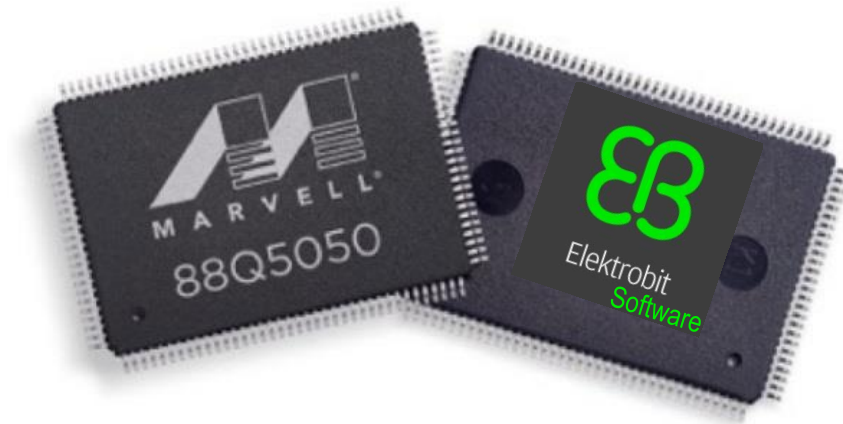


Smart Ethernet Switch Architecture

Michael Ziehensack, Elektrobit

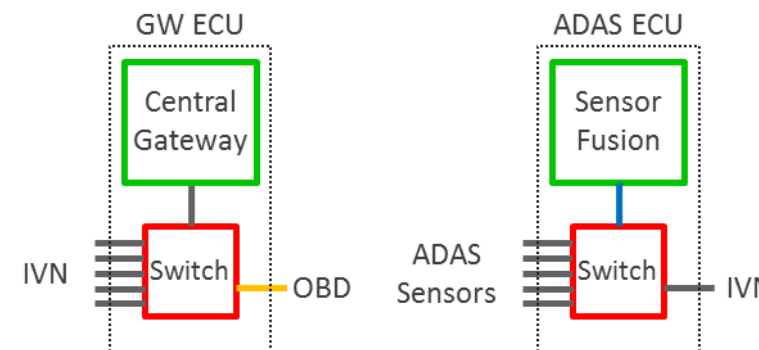
Manfred Kunz, Marvell



Introduction

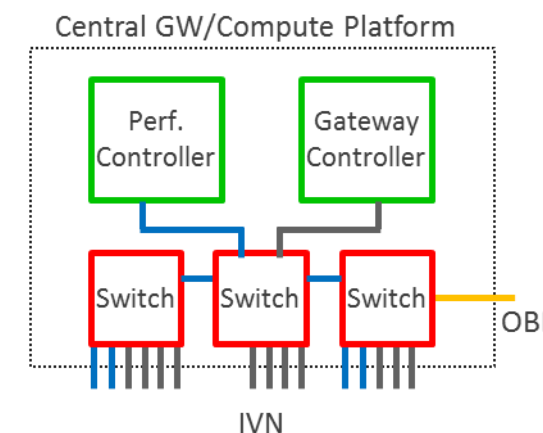
Initial use of Automotive Ethernet switches

- Ethernet switches are core components of an Automotive Ethernet network
- Focus on vehicle access and high bandwidth
- Typically switches are used in Gateway ECUs and ADAS ECUs



NEW: Ethernet switches for more advanced use cases

- Additional requirements to support Autonomous Driving and Connected cars: Quality of Service, Security, Time Synchronization and Safety
- New types of ECUs such as Highly Autonomous Driving Platform, Central GW/Compute Platform
 - Typically they provide multiple CPUs (Performance CPU, Management CPU) and require multiple cascaded switches to provide sufficient switch ports and redundancy.

