YOUR AUTOMOTIVE PROTOCOL STACK.

A journey from specification to SOP.

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TECHNICA ENGINEERING

YOUR AUTOMOTIVE PROTOCOL STACK.

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1 CHAPTER
PROTOCOL STACK DESIGN.

RULES FOR STACK DESIGN.

- Designing a protocol stack is not difficult, if you follow some rules:
  - Reuse standards as much as possible because this leads to better understanding and quality.
  - Limit the number of protocols to lower complexity and raise quality, since your resources are limited.
  - Learn from other OEMs and don’t reinvent the wheel. What has been implemented and tested for another OEMs has already a better quality.

PROTOCOL STACK RECOMMENDATION.

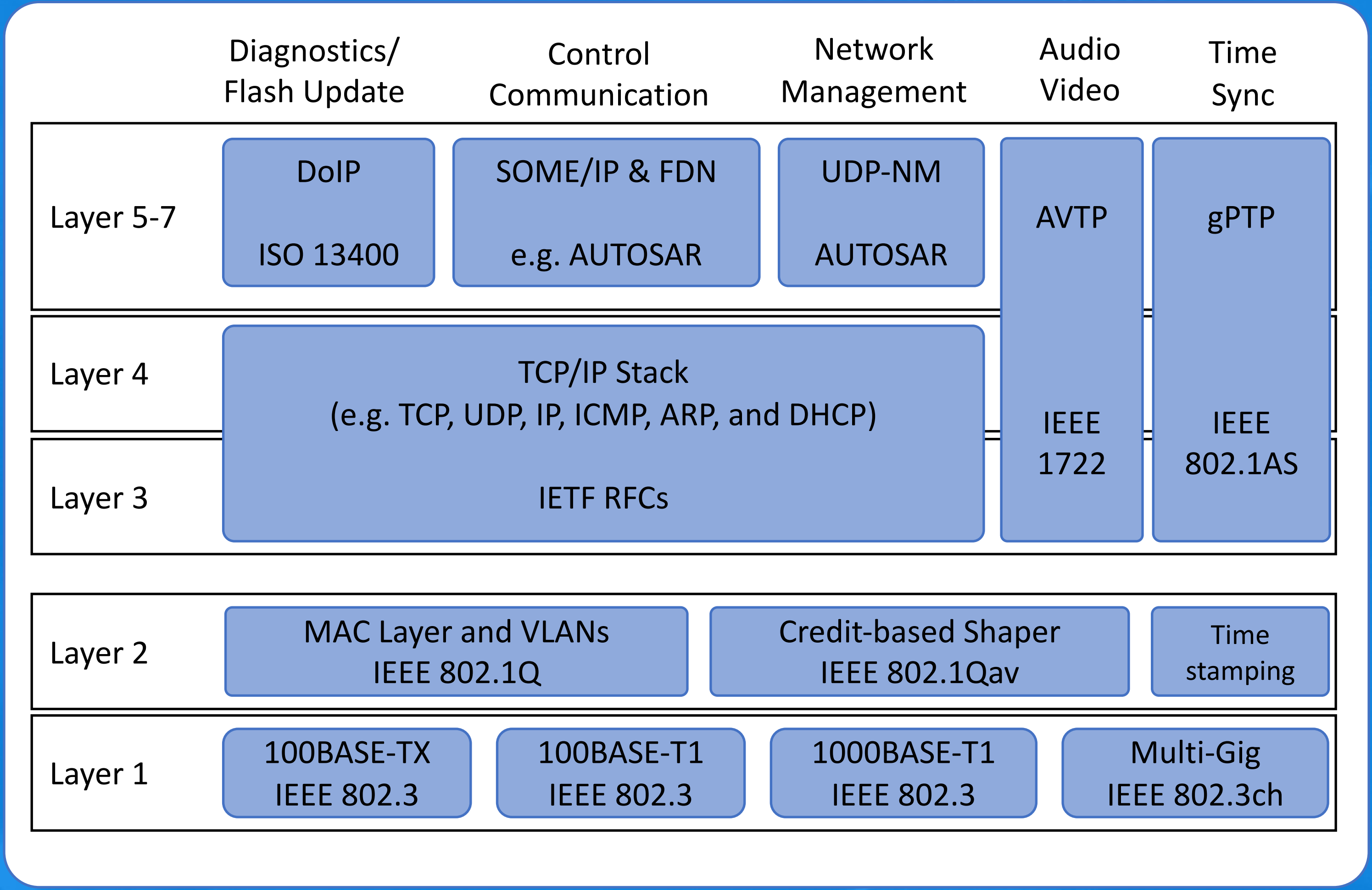

Figure: Technica engineering basic protocol stack recommendation.

