Real Life performance of IEEE 1722 Control Format (ACF)

in future oriented networking architectures

CETITEC connective technologies

Networking made simple

Real Life performance of IEEE 1722 Control Format (ACF)
in future oriented networking architectures

- Conventional Automotive Networks and AVTP Control Format (ACF)
  - Transition from Domains to Zones
  - Data path from peripheral devices on the network
- Benchmark set-up
  - Real life scenario signal paths with UDP and ACF communications
- Comparisons and results
  - Data throughput and performance between UDP and ACF in Zonal Architecture
- Further optimization possibilities
  - Efficiency increase with a Distributed Data System
- Summary and outlook

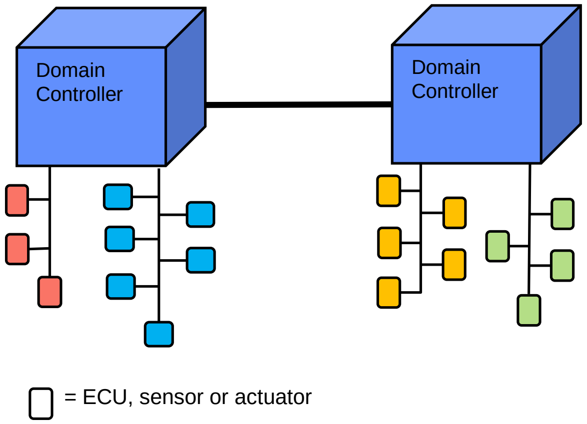
Real Life performance of IEEE 1722 Control Format (ACF)

Data path from lower end devices

- Transition from Domain Architecture to Zonal Architecture

Domain Architecture from Networking Perspective

- Access to ECUs, sensors and actuators handled by the Domain Controller
- Communication between the Domain Controllers requires gateways



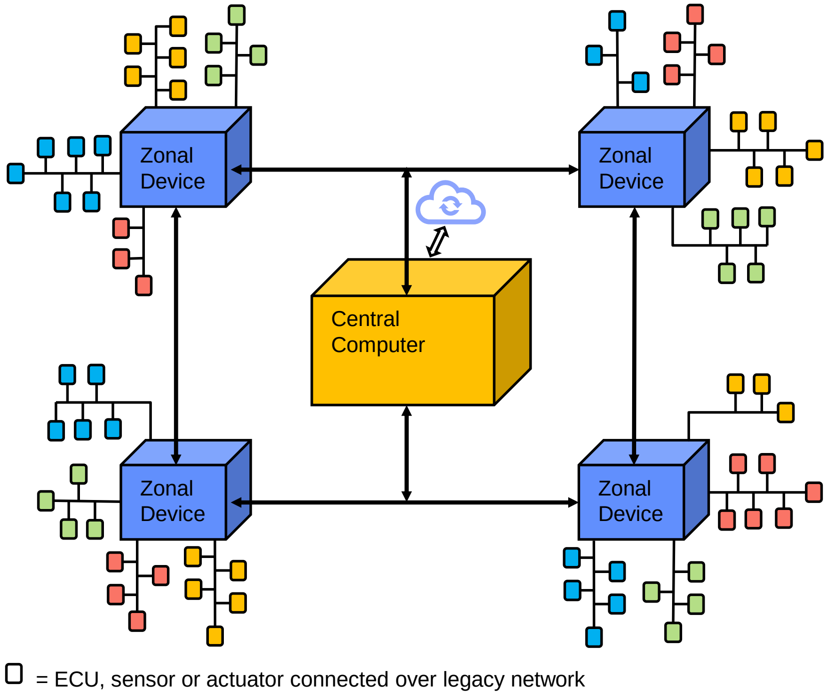
- **Conventional Networks**

- Communications over:
- CAN
- LIN
- FlexRay

- Domain specific real time constraints
- Central gateways distributing signals
- Signal to Service translation

Real Life performance of IEEE 1722 Control Format (ACF)
From Domains to Zones

- Transition from Domain Architecture to Zonal Architecture



- Transitioning requires efficient methods to exchange signal-based information with conventional networks