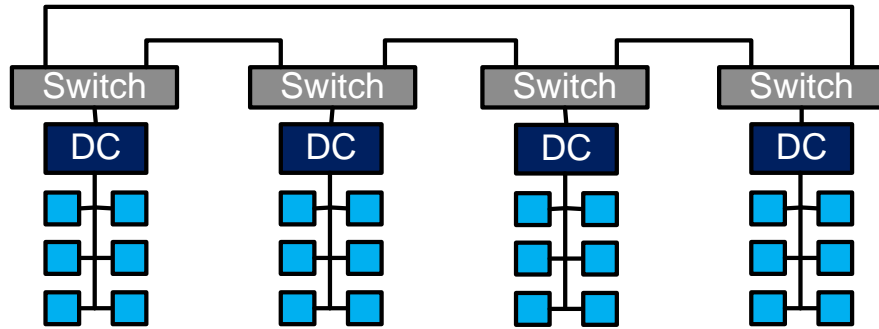


Switches in the E/E Network Architecture

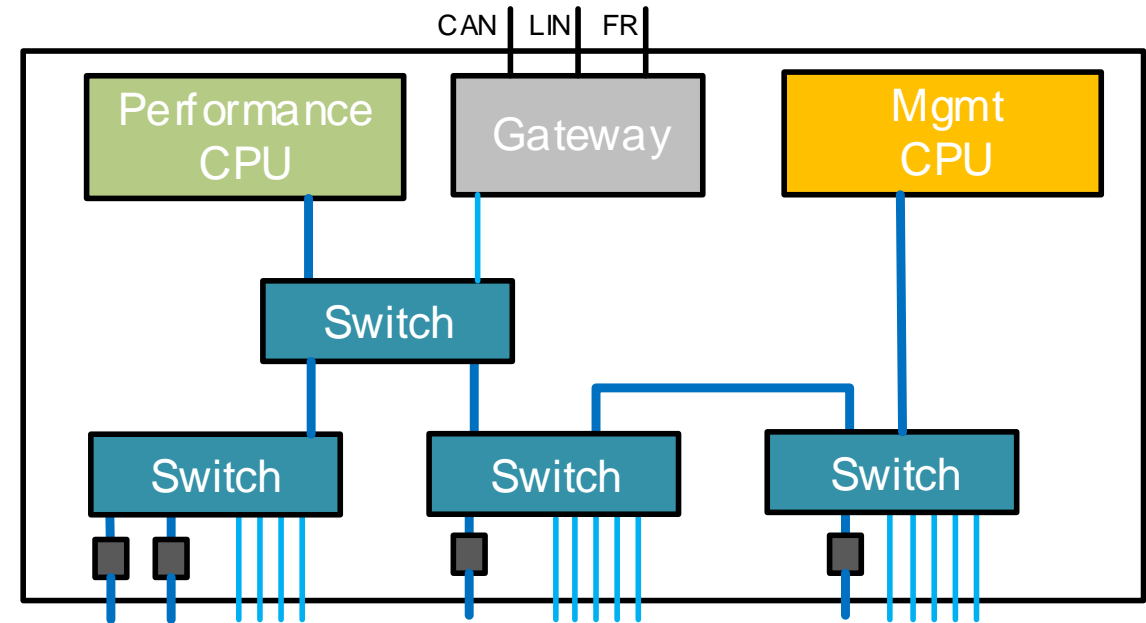
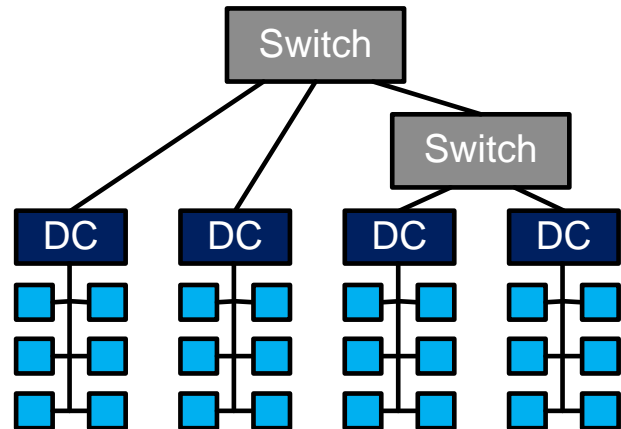
Domain Controller Architectures with Ethernet Backbone

Centralized Star Architecture (Network in a box)

