Smart Switches in AUTOSAR Eco Systems

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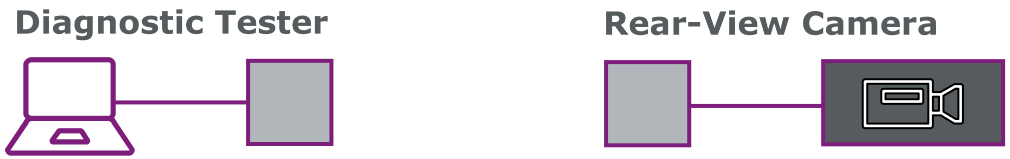
Agenda

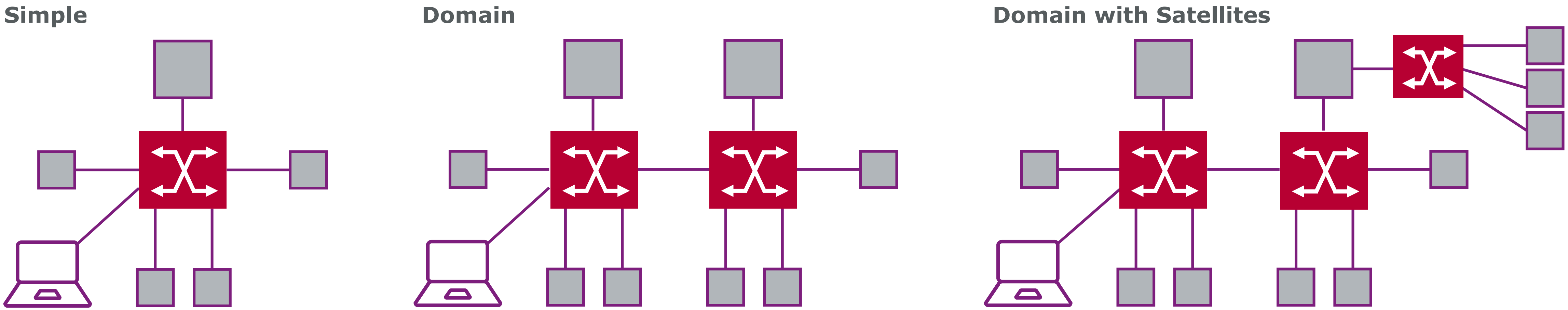
1. Automotive Switches: Software and Hardware Architectures
2. Automotive Switches and AUTOSAR
3. Smart Switches and AUTOSAR
4. Outlook

Evolution of In-Vehicle Ethernet Architectures

- Isolated point-to-point networks for dedicated use cases with increased bandwidth demand



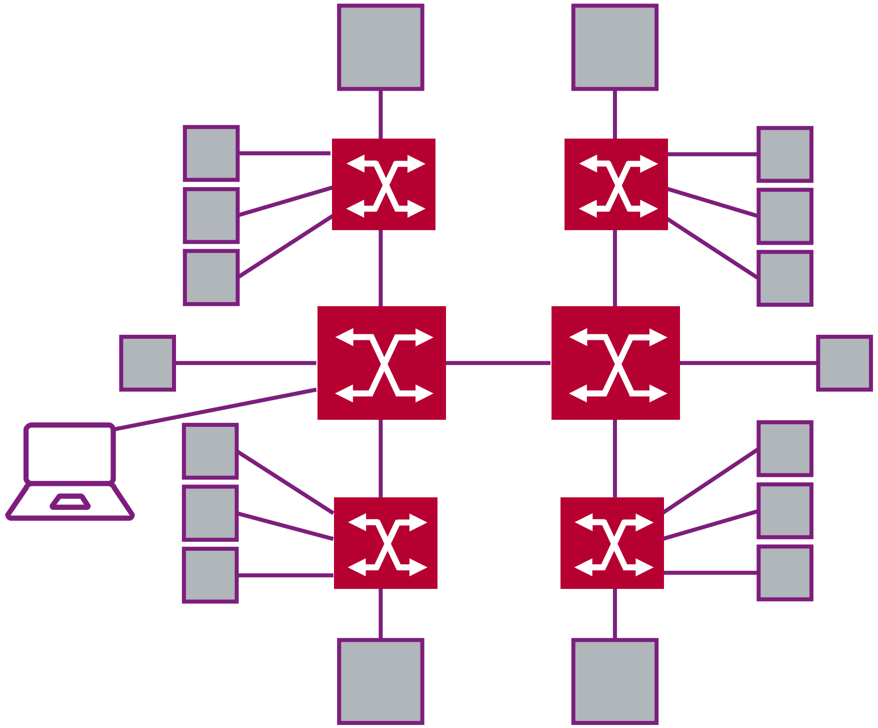
- Introduction of Ethernet switches and scaling the Ethernet network