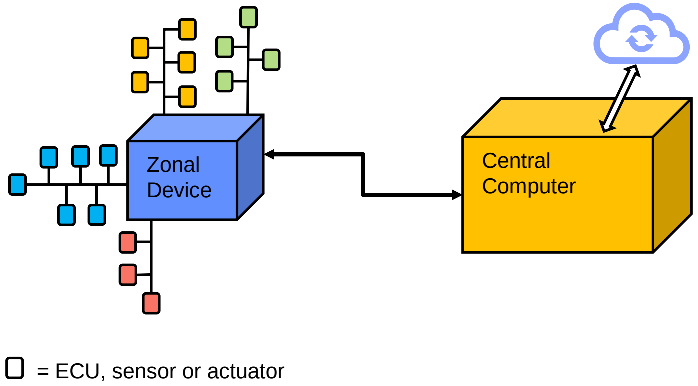
- **Conventional Networks**

- Relevant for communications
  - Sensors
  - actuators
  - Legacy ECUs
- Mostly CAN to Ethernet traffic
- Directly connected to the Zonal Device (Zone Gateway)
- Signal data converted in Zonal Device with a gateway
- Data is consumed in other Zone Devices and the Central Computer

Real Life performance of IEEE 1722 Control Format (ACF)

Data path from lower end devices

- Ideal conditions for ACF
  - Timing information can be preserved
  - Messages can be transferred by relatively easy means
  - AVB/TSN Mechanisms guarantee bandwidth
  - Reduce overhead in the device where data from conventional networks is aggregated
  - Maintaining and potentially improving performance



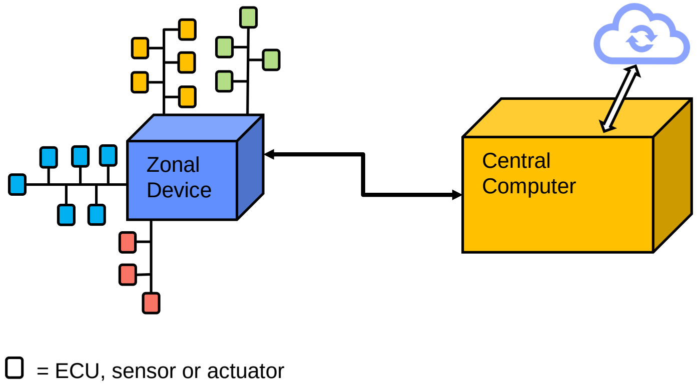
- **ACF: Potential Advantages**
  - Bandwidth reservation
  - Reduced overhead
  - Simple and easy
  - Already widely available technology

Real Life performance of IEEE 1722 Control Format (ACF)

Data path from lower end devices

Data path ACF communications

- Messages aggregated and sent over ACF
- Aggregated messages are sent to other Zonal Devices and Central Computer Device
- Signals are extracted where needed
- … and timing information is preserved



- **Performance hotspot**

- Data aggregation on zone device
- High performance requirements
- Short messages with high frequency
- Data is expanded and presented for consumption on central device

Real Life performance of IEEE 1722 Control Format (ACF)
Data path from lower end devices

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- Data Path for Conventional Networks

Data producers can be optimized

- Simple to send aggregated messages
- Easy to send synchronized data
- Data consumers can use information and repackage signals as needed
- Control data can be sent back to ECUs on this same way

So much for theory… So how does this work in practice?

- **Data path**

- Priorities can be set
  - Streaming classes
  - Bandwidth reservation
- Straight forward bandwidth management
- Data is synchronized
- Deterministic max transit time

Benchmark set-up

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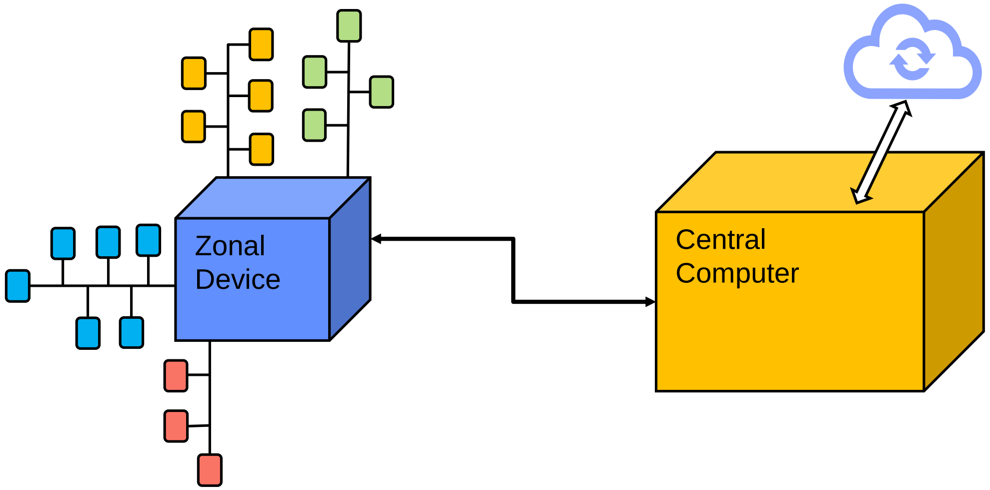
Real life scenario