PROTOCOL STACK EXTENSIONS.

- Layer 1: 10BASE-T1S:
  - New 10 Mbit/s Ethernet standard.
  - Half duplex bus with special “weighted round robin”-like arbitration.
  - May allow to close gap on low end.

- IEEE Time Sensitive Networking (TSN) features, e.g.:
  - 802.1CB – Frame Replication and Elimination for Reliability
  - 802.1Qbu – Frame preemption
  - 802.1Qbv – Enhancements for Scheduled Traffic
  - 802.1Qch – Cyclic Queuing and Forwarding
  - 802.1Qci – Per-Stream Filtering and Policing

- Optimal TSN feature set still under industry-wide discussion.

PROTOCOL STACK EXTENSIONS (2).

- Network Security
  - IEEE MACsec (802.1AE) can protect all unicast, multicast, and broadcast messages at line-speed.
  - SSL/TLS, IPsec, and VPN protocols for backend connectivity.
  - SecOC allows application layer protection for selected use cases.
- Access Control
  - Ethernet Access Control (802.1X).
  - SOME/IP policy enforcement.
- Filtering
  - Packet filters (mainly on layer 2, 3, 4).
- Intrusion Detection (IDS)
  - Scalable, distributed solution based on protocols build in.

WHY USE SOME/IP?

- Why is SOME/IP the most used middleware for automotive?
  - SOME/IP creates the abstraction needed for automotive applications.
  - SOME/IP scales from very small embedded devices to high performance ECUs.
  - SOME/IP Service Discovery allows "controlled flexibility" with user control.
  - SOME/IP supported by AUTOSAR (Classic and Adaptive).
  - SOME/IP is license free.
  - SOME/IP serialization is very efficient and fast.
  - SOME/IP is more than just serialization and service discovery.
  - SOME/IP was purpose-designed for automotive use cases.

INSIGHT: SOME/IP SERIALIZATION.

- The faster your communication gets, the more resources serialization needs. On embedded systems your resources are very limited.
- You want a middleware with high efficiency and high performance.
- Text-based formats are typically very slow in serialization and deserialization due to string operations.
- Self-descriptive formats are slow due to copy operations.
- SOME/IP allows you to build the most efficient high-performance system!
  - Format optimized for low resources and high speed.

