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ETHERNOVIA

Microservices in a Zonal Vehicle Architecture

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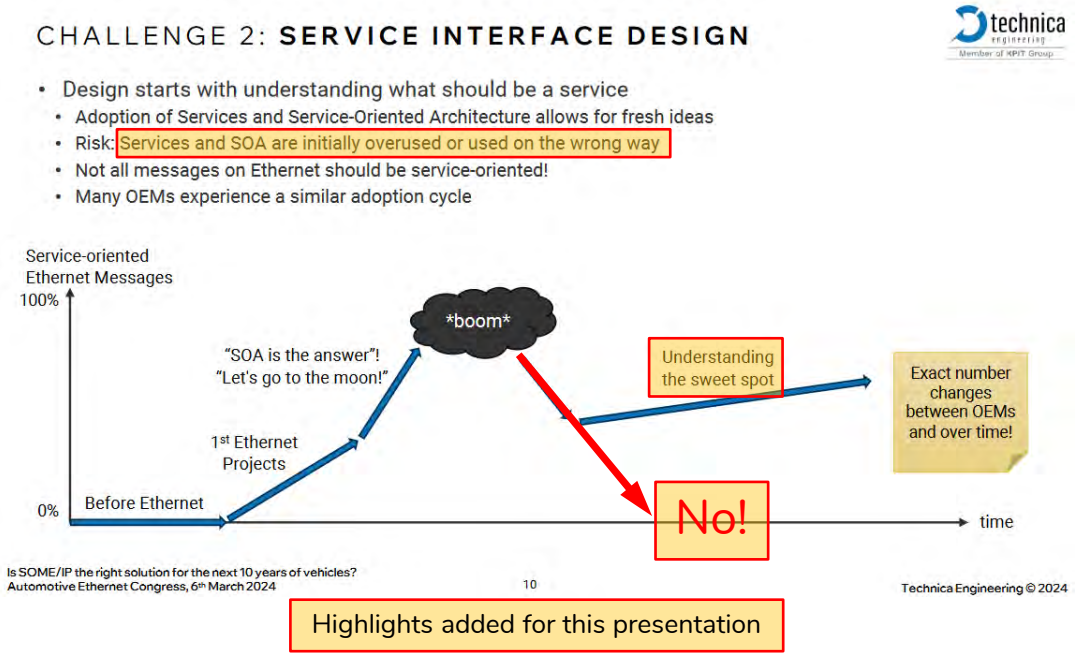
IEEE SA STANDARDS ASSOCIATION

Why Service orientation?

- Defining a good (micro-)Service is difficult!
- The current definition of what a “Service” is and some of the implementation choices hinder the industry from moving on to even fresher ideas
- Change what we call a Service and then go full blown SoA
- Make use of architectural trends (zonal) and embrace the SDV

Presented by Lars Völker, the “father” of SOME/IP



Highlights added for this presentation

SoA … Service oriented Architecture
SDV … Software Defined Vehicle

Why “micro-”Service?

- A Server can offer:
  - Subscribing to pub/sub elements
  - Calling of RPC methods
- A Service should ideally only be announced on SD if the full service is available (all pub/sub elements and all RPC methods)
- Modular software deployment allows fine granular updates of services with minimum disruption for users of other parts of the service
- Versioning and instantiation allow for early identification of incompatibilities and fall-back

