RELY-REC: a cost-effective solution for validating Ethernet convergence in Automotive networks.

In the upcoming years, automotive wiring harnesses will move from heterogeneous networks of different protocols to a hierarchical homogeneous Ethernet network. In this new scenario, laboratory testbeds, which are mirroring the real vehicle network, will demand analysing tools, capable to support them in the validation process of communications inside the car.

Customer Snapshot

- A Tier1 company for automotive E/E systems in the process of developing a new Domain Gateway for connecting the Driver Assistance and Infotainment domains to the converged backbone network inside the vehicle.

The Challenge

- Having the possibility not only to record the traffic, but also to save a timestamp alongside with it, and to filter and parse in a real-time basis ('on-the fly') the traffic underlying in the network section.

The Solution

- RELY-REC, a highly specialized analysis tool for seamless capture of Ethernet traffic, with the possibility to register the timestamp for all the stored messages.

Key benefits

- Multi-media multi-rate ports

- Advanced triggering tools with packet inspection and timestamped events log.

- Customizable filters for defining recorded traffic.

- Simultaneous remote traffic retrieve

- Records in PCAP format compatible with Wireshark applications

- Time-Sensitive Networking (TSN) ready

Automotive convergence to Ethernet. Rationale

The technology inside a car is getting more complicated and more connected. The newest applications and functionalities inside a car are driving up the bandwidth, latency, synchronization, high availability, QoS and reduced cost requirements. The current and legacy most used protocols in automotive (i.e. CAN, LIN, MOST, FlexRay, etc.) are not suitable enough for attending these upcoming needs. Under this scenario, Ethernet is clearly leading the IVN –In Vehicle Network– landscape, as it comprises many advantages in comparison with the rest of aforementioned protocols (see next comparison table as reference).

Network Type	Average Cost	Bandwidth	Complexity	Tolerance
CAN	Medium	Low	High	High
FlexRay	High	Medium	High	Medium
MOST	Medium	Medium	Medium	Low
Ethernet	Low	High	Medium	Low

Table 1. Most used protocols in automotive. A brief comparison

As in many other sectors (aerospace, railway, industrial automation, etc.), the convergence to Ethernet is a reality in automotive as well. MarketsAndMarkets expects the automotive Ethernet market to grow from USD 1.6 billion in 2019 to USD 4.4 billion by 2024. In the same way, by 2022, the total number of automotive Ethernet ports is expected to be higher than the total number of all other Ethernet ports combined, according to Frost & Sullivan.

Automotive IVN. Architecture evolution

Historically, the electronics systems into a vehicle have been divided into few "domains" (powertrain, chassis, body, comfort, and diagnosis, mainly). But additional new "domains" have emerged last years, such as infotainment, drivers assistance, in-vehicle experience, C–V2x, fog and cloud backend, etc.
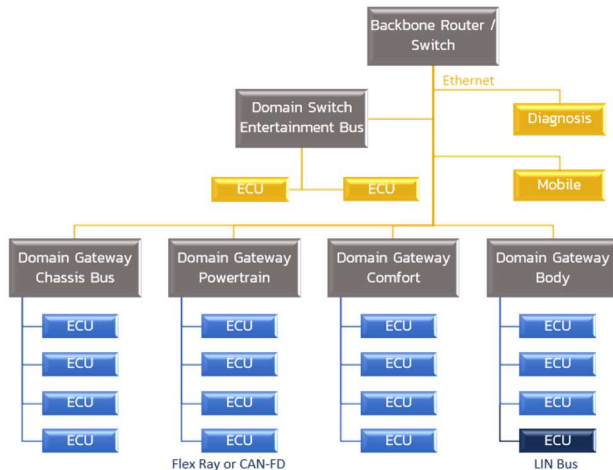

Figure 1. "Central Gateway + Domain Controllers" architecture

In a traditional approach, each domain has had an independent control, based on a dedicated ECU –Electronic Control Unit– for each specific mayor function inside the domain. Today, there is much more interaction and dependency between the domains, but they still typically have independent control systems. Furthermore, and due to legacy questions, the communication inside the most traditional domains is based on non–Ethernet protocols still. Thus, "Central Gateway + Domain Controllers" is one of the most used architectures for upcoming vehicles.