Ethernet Backbone Ring

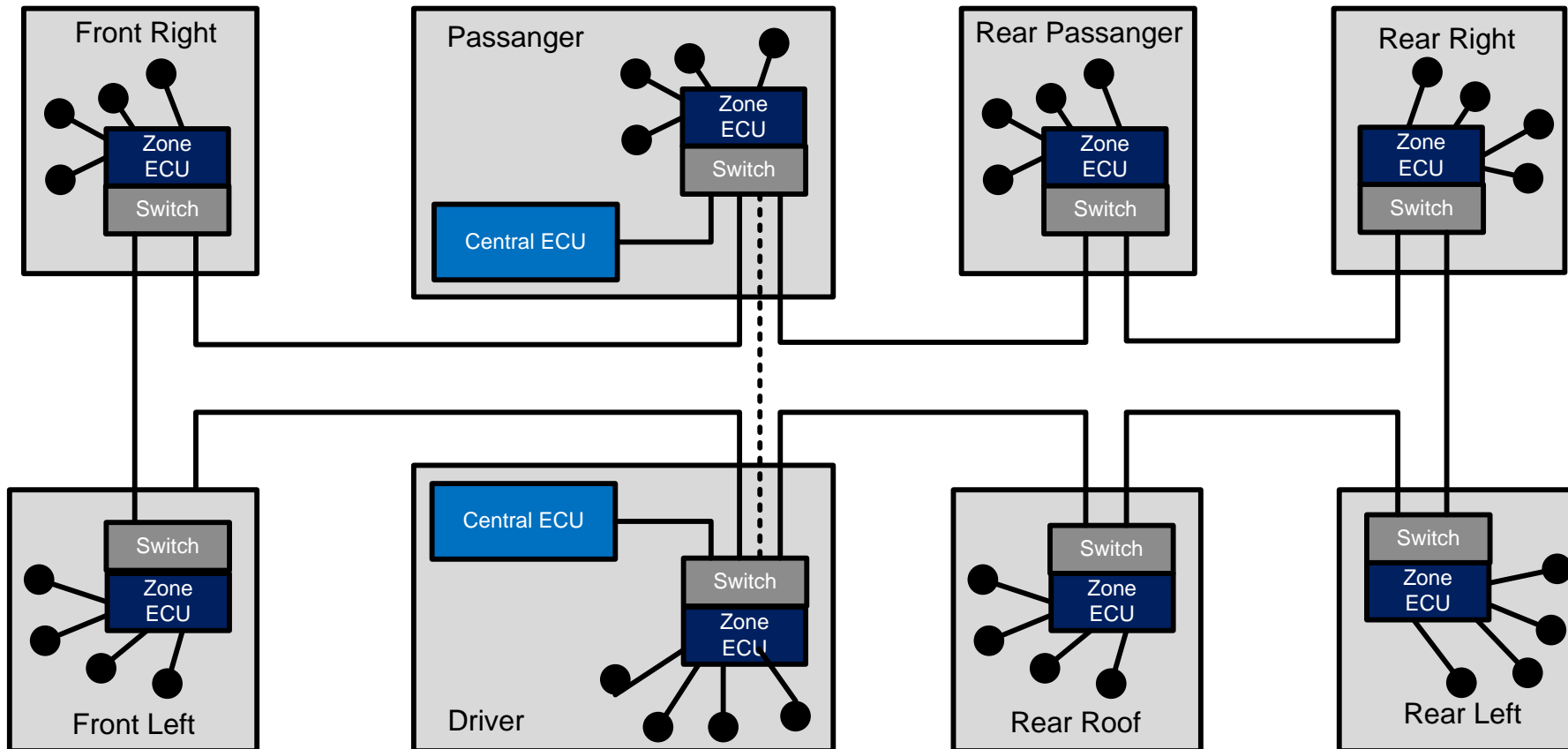


Ethernet Extended Star



Switches in the E/E Network Architecture

Zonal Architecture



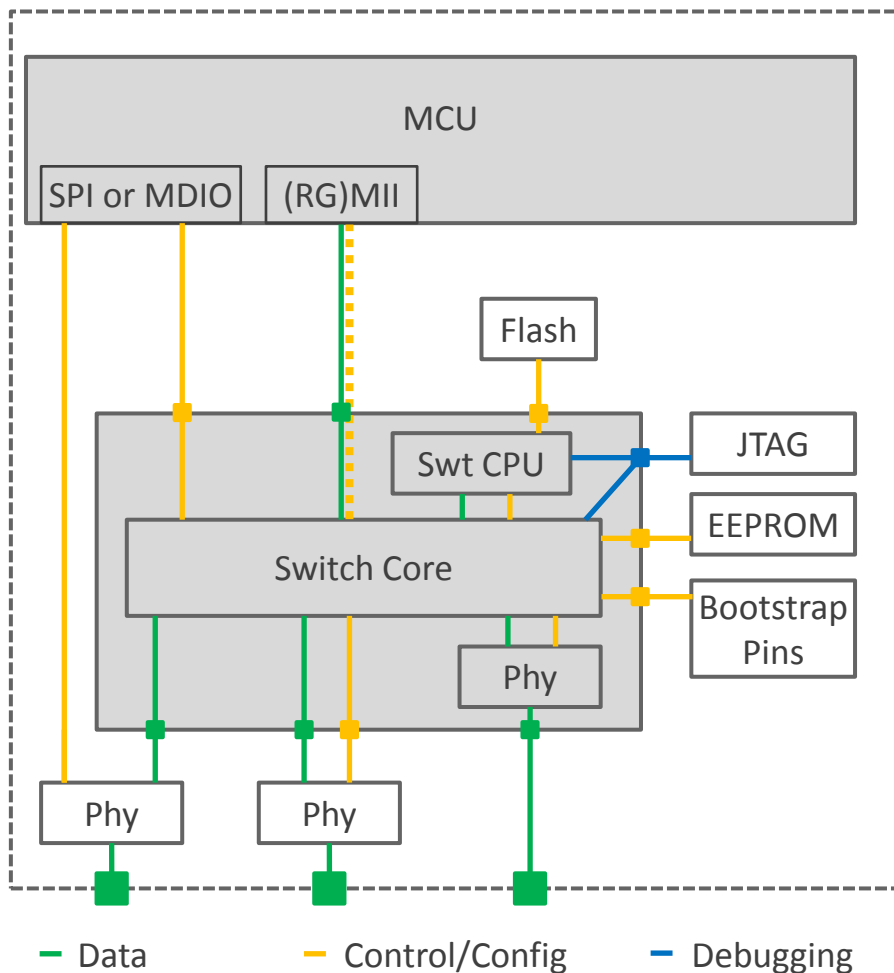
Requirements for an Automotive Ethernet Switch