RPC … Remote Procedure Call
SD … Service Discovery
pub/sub … publish/subscribe

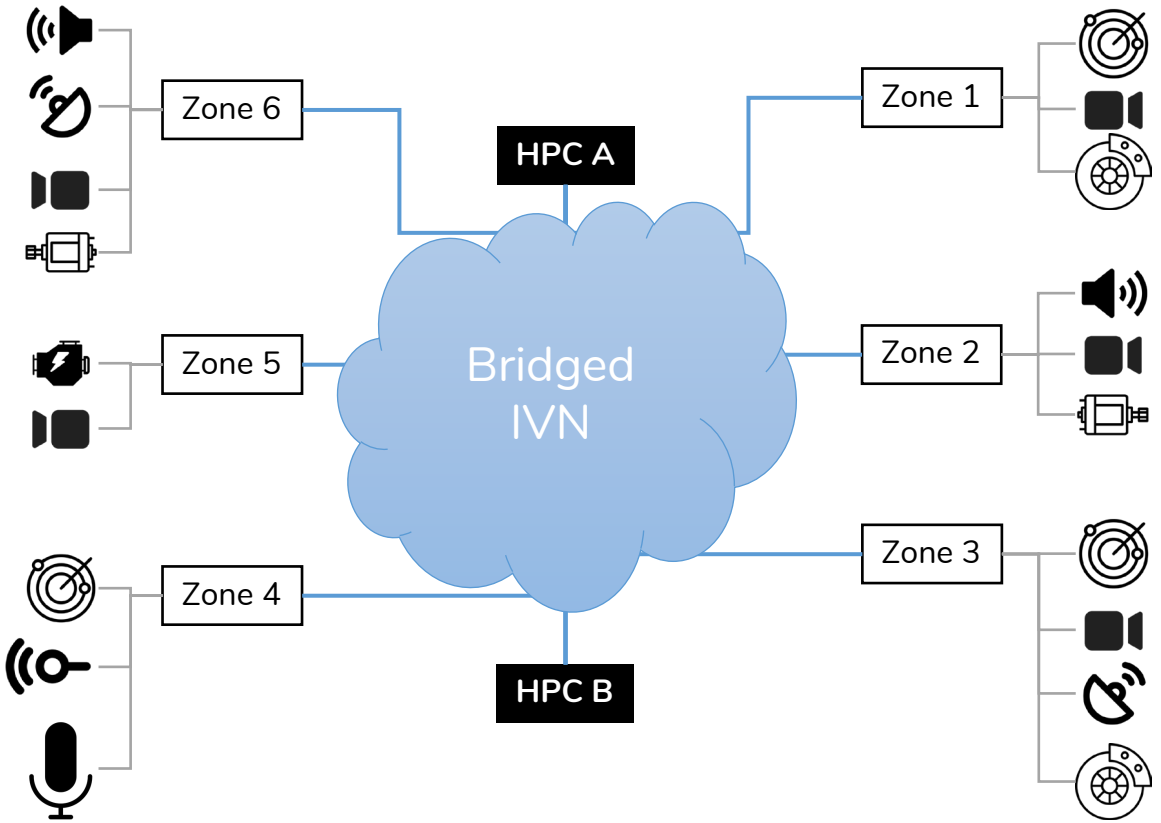
What makes a (micro-)Service a “Service”?

- The “Service Contract” + “Service Discovery”
- Service Discovery
  - Prevents usage of a Service (Instance) which is not available
  - Gives (last) details on how to reach a Service (Instance)
  - Allows dynamic network configuration for QoS configuration and Groupcast forwarding
  - Can make other resolution and discovery protocols redundant
- Service Contract
  - Name, numerical ID, and functional cluster
  - Functional specification
  - Defines the protocol and serialization of the messages transported
  - Provides versioning and multi instancing
  - Defines application and network QoS
  - Defines security requirements for clients and servers
  - The maximum number of concurrent users
  - Dependency on power states
  - Default and fall-back instance information