- Representative Data Path in Zonal Architecture



- **Key Points**

- Input on CAN Bus
- Known systems and platform

- Baseline for comparison:
  - Amount of data traffic remains constant
  - Performance as a function of resource consumption
  - Consumer application on Central Computer

- It is estimated that 90 - 96% of all routing operations are from CAN/LIN to Ethernet

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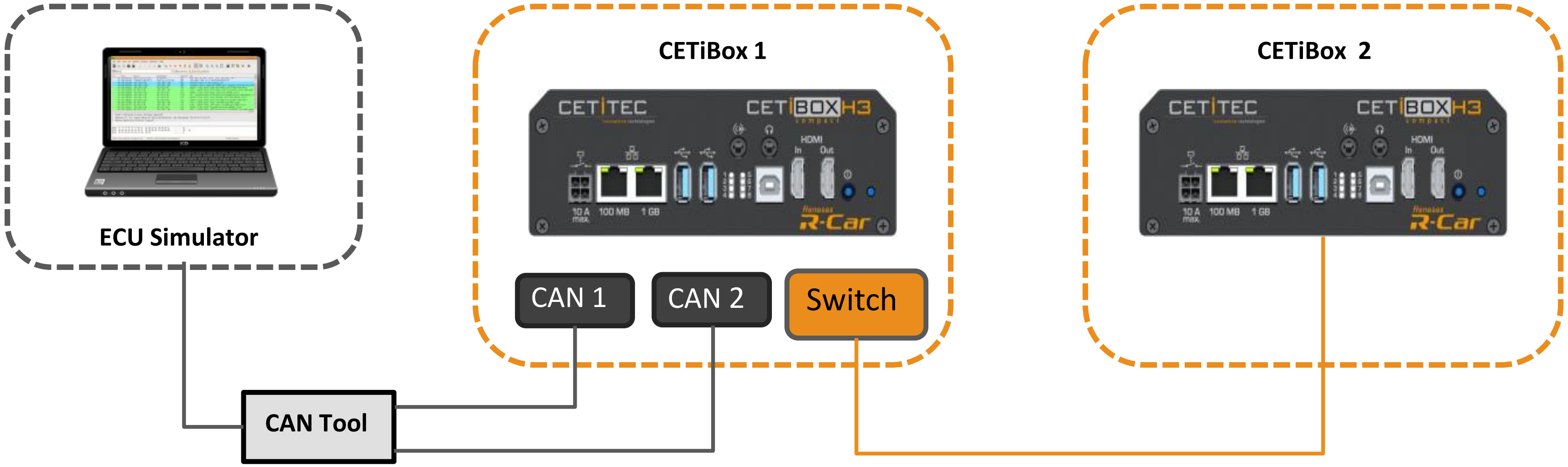
Benchmark set up

- Configuration
  - Same device for data producer (CETiBox 1) and consumer (CETiBox 2)
  - Test set-up consistent with current automotive applications
  - Devices are not optimized for networking performance
  - Input on CAN 1 and CAN 2



- **Data path**
  - Input: CAN 1 and 2 to Zonal gateway
  - Input CAN messages multiplied to generate traffic between CETiBox 1 and 2
  - Output sent to Central Device
  - Unpacked by receiving application
  - Simulate a data consumer and generate overhead