Requirements

- Powerful switch core
- AVB / TSN features (QoS, PTP, ...)
- Port scalability by cascading of multiple switches
- Support of multiple transceiver types/speeds including control
- Flexible low latency data inspection and data path manipulation capabilities
- Comprehensive and fast configuration and diagnostic interface (forwarding rules, filter, learning modes, queues, ...)
- Fast start-up including configuration
- High speed IP/VLAN Routing
- Security (authenticated configuration and control, traffic filtering, DoS prevention, IDS client ...)
- Automotive qualified

Ethernet Switch – Configuration and Control

Electronic Control Unit

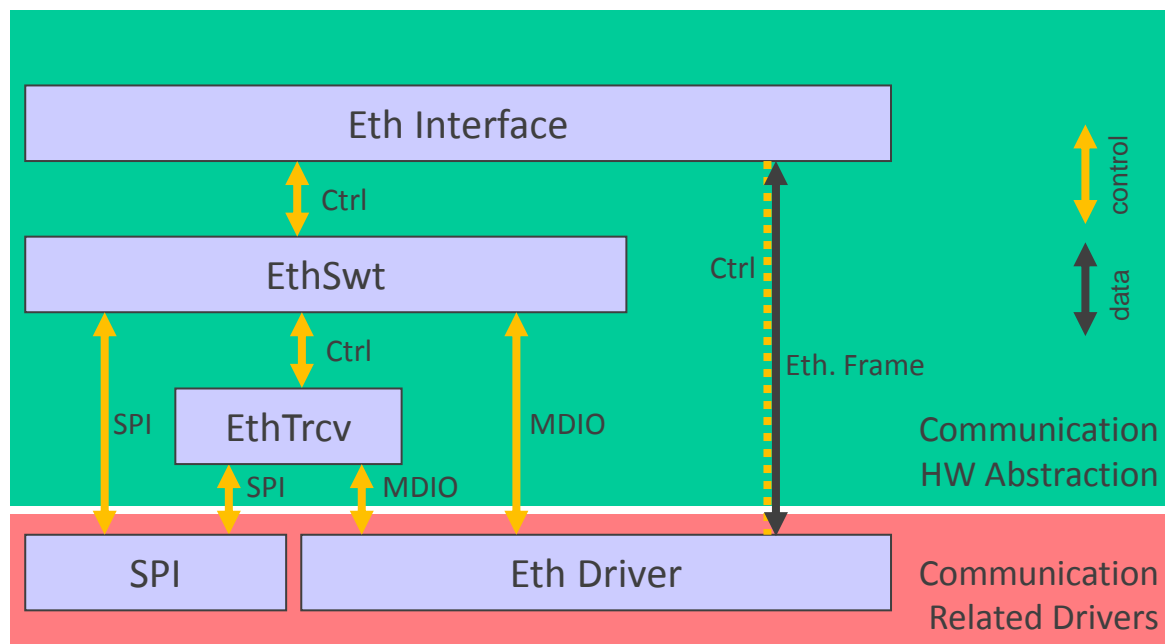


Different options to configure or control the Switch/PHY

- Unmanaged (configuration only, no control)
 - Bootstrap Pins: at startup, fast, but quite limited configuration
 - EEPROM: at startup, full register configuration
- Managed via external CPU
 - SPI or MDIO: config/control via external CPU
 - Ethernet: config/control via Ethernet frames from external CPU
- Managed via internal CPU
 - Flash: config/control via internal CPU that loads firmware and configuration from flash

Supported options depend on the device, also a mix of options is typically possible