QoS … Quality of Service

Ideal Zonal Architecture

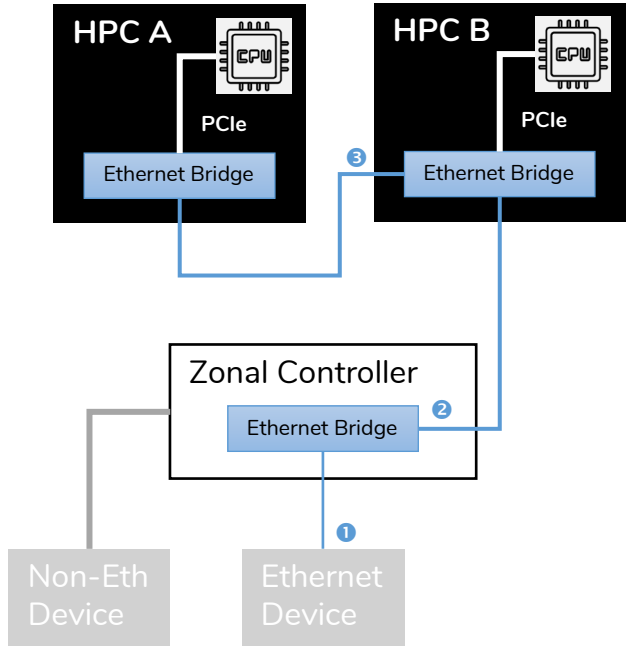
- Sensors and Actuators are connected to Zonal Controllers based on geometric location, not based on functional domain, nor data consumer, nor control entity
- Sensors and Actuators use various technologies (CAN, I2C, analog, 10BASE-T1S, LIN, …) to connect directly to the Zonal Controllers
- Communication is mainly between HPCs and Zonal Controllers or between HPCs, but not between Zonal Controllers
- The network topology is very much “Star like”, “radiating” out from an HPC cluster
- A (partial) Ring topology is feasible, but not the focus here



sensor/actuator symbols are examples only and not meant to be all-encompassing
the same is true for number of zones and HPCs

What makes a Zonal Architecture "zonal"?

- HPCs handle the majority of compute tasks
- Zonal Controllers connect the sensors/actuators for all functional domains
- There are never more than ❸ "hops" between 2 devices on the network
  - 2 of those will be (AVB) hops as per IEEE Std 802.1BA
  - 1 may be a different communication technology
- Communication links traversing the vehicle connect to Zonal Controllers only, not to other devices
- Devices connected to a Zonal Controller should be as "dumb" as possible, ideally they are only "analog" sensors/actuators
- Larger functional domain blocks could be substituted for a Zonal Controller

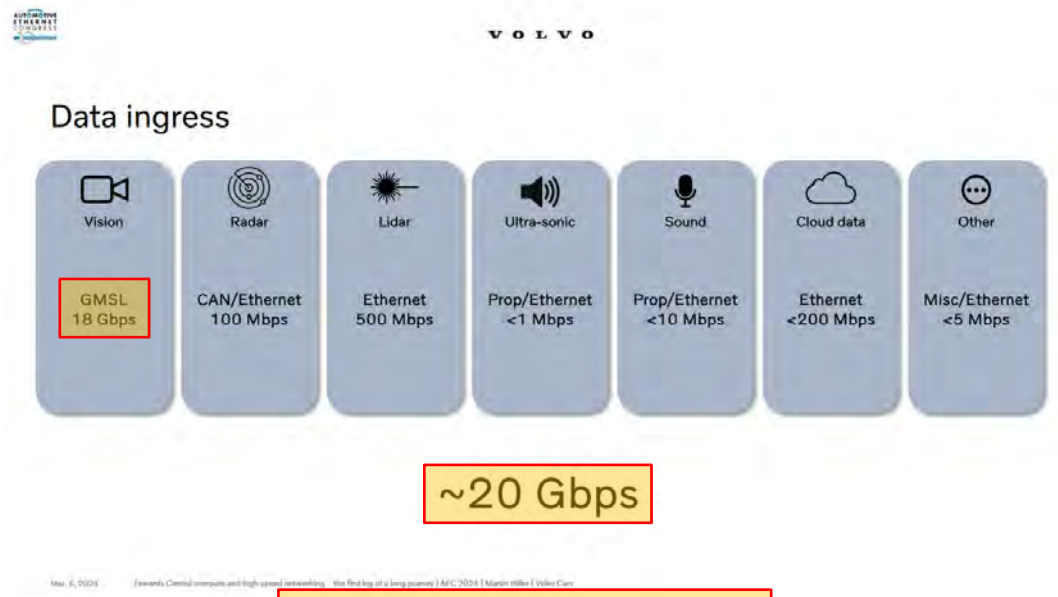


HPC ... High Performance Compute
SOTA ... Software Over The Air
NM ... (automotive) Network Management
SD ... Service Discovery
NVM ... Non Volatile Memory

Why Zonal Architecture?