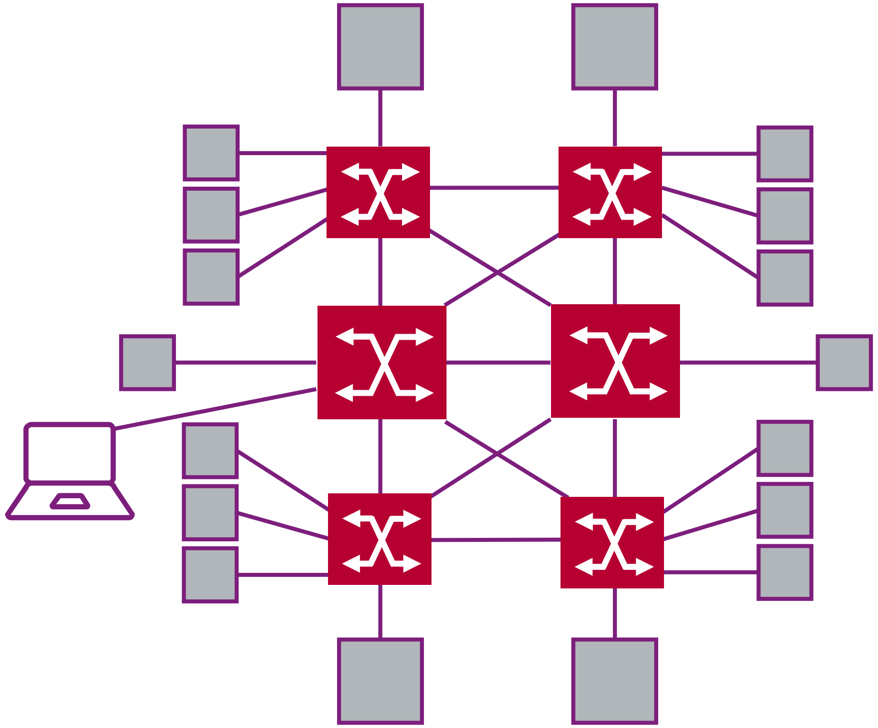
Evolution of In-Vehicle Ethernet Architectures: Next Generation

- Scaling Ethernet and tackle wiring complexity with zonal architectures
- Mindset: Ethernet is a shared, "cross domain" communication medium
- Redundancy on Ethernet will require enhanced TSN features to be supported by all switches

