Advances towards a compact in-vehicle Ethernet-, Camera-, Radar- & LIDAR-measurement for high-bandwidth driver assistance systems
ADAS Logging

Growing Sensor Arrays, more Diversity and Increasing Data Rates

Sensors and Recorded Data for L3 - L5

- Camera
- Radar
- Lidar
- Fusion ECU
- Recorded Data in MB/s

Number of sensors

Data in MByte/s

Autonomous driving level
Storage Cost - and what it implies for logging

- 1 PB in Cloud \(\sim 400k$/yr\)*
- Validation of fully automated vehicles
  - 240 Million kms required**
  - 5% real driving data, rest simulation
  - Even at only lowest bandwidth level \((\sim 325M\text{Byte/s})\) that’s \(\sim 9\text{TB}/8\text{h shift or } \sim 136PB\) of total storage

\[ \rightarrow 55\text{ Million}\text{U}$/yr\]

\[ \rightarrow \text{Data compression, early on} = \text{value} \]

- Lossy compression - e.g. H.264 for video
  - Not suitable for signal based data
  - Not ideal for raw video from automotive cams
  - resimulation / DNN learning typ. needs full info
- **Lossless** compression - e.g. JPEG lossless (typically)
  - **Up to 40% reduction** in size possible


** Klaus Büttner/BMW, BMWBlog Oct’17
Strong reason for ADAS – new EU legal regulations for 2022/24

Road safety: Commission welcomes agreement on new EU rules to help save lives

Brussels, 26 March 2019

The EU institutions have reached a provisional political agreement on the revised General Safety Regulation. As of 2022 new safety technologies will become mandatory in European vehicles to protect passengers, pedestrians and cyclists.

New technologies on the market can help reduce the number of fatalities and injuries on our roads, 90% of which are due to human error. In May 2018, the Commission proposed to make certain vehicle

Driver drowsiness and distraction (camera/radar)

Intelligent speed assistance (camera, GPS)

Lane-keeping assistance (camera)

Advanced emergency braking (camera + radar)

Blind spot detection (truck/bus, 2024) (short range radar, camera)
Mechanical & environmental considerations

- Confined trunk volume ~500-600l
- Temperature management can be difficult, esp. hot climate/summer testing
- Cabling - shall be robust
  - Make system easy to setup & compact – esp. for high-channel count setups
  - Use Ethernet where possible as reliable intra-measurement system connection
Many & diverse Sensors and Devices must be measured in one System

- Radar (RAW Data, XCP, proprietary)
- Reference LIDARs (IBEO, Teledyne, Quanergy, ...)
- Context Cameras
- Vehicle Cameras (MobilEye-based, RAW Data ...)

- XCP-based Systems
- Analog sensors (pressure, accelerometer ...)
- GPS / IMU (GeneSys ADMA, OxTS ...)
- Vehicle Networks
- Other proprietary sensors
ADAS Logging – System view

Scaling up to multichannel systems - today

- Std. Eth (gPTP)
- Vehicle Network
- USB
- HSSL2

Configuration Visualization
User Interface

Timesynced Logger-Cluster

4 x Corner Radar

CANape + DHPRs

- REC

AXIS Camera

UTC Time Support

ABS/ESP

Fusion ECU

Front Radar

Vehicle Cam

4x Context CAM H.264

VX1135

VX1135

VX1135

VN5640

CAN FD
Auto.Eth.

Raw Data

Raw Data

TAPI Data

REC

REC

REC

REC

REC

Vector

Vector

Vector

Vector

Vector
3 in 1 Use Case: Visualization & Calibration / Logging / Data Analysis

- **Engineer Mode (day shift):**

  - CANape Configuration
  - Visualization
  - CANape log
  - Mobile UI
  - Visualization
  - CANape/ vSignalyzer Offline
  - Data Analysis
  - Same high-end logging system in the trunk

- **“Just Collect miles” Mode (night shift/weekend):**

  - CANape Configuration
  - Visualization
  - Mobile UI
  - Visualization
  - CANape log
  - CANape/ vSignalyzer Offline
  - Data Analysis
On the PC
- Configuration of Sensors, ECUs, interfaces ...
- Measurement configuration – signals, busses, objects
- Trigger & “log file splitting” definition
- Visualization
- Logging