As the figure above depicts, this Central Gateway based novel architecture requires a main Ethernet based backbone (the so–called 'converged backbone network'), connecting all the different domains distributed throughout the entire car. This Central Gateway is a sort of Ethernet multiport Router/Switch with additional vehicle control level functionalities. At the same time, there is a domain specific Gateway connecting each domain with the Ethernet backbone. When the protocol inside the domain is Ethernet as well, that Domain Gateway becomes in a domain Switch, as it runs in some way as a regular Ethernet Switch.

By next upcoming years, automotive wiring harnesses will change from heterogeneous networks of different protocols (CAN, LIN, MOST, FlexRay, etc.) to a hierarchical homogeneous Ethernet network.

The challenge

A Tier1 company for automotive E/E systems is in the process of developing a new Domain Gateway for connecting the Driver Assistance and Infotainment domains to the converged backbone network inside the vehicle. Those two domains are using a single Domain Gateway, as both of them belong to a single car macro–function, the ADAS –Advanced Driver Assistance System– service.

The protocol used inside those domains is Ethernet with AVB –Audio–Video Bridging– support. Thus, the Domain Gateway in this case plays the role of a multiport Ethernet switch with specific and application tailored functionalities, such as Ethernet AVB support. AVB over Ethernet is a set of extensions to the IEEE802.1 specification that enables local Ethernet networks streaming time and loss sensitive Audio/Video data.
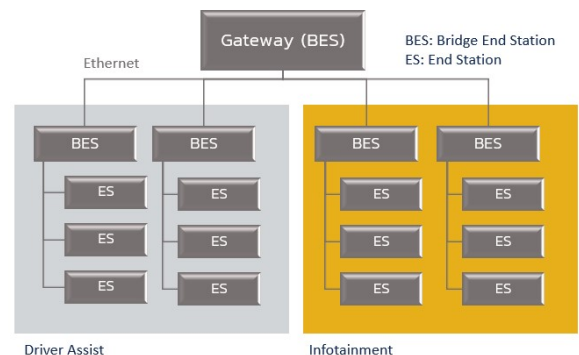

Figure 2. Multi–port Ethernet Domain Gateway.

In the validation process of that Domain Gateway, once at the laboratory testbed, which is mirroring the real vehicle network, the company is missing the following specific capabilities:

- Having the possibility to record traffic in the testbed, in order to feed the simulation model of the Domain Gateway with the most real traffic possible.

- Having the possibility to record specific frames/packets, and under certain conditions. As an example, supposed that it is necessary to recorder all IEEE802.1Qat frames after a certain time mark at the IEEE802.1AS plane. Qat and AS are a couple of extensions to the IEEE802.1 specification, defining the stream reservation and timing synchronization.

For those purposes, it is necessary not only to have the possibility for recording the traffic, but also to save a timestamp alongside with any recorded packet, and to be able to filter and parse in a real-time basis, 'on-the fly', the traffic underlying in the network section.

The solution

To respond to the needs of the Automotive sector, Relyum has launched RELY-REC, a highly specialized analysis tool for seamless capture of Ethernet traffic, with the possibility to register the timestamp for all the stored messages.

Figure 3. RELY-REC traffic recorder

This stand-alone device embeds all the logic for monitoring, filtering, timestamping and capturing the traffic of the most complex Ethernet networks in a low-consumption compact format.

For the particular use case described in this document, RELY-REC would be installed in TAP mode in the "network-under-test" network link, allowing simultaneous remote retrieve of recorded traffic (PCAP format) through its service port.
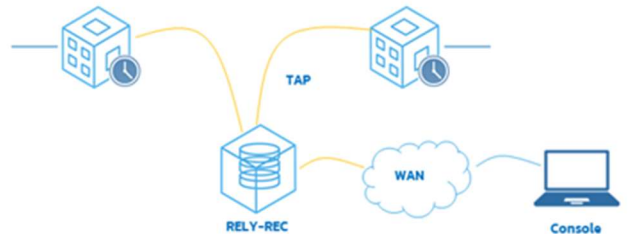

Figure 4. RELY-REC TAP configuration

Conclusions

A first conclusion is the fact that Ethernet convergence is already a reality also in Automotive networks

Therefore, new needs arises for the validation and integration of new devices in Automotive networks:

- Conformance Testing. The idea is to validate protocol compliance and interoperability. TCP/UDP/IP conformance tests for automotive stacks and components.