- Without Video/Radar/Lidar the vehicle needs way less then 2Gbit/s of data transport in total!
- Some Imaging LIDAR and RADAR might move to the “Vision” cluster
- For the multi-purpose Ethernet to compete with specialzed communication systems, one needs an “excuse” to use higher data-rates than are required for the application (compare VoIP vs. SDH/SONET and “triple play”) – Zonal aggregation enables this for the IVN
- High line-rate links offer low latency for small control frames (“The Free Rider Principle”[1])

Presented by Martin Hiller



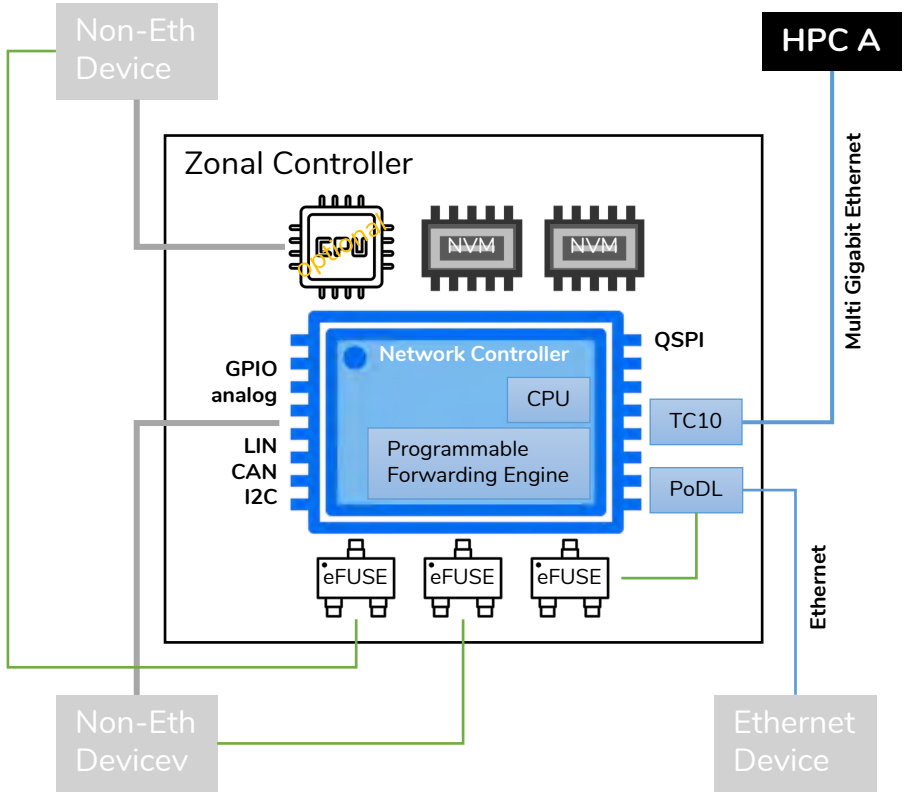
Highlights added for this presentation

IVN … In Vehicle Network
SDH/SONET … Synchronous Digital Hierarchy / Synchronous Optical NETworking
VoIP … Voice over IP
“triple play” … TV + VoIP + Data

[1] Max Turner, “The ‘Free Rider Principle’ for Low-Bandwidth Flows in High Line-Rate Networks,” presented at the 2021 IEEE Standards Association (IEEE SA) Ethernet & IP @ Automotive Technology Day, Munich, Nov. 04, 2021.