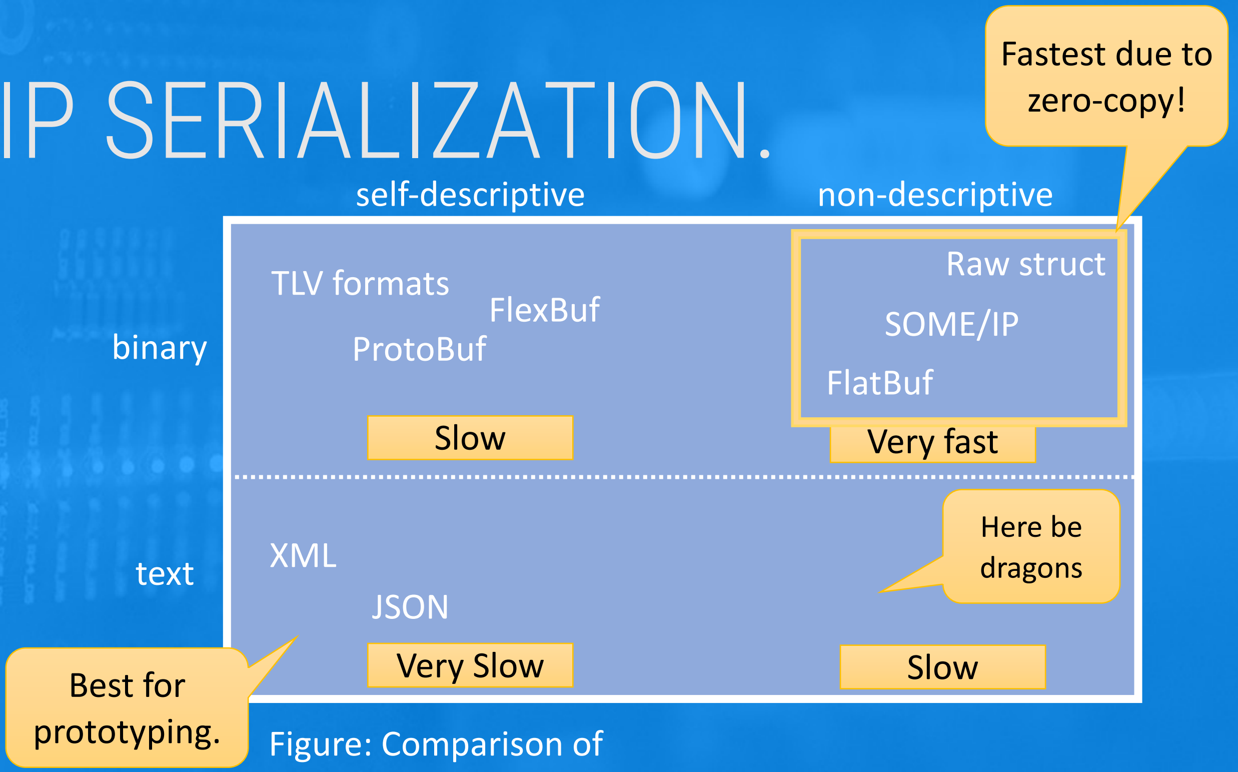

Figure: Comparison of serialization methods.

INSIGHT: SOME/IP-SD TIMINGS.

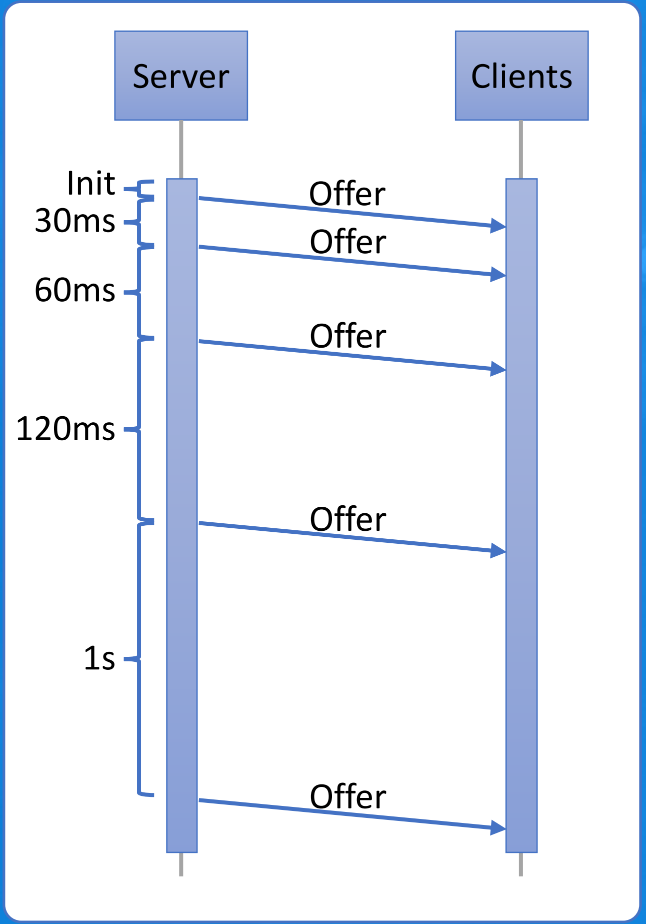

Figure: SOME/IP-SD timing example.

- SOME/IP-SD defines three phases:
  - Initial wait phase: allows to system to get ready.
  - Repetition phase: used for fast synchronization.
  - Main phase: stabilizes the system.
- The choice of the timings is very critical:
  - Determines startup performance.
  - Defines the behavior, when errors occur.
  - A thorough analysis is required, and experience helps!
- Starting point:
  - `RepetitionBaseDelay=30`
`RepetitionsMax=3`
`MainCycle=1s`
`TTL=3s`

TRANSPORTING CAN OVER ETHERNET.

- Transporting legacy CAN messages.
  - How to transport and how to gateway?

- Insights of our “Flexible Digital Network” work:
  - Avoid complex gatewaying to keep performance up and latency down.
  - Use standard transport for CAN/FlexRay.
  - CAN-FD to Ethernet and back to another CAN-FD: below 2ms latency.