- Protocol Validation and Performance Testing. The main aim here is to validate the data-plane based application performance, as well as lower level synchronization plane accuracy and behaviour.

- Central Gateway and Domain Gateway Ethernet switching functionality testing; AVB capability, getting expected packet loss, bandwidth, and latency for each class of service (Qos), switchover and convergence times after a link failure, behaviour under certain nodes misbehaving situation, etc.

Bringing those needs into more accurate requirements:

- See live traffic transmitted in the network.

- Filter traffic on the fly

- Collect real-time data, timestamped according to the vehicle synchronization plane (IEEE 802.1AS, for instance)

- Trigger data capture action based on multiple configurable user-defined event

- Save data to an internal data logger and later transfer to the PC for post-analysis tasks.
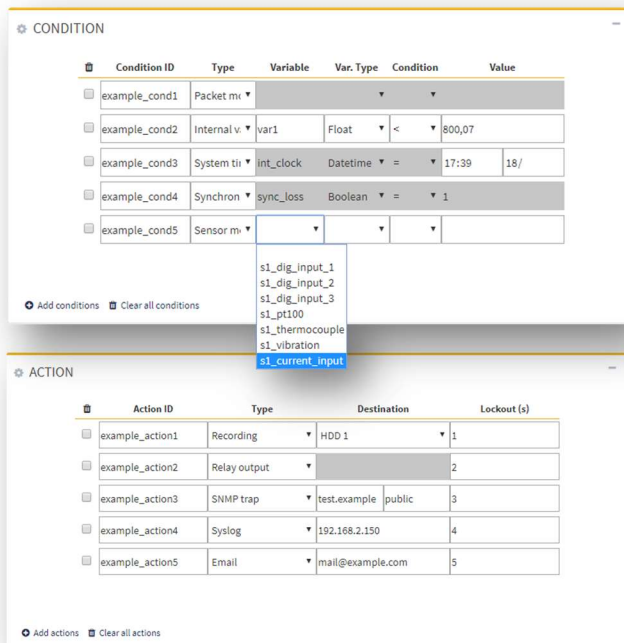

Figure 5. RELY-REC Condition and action configuration example in Trigger menu

RELY-REC, a stand alone traffic recorder developed by Relyum, is compliant with all the above functionalities.

Additionally, it is a TSN ready device, that can be upgraded to TSN, the next step in Automotive IVN networks.

The Equipment. RELY-REC

In critical systems, it is essential being able to analyze the network communications at frame level for testing and forensic purposes. Furthermore, the validity of this analysis will be constrained by the capability of the infrastructure to correlate the frames with a common time reference. For that purpose, Relyum has developed RELY-REC, a device that is able to inspect, timestamp and record regular Ethernet and high-availability Ethernet traffic, using the same PTP timing reference than the network under analysis

Some of the key benefits of this equipment is its adaptability to any use case, thanks to its multi-media multi-rate Ethernet ports, based on SFP modules for supporting the most extended interfaces used in the Automotive sector.

The device includes a powerful triggering tool, that allows to define triggers based on nested conditions (AND, OR) and to link multiple actions to one trigger.

It supports multiple input type conditions (analogue / digital input signals, alarms and signals from third party systems, time schedule, synchronization loss, packet inspection), connected to output actions (traffic recording, email notification, SNMP trap, syslog message, alarm output).

For simplifying access to stored traffic, RELY-REC supports configurable filters for storage optimization and efficient monitoring. These filters can be customized by the end user, based on Wireshark semantic or can use predefined fields, based on layer 2 & layer 3.

Additionally, RELY-REC allows simultaneous remote access to the records stored internally through the service port. A timestamped event log available in the device simplifies the correlation of the triggers with the corresponding records.

About RELYUM

Relyum is born to provide innovative solutions for networking, synchronization and cybersecurity in critical systems. Its product portfolio is based on. SoC-e technology, which has been identified as a major key and innovating vendors of the automotive Ethernet market by Markets&Markets company, a well-known firm focused on market researching.

www.relyum.com

T. +34 944 420 700
info@relyum.com

Edif. Udondo, 6° planta
Avda. Ribera de Axpe, 50
48950 Erandio – Bizkaia | **SPAIN**