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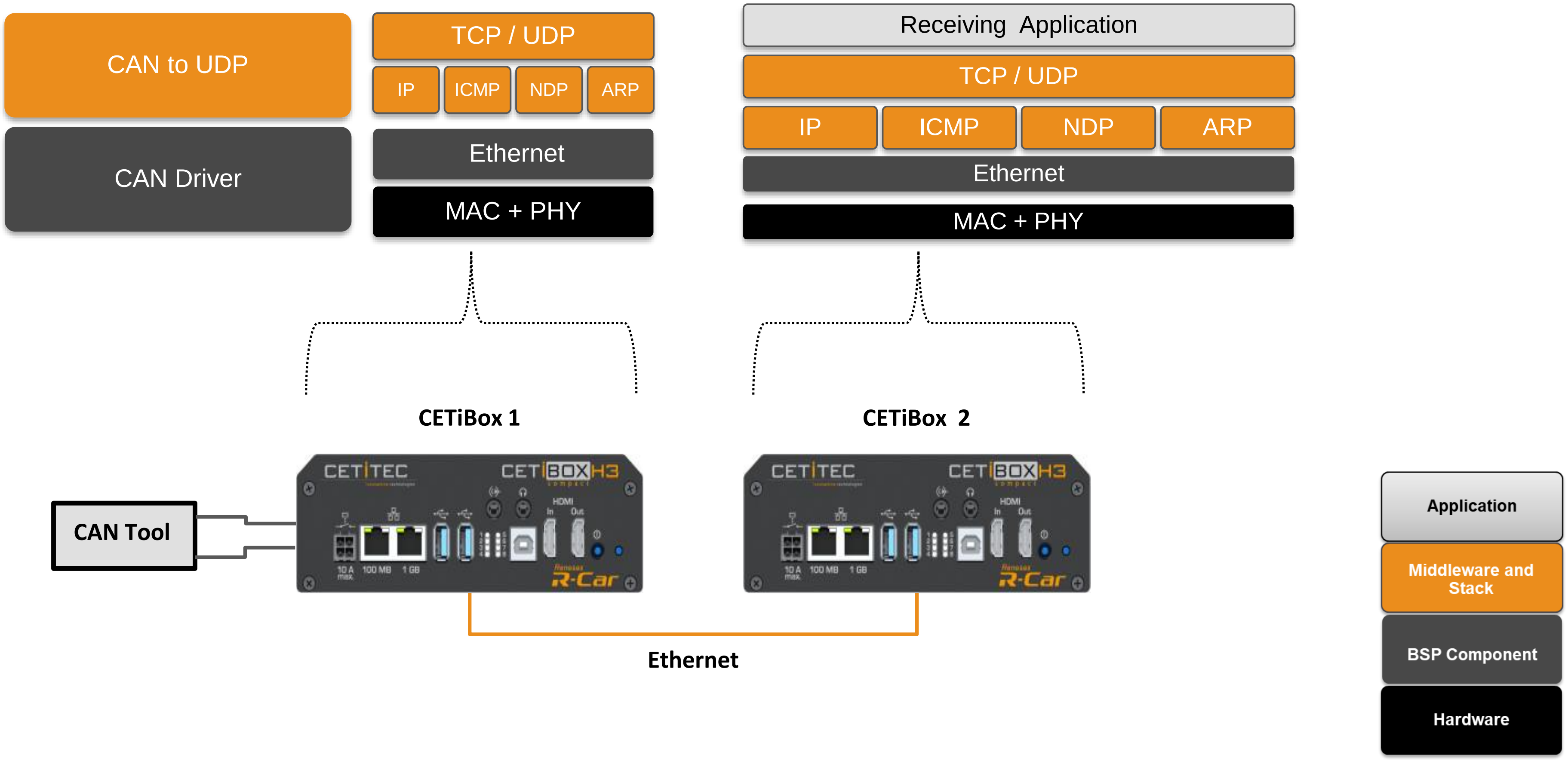
Benchmark set up for UDP