Ethernet Switch – Configuration and Control



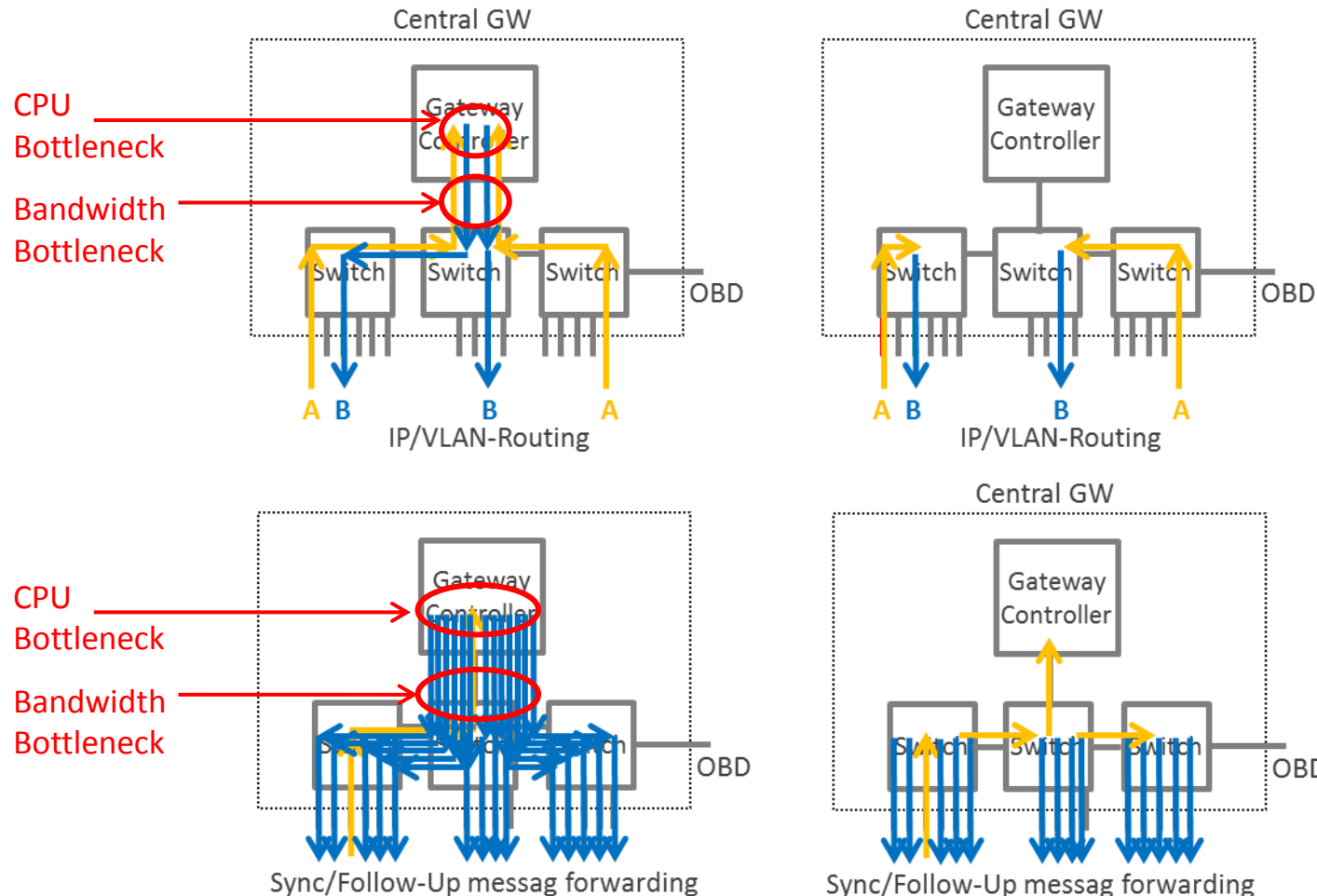
AUTOSAR Stack for Switch configuration and control

Configuration and control path

- Switch config/control via external CPU
 - Eth Interface calls EthSwt for switch (and related transceiver) config/control
 - Access to Switch via SPI or MDIO or Ethernet frames
- Transceiver (PHY) config/control via Switch
 - EthSwt calls EthTrcv for transceiver config/control
 - Access to Transceiver (PHY) via Switch
- Transceiver (PHY) config/control via external CPU
 - EthSwt calls EthTrcv for transceiver config/control
 - Access to Transceiver (PHY) via SPI or MDIO

Supported options depend on the device, also a mix of options is possible

External vs. internal Management CPU



- IP/VLAN-Routing Use Case

- Network can be split into security zones by using Virtual LANs with a separate IP-Subnet in each VLAN.
- Communication between these security zones need a IP/VLAN-Router then.

- Time Synchronziation

- IEEE802.1AS time synchronization requires the switch to forward all Sync/Follow-up messages and to compensate the residence time for all switch ports