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2 CHAPTER
REQUIREMENTS ENGINEERING.

REQUIREMENT ENGINEERING.

- Typical issues with specifications:
  - Specification is hard to understand.
    Often the goal is to specify and not to explain. But Tier-1 needs to understand.
  - Specifications are too large and too many.
    Implementers cannot remember 1000+ spec pages.
    Reference standards instead of creating your own.
  - AUTOSAR configuration changes behavior a lot.
    Hard to understand the behavior OEMs want.

ID	Type	Text
Ex-001	Info	This specification determines how SOME/IP is used as the in-vehicle Middleware.
Ex-002	Req.	The ECU shall support SOME/IP based on [1].

- Better:
  - Include explanations in specification.
  - Reference as much as possible and stick to standards.
  - Presentations for the specification and system design.

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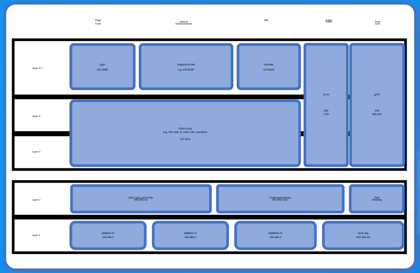
3 CHAPTER

TESTING AND INTEGRATION.

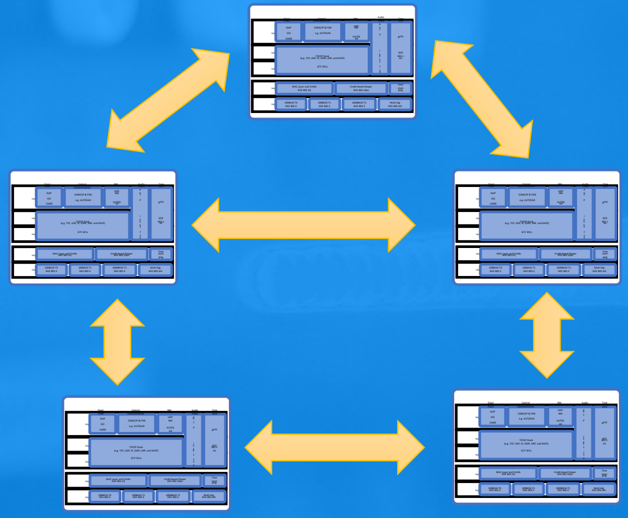
STACK TESTING.



- Many OEMs are not testing the stacks enough.
- Since this is "new" technology and quite complex:
  - Stack testing is hard.
  - Stack testing requires experts.
- Common mistake: leave Tier-1 alone with stack testing:
  - If Tier-1 misunderstands requirements, Tier-1 cannot find the issue.
  - Recommendation: use 3rd party or 3rd party tools for testing.
- Common problem: OEM specifics are not tested by standard tools.

INTEGRATION.

- Many aspects of the communication stack are distributed.
- Problem: You cannot find all problems in just testing a single ECU. So you find them, when you put together the vehicle for testing.
- Solution: Front-loading of integration of Ethernet network.
  - For better quality you want to integrate all Ethernet ECUs as early as possible.
  - You need to record the data.
  - You need to test the integration.
  - You need to analyze results.
- Benefit: Ethernet cluster is stable faster. Overall quality much better!



4 CHAPTER
LOGGING AND RECORDING.

COMMON PROBLEMS IN LOGGING.

- Ethernet logging is more difficult than CAN logging.
  - Data is only present on the links needed → you need to log all links!
  - The amount of data can be quite high.

- The logging setup must no interfere with timing sensitive protocols (e.g. IEEE 802.1AS / PTP).

- Even CAN-FD does not like changes to the topology!
  - In many vehicles it is impossible to record all CAN-FDs with a logger only.

- Solution:
  - Look for equipment designed for Ethernet.
  - Split data acquisition probes off the data logger.

DLT, XCP, ETC. IN VEHICLES.

- Problem:
  - Packet injection for DLT or XCP needed for logger to talk directly to ECU.
  - Packet injection can interfere with timings on link (changing the system you are measuring) and this is not acceptable for IEEE 802.1AS and others.

- Solution:
  - Ethernet packet injection without changing the link timings when injecting is needed.

LINKS AND TIMESTAMPS MATTER.

