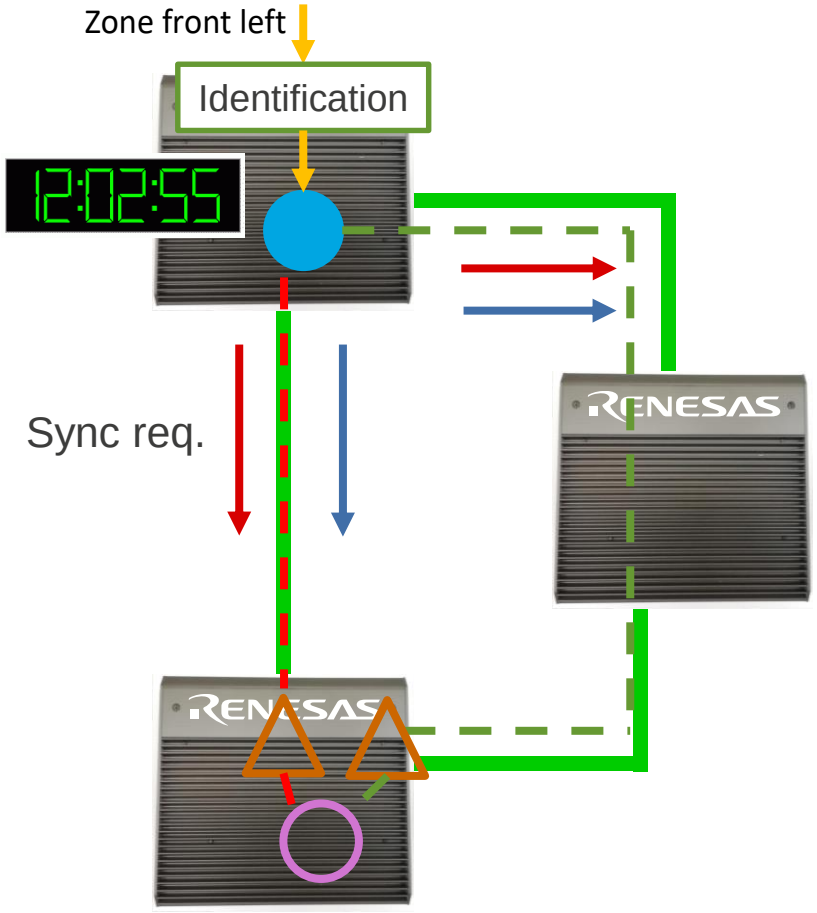
- There is more about time synchronization
  - Grad master selection
  - Link delay
  - Signalizing
- Want to learn more? Check www.ieee802.org/1

- Important takeaway:
  1. Shared time is important for A/V, sensing applications and control systems
  2. IEEE 802.1AS provides a standardized way for ECU accurate time synchronization
  3. Supported by most of automotive products

REDUNDANT CLOCK SYNCHRONIZATION

CLOCK SYNCH OVER REDUNDANT NETWORK PATHS

WHAT IF ....

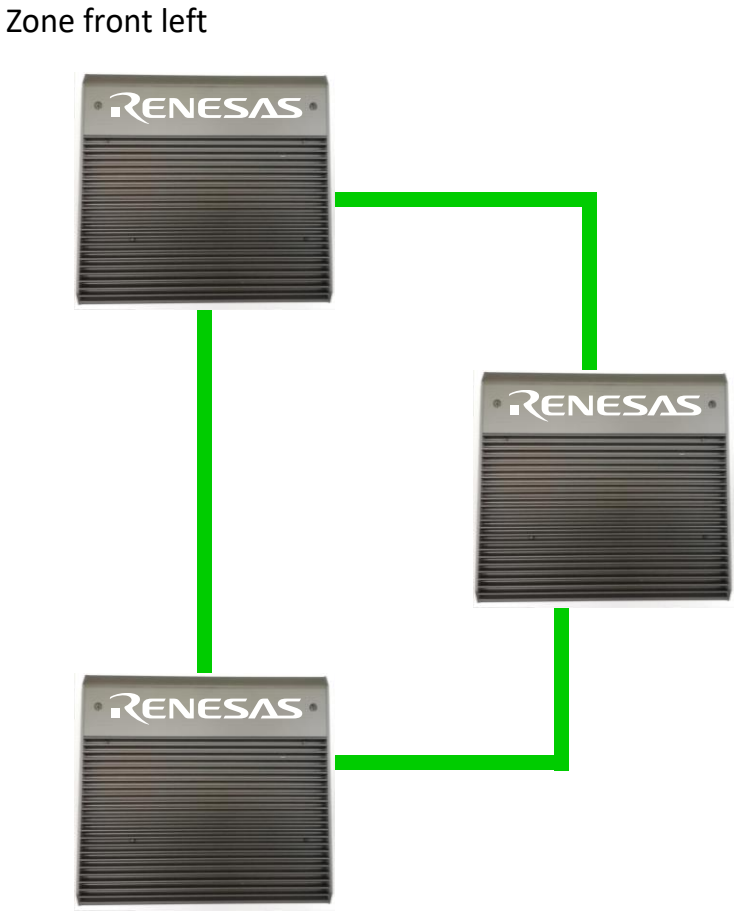


... I want to synchronize network using redundant paths?

- IEEE 802.1CB is not an option
  - Bridges would route synchronization frames
    - Residence time not considered
  - Receiver does not know which path was taken
    - 802.1CB is transparent to application
    - gPTP middleware could sort out frames from different paths
    - gPTP timer would need to work on two different set of information for rate correction
  - Receiver would get wrong time information

CLOCK SYNCH OVER REDUNDANT NETWORK PATHS

SOLUTION: 802.1AS-REV



- IEEE 802.1AS-rev improvement points
  - Redundancy considerations
    - Single grand master transmitting copies of its clock using separate paths (like 802.1CB)
    - Allows more than one grandmaster in a system
    - Or a combination of both
  - Multiple timing domains
  - IEEE 802.11 support
  - Support for link aggregation
  - ... and many more
- Implication to hardware
  - Multiple gPTP timer instances

CONCLUSION

- We cannot rely on the network by itself

- Automotive Ethernet will be shared medium for a/v/c, safety critical not safety critical
  - TSN developed to support all data types; not just Audio and Video
  - TSN helps to achieve better performance through lower latencies
  - TSN achieves low packet loss rates by supporting various levels of redundancy

- TSN is a toolbox concept to enable auto/ video and control data transfer in safety critical applications
  - Right standards needs to be selected for each application and topology

- Most features are transparent for application but slightly impact application layer

COME AND SEE ALL THESE FEATURES IN ACTION AND DISCUSS

Renesas.com