Smart Ethernet Switch

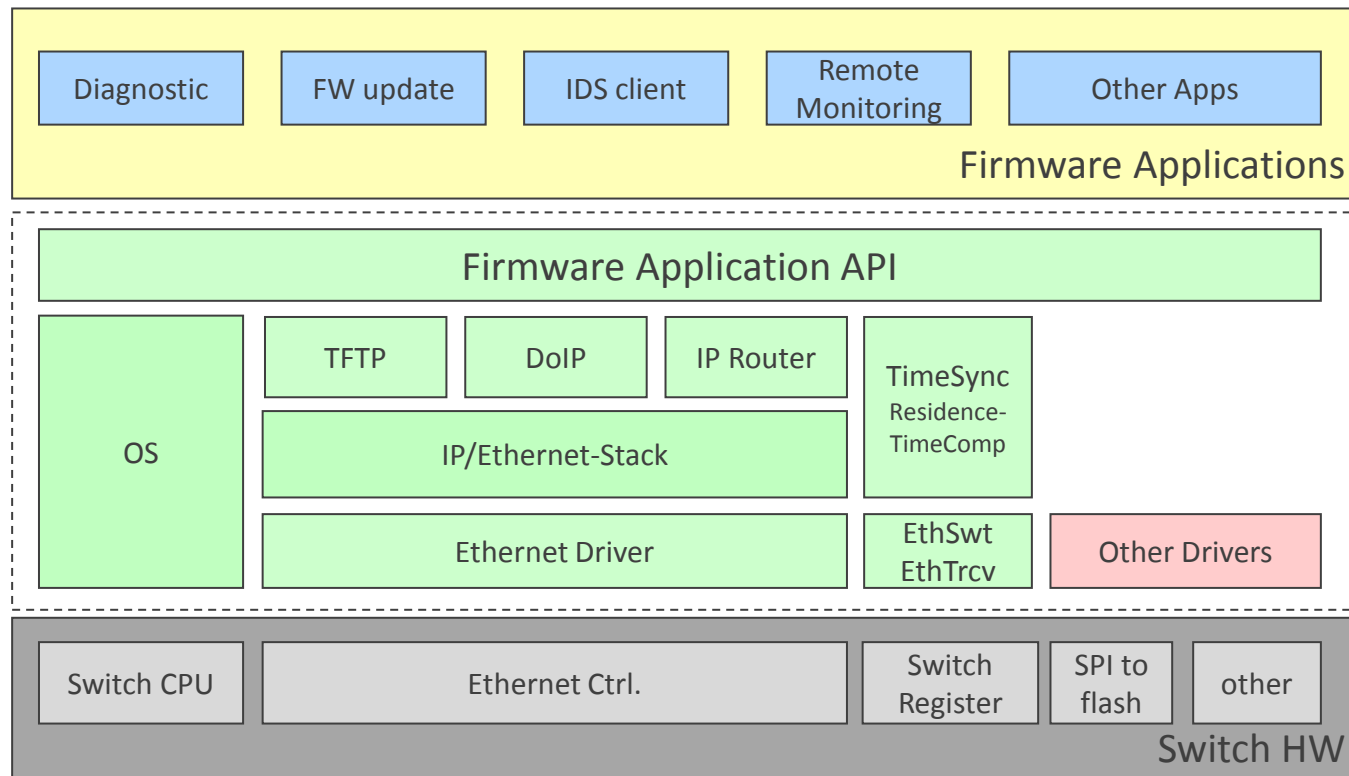
- Definition of a Smart Ethernet switch:

Ethernet switch that provides an integrated/dedicated CPU with high-speed data access for switch configuration/control and “data plane access”

- Key-Advantages

- No CPU and bandwidth bottleneck (see previous slide)
- no cross-dependencies with other ECU features (e.g. time sync for ECU time slave vs. time sync management of switch)
- faster, parallel startup (i.e. configuration of switch in parallel to ECU startup)
- independent reboot of switch and MCU
- high scalability, because each switch brings related CPU power
- Extendibility (e.g. PTP with data protection and user data)

Ethernet Switch Firmware Architecture



Features:

- Switch Management (config/control)
- Residence time compensation, support of CRC protected time sync messages and user data
- Firewall, IP/VLAN-Routing
- Extended diagnostic, Intrusion Detection System Client, i.e. reporting of traffic statistics, forwarding of suspect frames,
- Remote network monitoring

Requirements on an Automotive-Grade Switch Firmware

Requirements based on feedback from OEMs and Tier-1s (2016/2017)

- Quality:
 - Development process and documentation according to ASPICE L2 (or higher)
 - MISRA C, Static code analysis, 100% requirements and code coverage
- License:
 - Non-GPL, must not contain any open-source code
- Security:
 - Secure boot of firmware, i.e. authenticated firmware image verified at each start-up
 - Secure configuration, i.e. authenticated configuration
- Extendibility for specific use cases:
 - Base firmware as binary image, SDK for small firmware extensions, Fully customized firmware
 - AUTOSAR driver interface