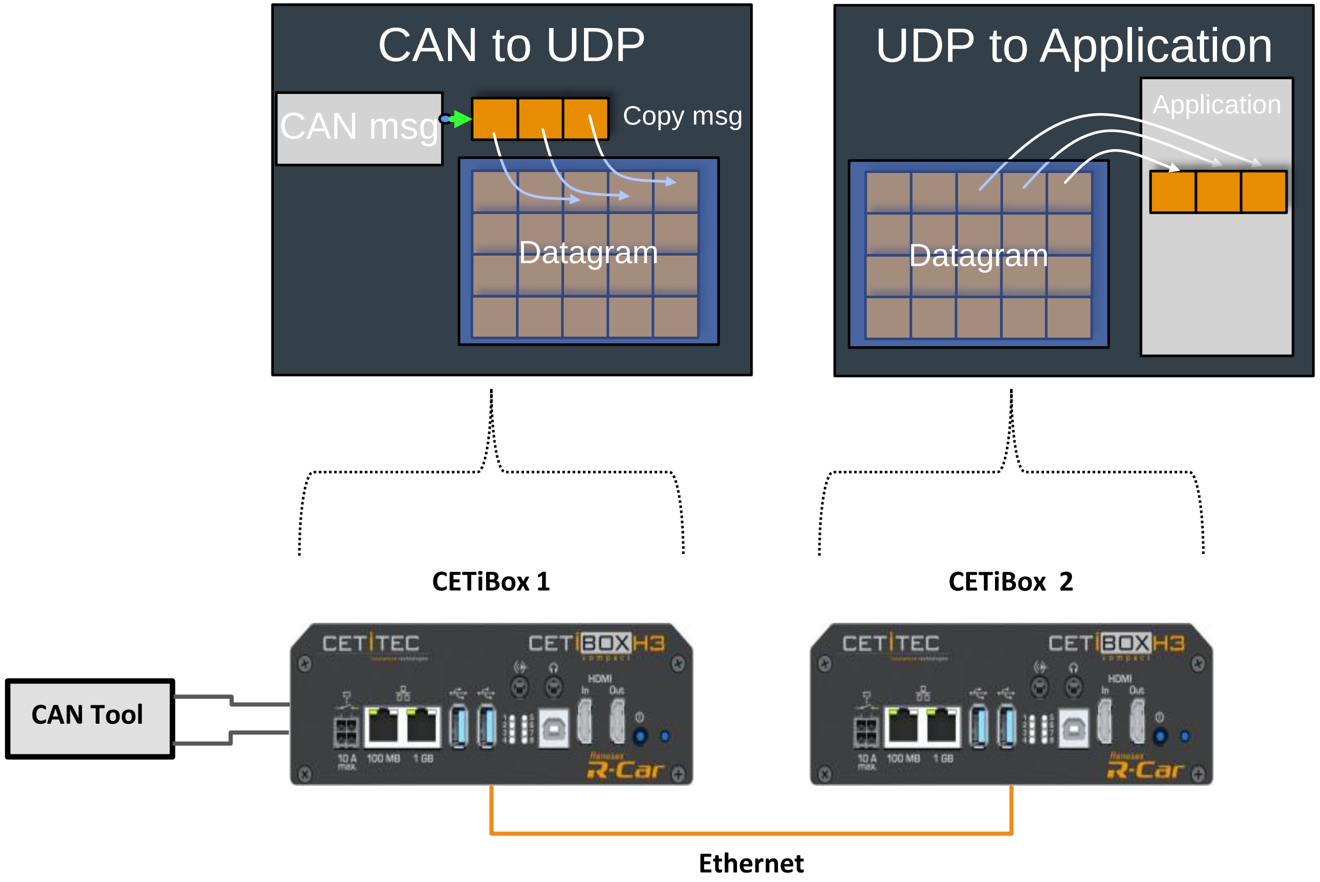
- Configuration for UDP



Real Life performance of IEEE 1722 Control Format (ACF)

Benchmark set up for ACF

- Configuration for UDP



- **Test Configuration**

- CAN Bus input with message injection
  - CAN1: 100 msg/s 8 bytes payload
  - CAN2: 100 msg/s 8 bytes payload