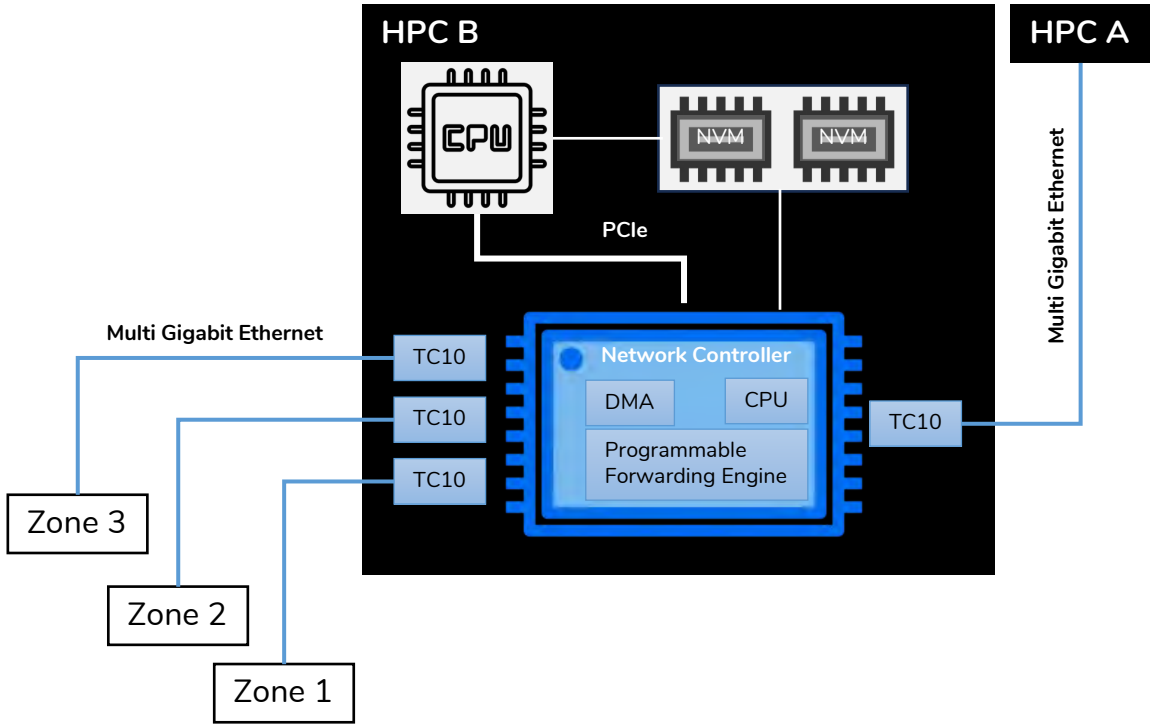
Defining Features of the Zonal Controller

- Zonal Controllers handle NM and SD for the connected devices
- Zonal Controllers manage the powersupply for all connected devices
- Zonal Controller's SW can be updated through SOTA to dual NVM via the Network Controller
- Zonal Controllers can update connected devices, although that is not desirable
- Zonal Controllers should not have to "touch" every piece of information going between an HPC and the devices
- Zonal Controllers protect connected devices from overload
- Zonal Controllers protect the HPCs from overload



How about the HPC?

- High data ingress load requires HW support
- Limit the communication stack tasks in the Host CPU/SoC to a minimum
- Header analysis and packetization in programmable HW
- Exchange of structured data between the Host CPU/SoC and the Network Controller via DMA
- Applications on Host CPU/SoC can mostly run in polling mode to prevent context switching
- SD, NM and other network administration tasks can run on the Network Controller's CPU
- HPC's SW can be updated through SOTA to dual NVM via the Network Controller



Conclusion

- The overall data transfer for the in-vehicle network is dominated (**>90%**) by imaging technologies like **cameras**, radars, and/or lidars
- Bringing this image data to Ethernet allows for the vehicle network to benefit from the **higher data-rate** connections for other applications (audio, control, …)
- Zonal Aggregators can **reduce the number of ECUs**, **simplifying the update process** and enabeling more efficient resource usage
- Moving from MII-like interfaces to **PCIe** between the network attachment and the processor in the central compute modules, enables **DMA** data transfer as well as offloading of network administration (SD, NM, QoS, …)
- While network infrastructure had to be invisible when Ethernet was introduced into the in-vehicle network around 2010, high data-rates and **Zonal Architecture** warrant the introduction of **specialized hardware** for networking, just like for articicial intelligence, graphics, signal processing, …
- In turn this enables the **Software Defined Vehicle** to run on **Micro-Services**, thereby simplifying **software orchestration**

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