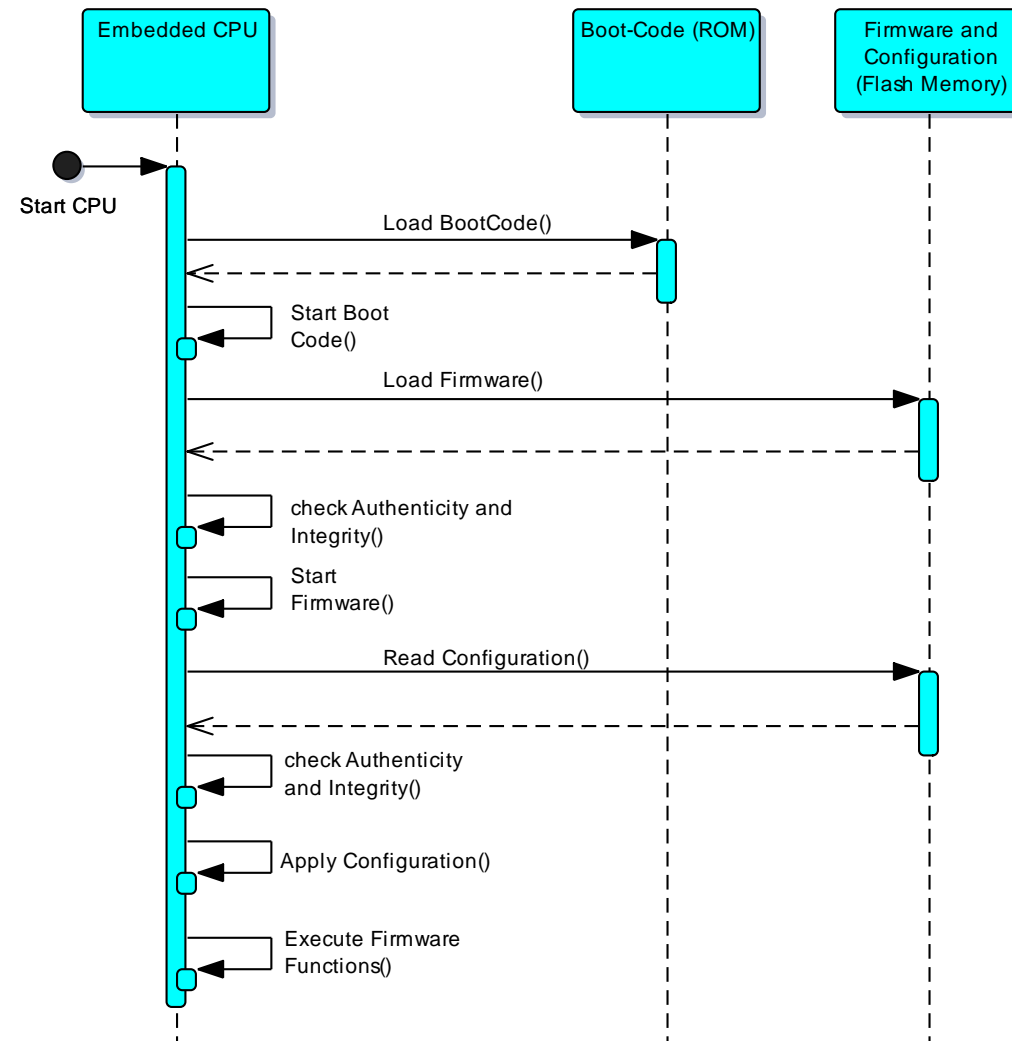
Secure Ethernet Switch Firmware

Security requirement:

- Ensure authenticity and integrity of any software running on the device

Solution: Trusted Boot concept

- Uses asymmetric cryptography
- Chain-of-trust
- Only public key is needed locally (immutable stored on the device)
- OEM has the private key to sign