CANape log on BRICK PC
- Download of CANape project
- Synchronization of CANape project
- Sensors, ECUs, interfaces ... are connected to the BRICK
- Interactive working still possible

Mobile UI
- Visualization of logger status
- Visualization of signal values
ECU & Raw Data Measurement

**VX1000 system for high-speed measurement**

Single source raw & debug data measurement

Multiple sources raw & debug data measurement

Size reduction? Easier setup & cabling?
ECU & Raw Data Measurement

VX1161 – Multi channel module for compact measurement setups

- Compact, highly flexible and scalable system
- Multi ECU support

- Reduced wiring efforts

- Time synchronization
  - IEEE1588 PTP
  - Vector Hardware Sync

- Up to 20 Gbit/s measurement data rate
- Data transfer to Host PC via 2 x 10 Gbit/s Ethernet
- Cascading of several Base Modules

- 4 ETH ports to connect addtl. measurement devices

- Powerful SoC for Add-on features
ECU & Raw Data Measurement

Video logging – Common System Setups

A1) Video via built-in measurement adapter (by ECU maker)

A2) Built-in video-TAP in ECU

B) Video TAP in grabber (centralized video ECU)

C) Raw-data-over-ECU-trace
Video Logging – Grabber HW for Multi-Channel System

**VX1161.51 Video Card**

- Slot-in-card for multi slot measurement rack
- First release ~end of Q3/2019 (video use case) with
  - FPD-Link III SerDes card
  - Support for up to 4 ch “endpoint” mode - record video stream from TIER1 camera measurement adapter
Dramatic increase in vehicle network data rates

100BASE-T1/1000BASE-T1 Network

Sum of data rates:

\[
\begin{align*}
& 2022 \text{ Mbit/s} \\
+ & 565 \text{ Mbit/s} \\
= & 2587 \text{ Mbit/s}
\end{align*}
\]

Logging specific Requirements:

- Monitor high Eth data rates in-vehicle
- **Must have**: Data Preselection in HW
- Logging: Avoid “duplicates” → Option to record information once at source only
Interfaces for Logging of Next Gen Network

- Today: VN5640 12+4 Channel
  6 x / 3 x TAP 100BaseT1
  6 x / 3 x TAP 100/1000BaseT1
  4 x 1000BaseTx

- Robustness: Harting iX industrial connectors

Brick-LE Example Setup with 24 x Auto-Eth

- 12 + 4 x Debug Interfaces
- Lidar, LowEnd Fusion-ECU & Radar

Outlook: VN5240 12 * 100/1000BaseT1
PC connection 10 Gb/Eth + 10 Gb/eth cascading port
Features for in-vehicle logging - Passive Bypass

- Onboard high frequency relays $\rightarrow$ closed TAP connection between two ECUs while the VN5240 powered down

- Initial state of the relays after device-power up configurable (open/closed)

- Opening passive TAP on power-up, depending on configured use-case and initial power-up configuration

$\rightarrow$ Active TAP & measurement practically instantaneous
### Features for in-vehicle logging - Monitor Filter

- Only subset of Ethernet frames typ. relevant
- Avoid duplicates on multi-hop connections for Logging use case

- Hardware based frame filter mechanisms
- Support of various protocol-parts/layers
  - MAC-address (source/destination)
  - Ethertype
  - IPv4-address (source/destination)
  - IPv6-address (source/destination)
  - TCP/UDP port
Monitor Filter Example: Transmission from ECU #A to ECU #E

Events to Application

T1 = RX_Event: Source Address A (Channel 1)
T2 = RX_Event: Source Address A (Channel 3)
T3 = RX_Event: Source Address A (Channel 6)
T4 = RX_Event: Source Address A (Channel 8)
Summary

- Ease of use for "collecting miles" scenario - CANape log

- Size reduction - Compact multi-channel sensor logging interface
- Video logging as part of multichannel system – also compressing data in HW

- Ethernet – ideal as measurement network
  → More robust cabling, compact HW setups by cascading
  → Precise timesync via PTP

- Ethernet as vehicle network backbone → Filtering required
  → Saves disk space & CPU resource

Thank you for your interest – Your questions?
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