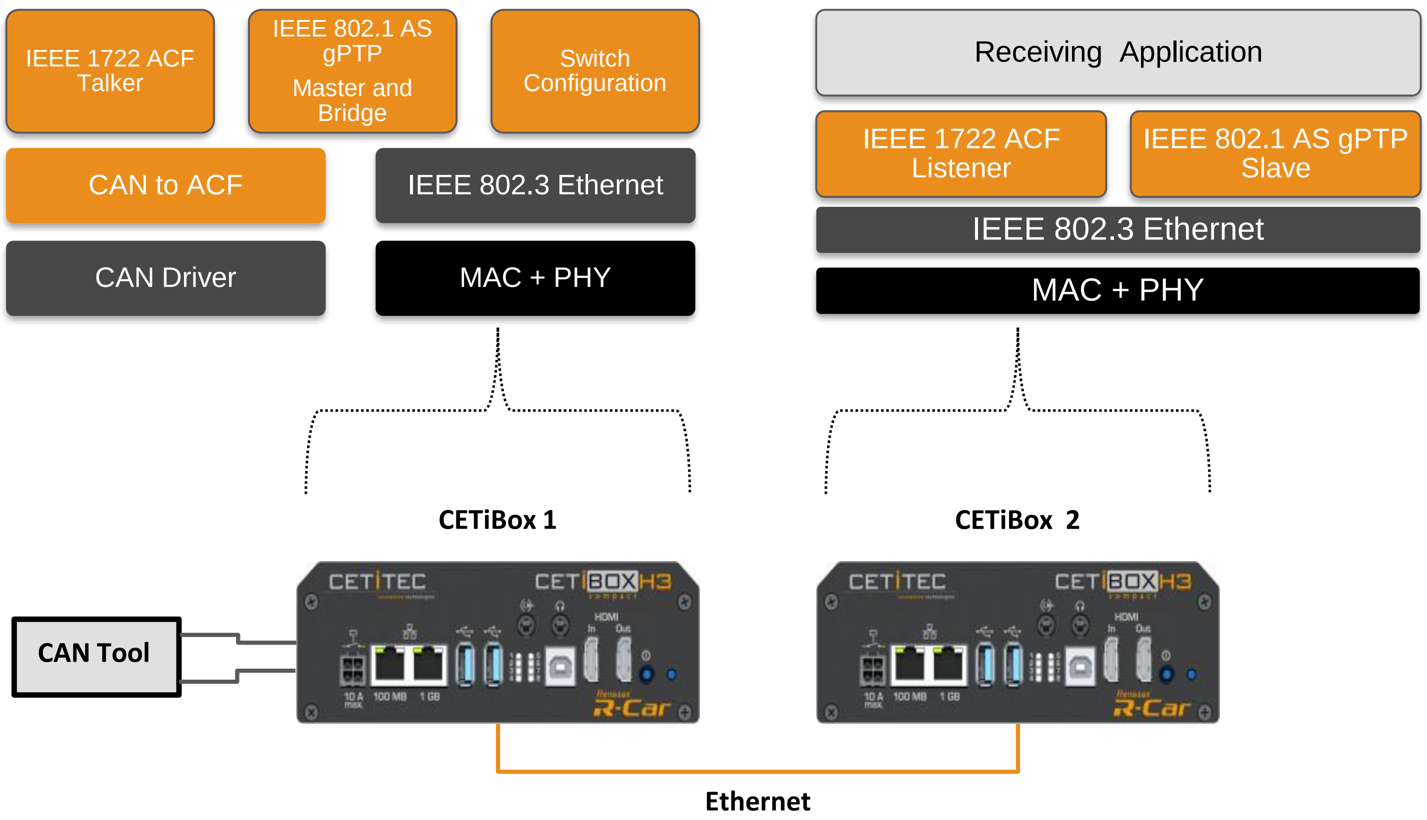
- Input msg/s as reference
- Generate different message loads (message injection)
  - 10K msg/sec
  - 15K msg/sec
  - 20K msg/sec

- 24 Bytes per input message packetized: collect N messages ((msg/sec)/750) and send without delays