- Problem: you need to analyze lost or misrouted data, but the recorded logs do not have the required information to find the problem.

- Solution:
  - Data needs to be recorded on every link and marked with link and direction as well.
  - Data needs to be timestamped right at the link.

LINK FAILURES.

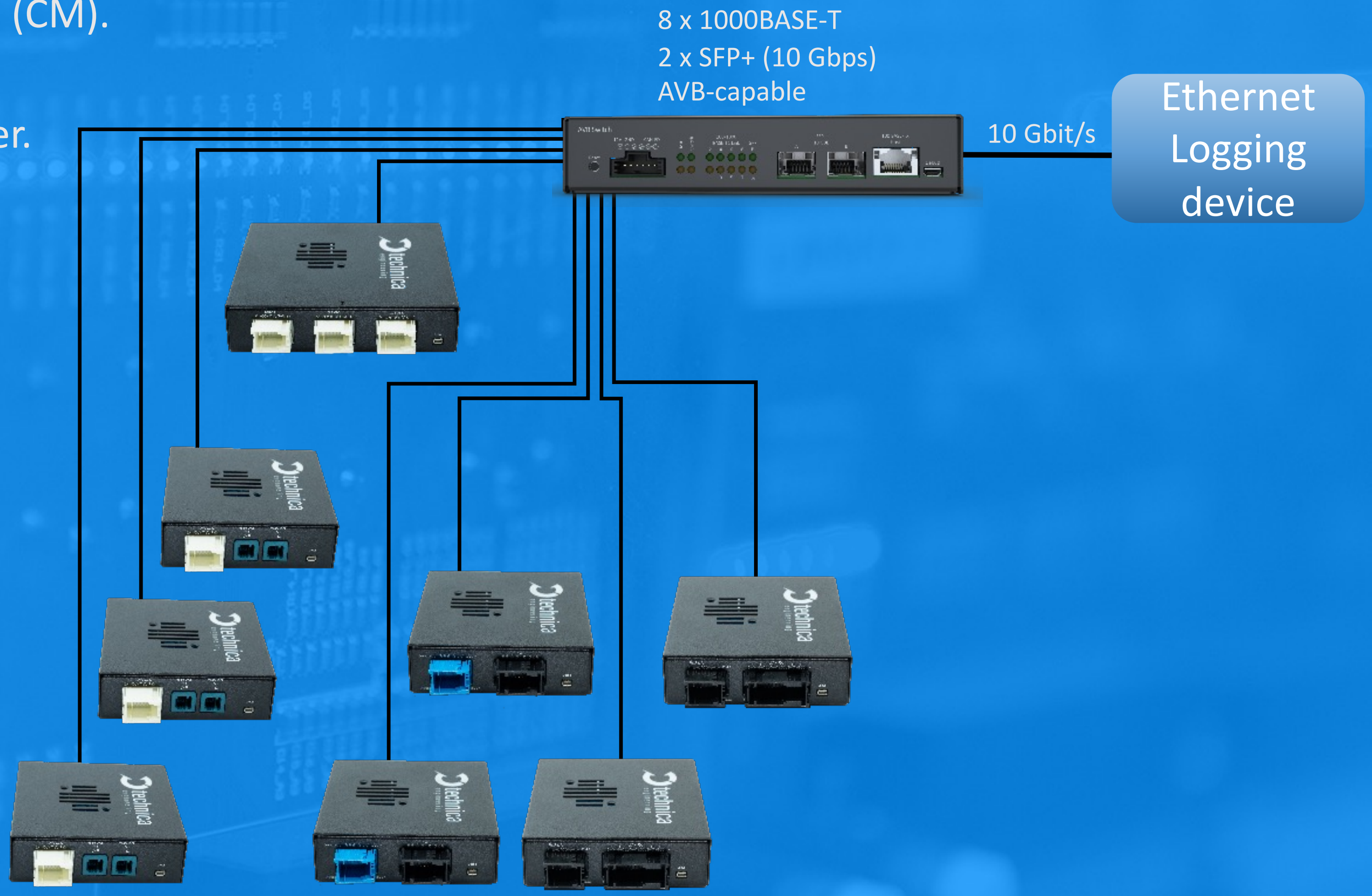
- Problem: In vehicles with a logging setup[1], packets seemed to be lost and the communication was not stable.
- Analysis: It turned out that links were not stable and short link-down/link-up cycles happened from time to time. Analysis was very hard and the root cause was even harder to find.
- Solution:
  - Record link quality.
  - Record link-up / link-down.
  - Do automated analysis on this data.
  - Quality control you test car fleet.