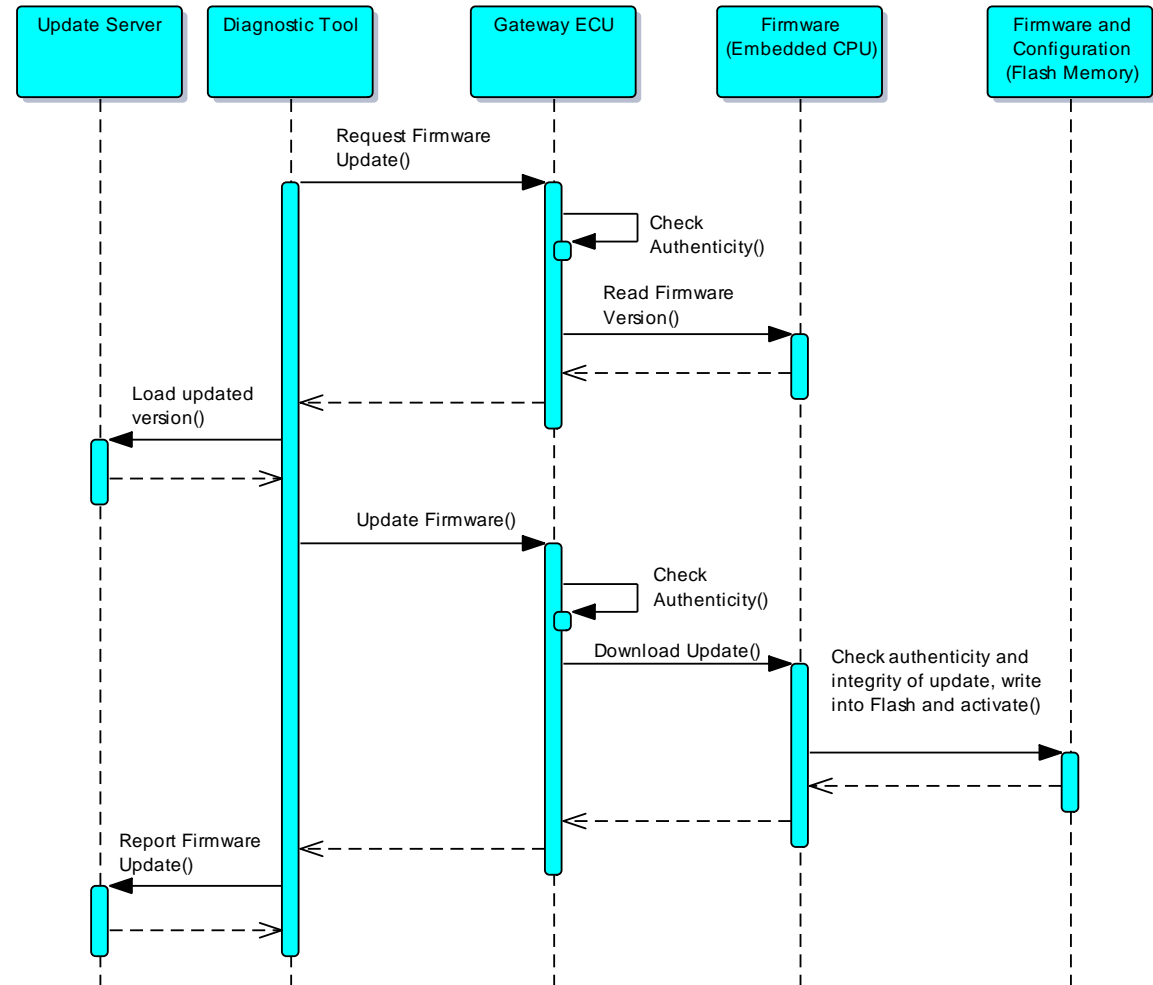
Secure Ethernet Switch Firmware

Requirements:

- Ensure authenticity and integrity of any software and/or configuration update before using it
- Ensure that any failure during the update process still results in a bootable and trusted firmware and configuration (fail-safe)

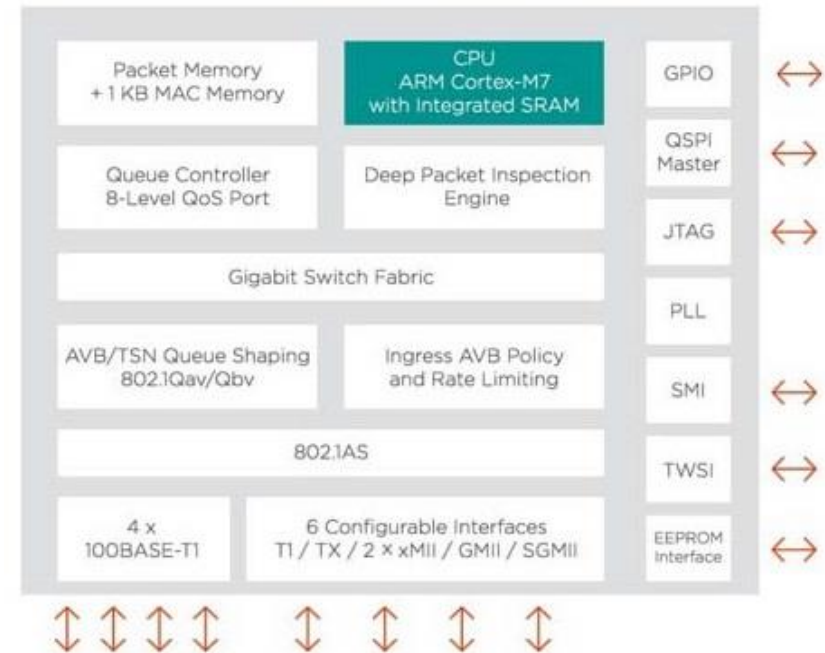
Solution: Trusted Update Concept

- Use the measures from Trusted Boot and Trusted Configuration for every update block **before** activating it
- Use backup images to ensure fail-safe operation



Smart Ethernet Switch – Available TODAY!

- Marvell’s Secure Automotive Ethernet Switch is available today
 - Integrated ARM Cortex-M7 CPU, 250 MHz
 - Advanced automotive security features, including deep packet inspection (DPI) and Trusted Boot functionality
- EB Software for Automotive Ethernet Switches is available today
 - Switch Driver and Transceiver Driver based on AUTOSAR
 - Ethernet Firmware extension (Firewall, Routing between IP-subnets/VLANs, IDS-Client, APnP*, Remote Monitoring*)





Thank you for your attention !!

Author information

Dr. Michael Ziehensack, Elektrobit
Director, Car Infrastructure Software
michael.ziehensack@elektrobit.com

Manfred Kunz, Marvell
Senior Director Engineering
mkunz@marvell.com