- Interfering traffic: 5K msg/sec TCP traffic with light payload

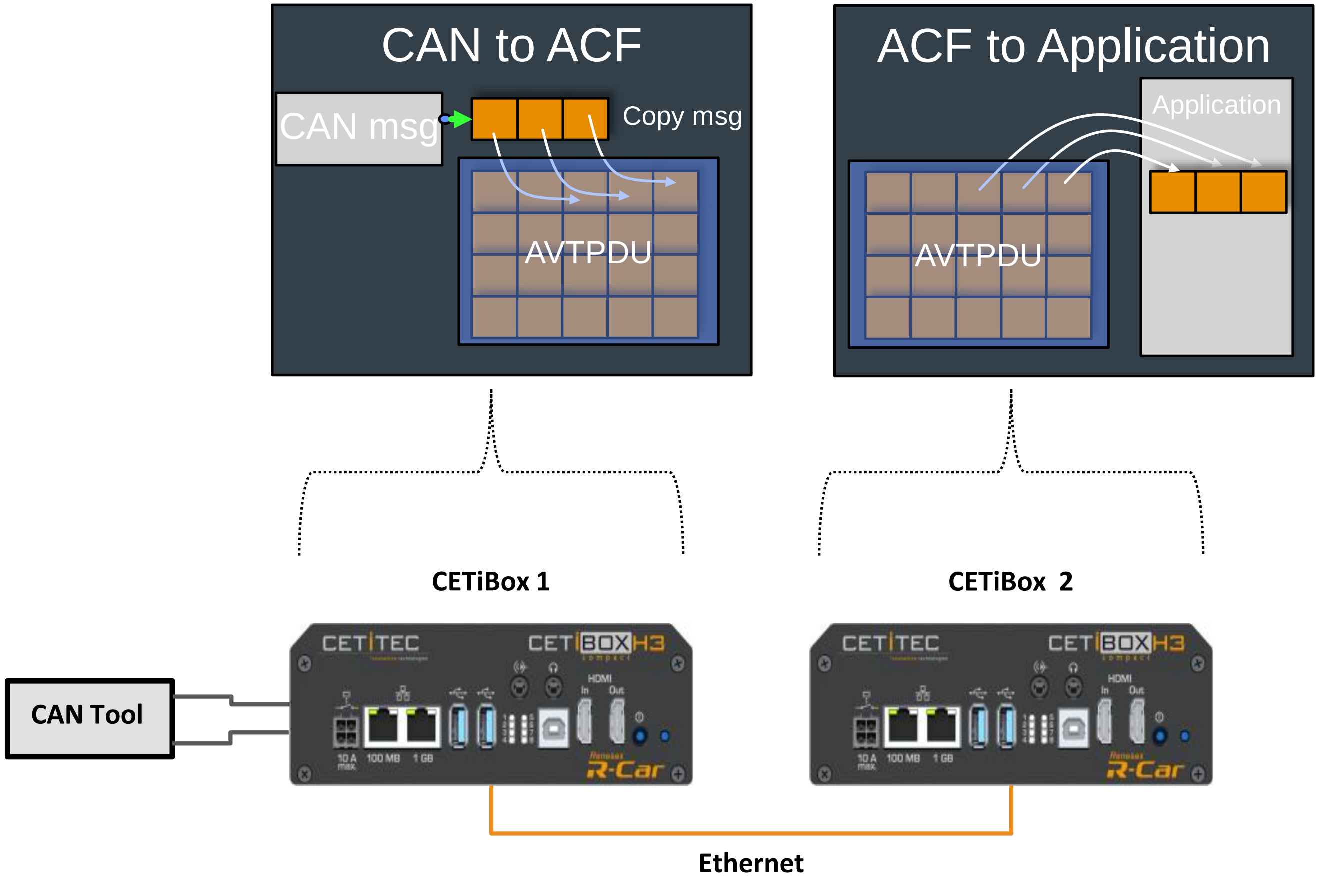
Real Life performance of IEEE 1722 Control Format (ACF)
Benchmark set up for ACF

- Configuration for ACF



Real Life performance of IEEE 1722 Control Format (ACF)
Benchmark set up for ACF

- Configuration for ACF



- **Test Configuration**

- CAN Bus input
  - CAN1: 100 msg/s 8 bytes payload
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- Interfering traffic: 5K msg/sec TCP traffic with light payload

- ACF Class C(750 msg/sec)

Comparisons and results

Real Life performance of IEEE 1722 Control Format (ACF)
Data throughput and performance

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- Performance comparison: ACF Talker vs. Sender using UDP

Configuration	10K msg/sec	15K msg/sec	20K msg/sec
Reference using UDP	Reference level (100%)	-	- 0,1%
Using ACF	+0,1%	+0,1%	+0,1%
Results with Interfering TCP traffic			
UDP + 5K msg/sec TCP traffic	+2,3%	+2,1%	+2,3%
ACF + 5K msg/sec TCP traffic	+3,4%	+2%	+1,5%