(1) Equipment of another vendor, so we cannot share details.

LOGGING – STATE OF THE ART.

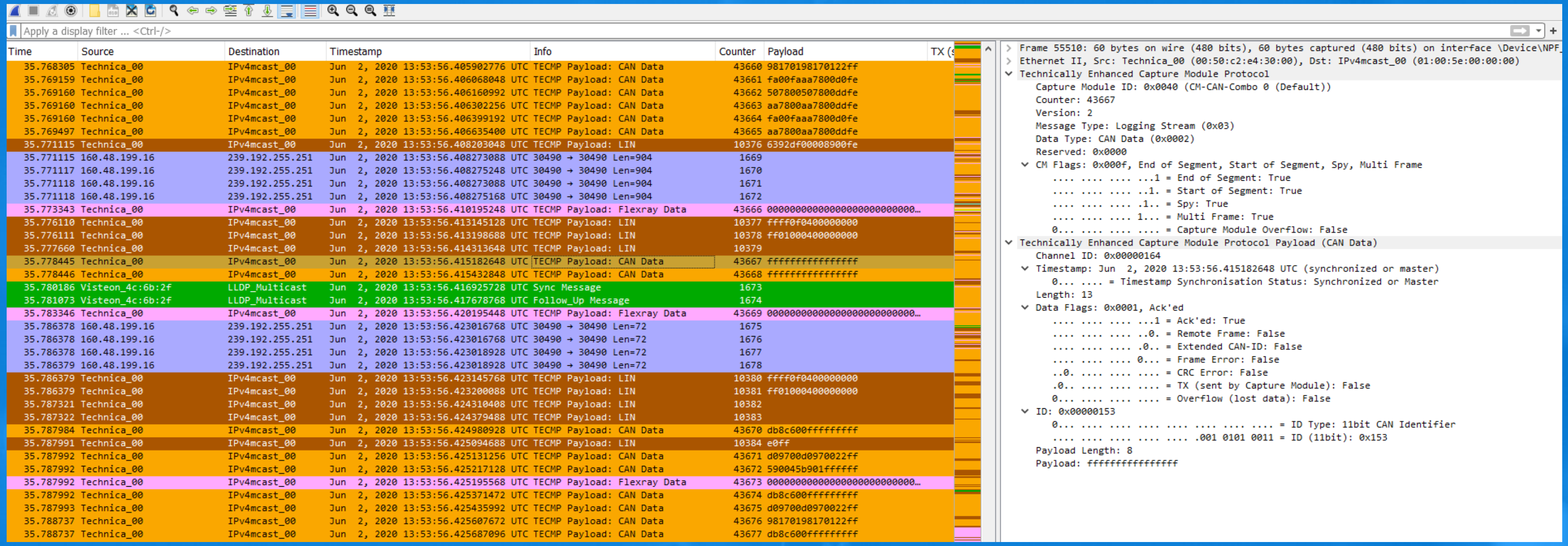
- State of the art logging setup:
  - Split Logger and Capture Modules (CM).
  - Logger synchronizes time to CMs.
  - CMs send data via TECMP to logger.

- Small example on the right:
  - 3x 1000BASE-T1 lines
  - 12x 100BASE-T1 lines
  - 12x CAN/-FD
  - 2x FlexRay ChA
  - 20x LIN
  - 4x RS-232
  - 8x Analog/Digital
  - 4x Analog/Digital (galv. Isolated)



LOGGING – STATE OF THE ART (2).

- Technically Enhanced Capture Module Protocol (TECMP)
  - Free and open state-of-the-art protocol.
  - Support data and meta data exchange between capture modules and logger.
  - Support Ethernet, CAN, CAN-FD, FlexRay, LIN, RS-232, Serial, Analog, and others.
  - Fully supported by Wireshark 3.4. Out now!



SUMMARY

- Protocol stack design:
  - Reuse standards and be focused.
- Requirements engineering:
  - Make Tier-1s/2s understand.
- Testing and integration:
  - Let a 3rd party test and integrate early.
- Logging and recording:
  - Go for state-of-the-art solutions with all key features.

- Overall these recommendation raise the quality of your product.

STAY CONNECTED.

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