- + denotes a performance penalty, - denotes performance benefit
- Performance is averaged over a 60 seconds interval with the sampling delayed for 120 seconds once communications have been stablished
- All input messages are transmitted to the output. 0% drops

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- Performance comparison: ACF Listener vs. Receiver using UDP

Configuration	10K msg/sec	15K msg/sec	20K msg/sec
Reference using UDP	Reference level (100%)	+0,1%	- 0,1%
Using ACF	-0,1%	+0,3%	-0,1%
Results with Interfering TCP traffic			
UDP + 5K msg/sec TCP traffic	+1,7%	+1,8%	+2,5%
ACF + 5K msg/sec TCP traffic	+1,7%	+3,1%	+1,7%

- + denotes a performance penalty, - denotes performance benefit
- Performance is averaged over a 60 seconds interval with the sampling delayed for 120 seconds once communications have been stablished
- All input messages are received

Real Life performance of IEEE 1722 Control Format (ACF)
Data throughput and performance

- ACF compared to UDP communications

In Zonal Architecture

- No significant difference in performance could be observed under the benchmark conditions

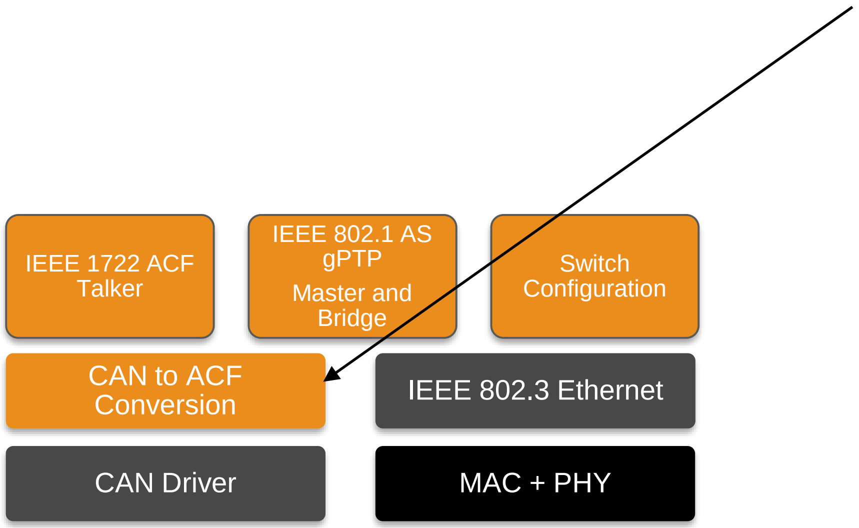
What is **actually** obtained:

- Guaranteed max transit time using
- Bandwidth reservation
- Reuse of simple and universally available AVB/TSN mechanisms
- ACF preserves timing information at message level
- Relatively easy configuration for message forwarding

Further optimization possibilities

Real Life performance of IEEE 1722 Control Format (ACF)
Further optimization possibilities

- The best interrupt is the one that doesn't come…



Optimization potential

- Selective channel usage based on what data the application consumes
- Flexibility to adapt to different load scenarios
- Even easier configuration workflow
- Signal level optimizations

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Further optimization possibilities

- Flexible optimization with a Distributed Data System

- Simple data producer implementation
- Flexible database deployment

- In-memory database
    - CRUD (Create, Read, Update and Delete) interface
    - Non-relational
    - gPTP derived time stamps for data synchronization and data expiration
    - Data throttling and filtering on Signal level

- Self describing binary format

Using IEEE 1722 ACF mechanisms for simple and reliable data transfer

Summary and outlook

Real Life performance of IEEE 1722 Control Format (ACF)
Outlook and Future Work

Using IEEE 1722 ACF

- Has the additional **benefits of AVB/TSN mechanisms**

For simple and reliable data transfer

- AVB/TSN mechanisms already **widely available**
- Data can be packaged **easily and efficiently** in ACF messages

Can be further improved

- Selectively packaging and sending on **signal level**
- Data **throttling and filtering** at the producer

- **Scope of future work:**

- Performance evaluation with further scenarios and criteria
- Optimizations in ACF talker and listener implementation
- Performance difference when is sent with ACF class A and B
- Further improvement with a Distributed Data System approach

Thank you very much!

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