Zones



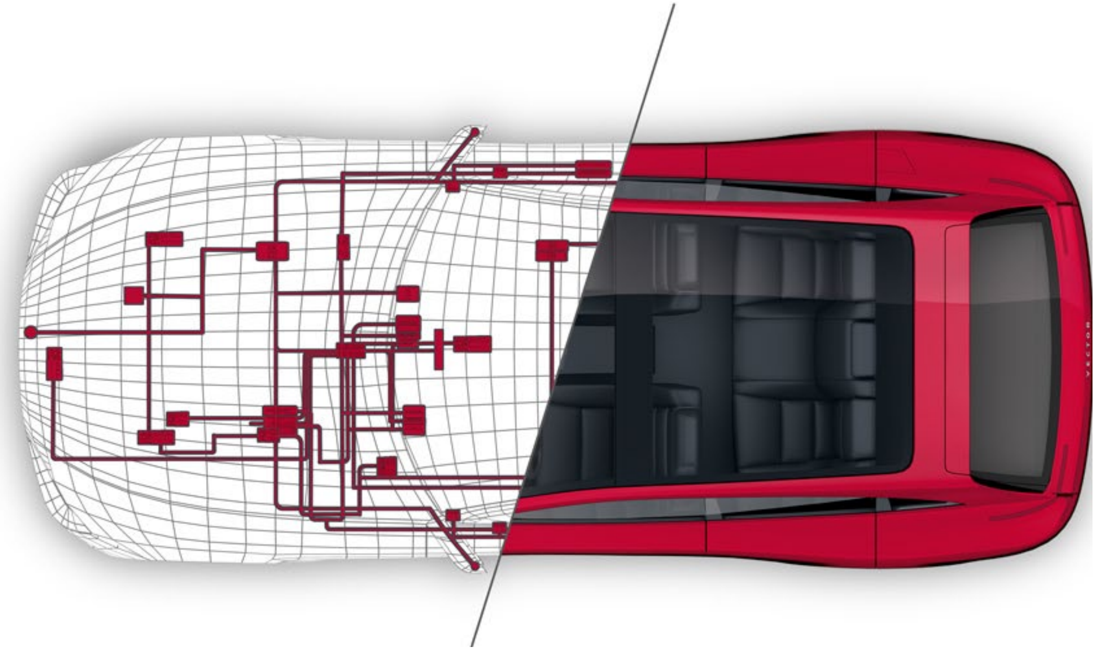
Zones with Redundancy



Evolution of Ethernet Communication Requirements

- Requirements changed over time
  - **from** the “sheer need for more bandwidth”
  - **to** a reliable and secure networking in-vehicle backbone

- **flexible** / dynamic service-oriented communication exists in parallel
- with control and streaming traffic with **“TSN”** requirements on the same Ethernet network



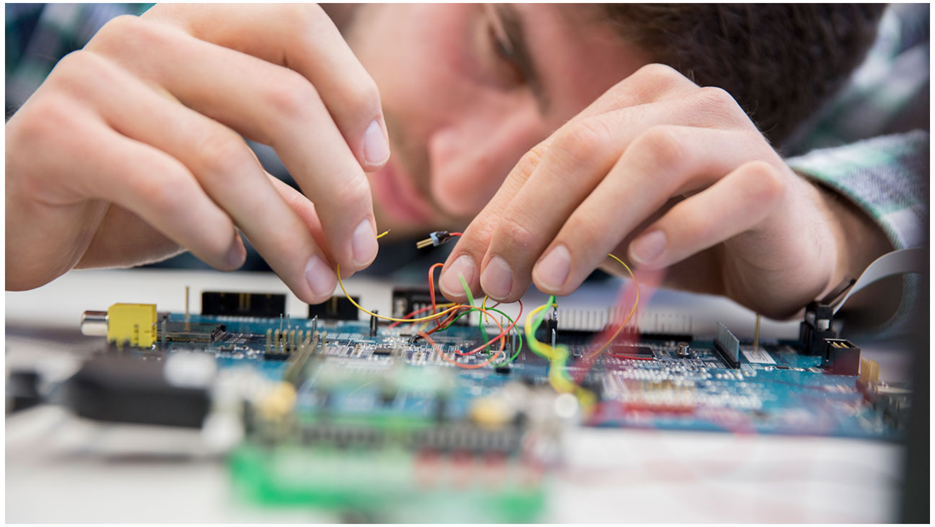
Challenges

- **Switches are essential** for Ethernet networks
  - enable communication between multiple Ethernet nodes
  - control network access, latency and bandwidth
- **Switches play a central role** to deploy
  - time synchronization and TSN features
  - Network reliability and - security

- The number of switches in-vehicle is increasing
- The feature set to be displayed is increasing as well
  - ➜ **Increased configuration and qualification effort**

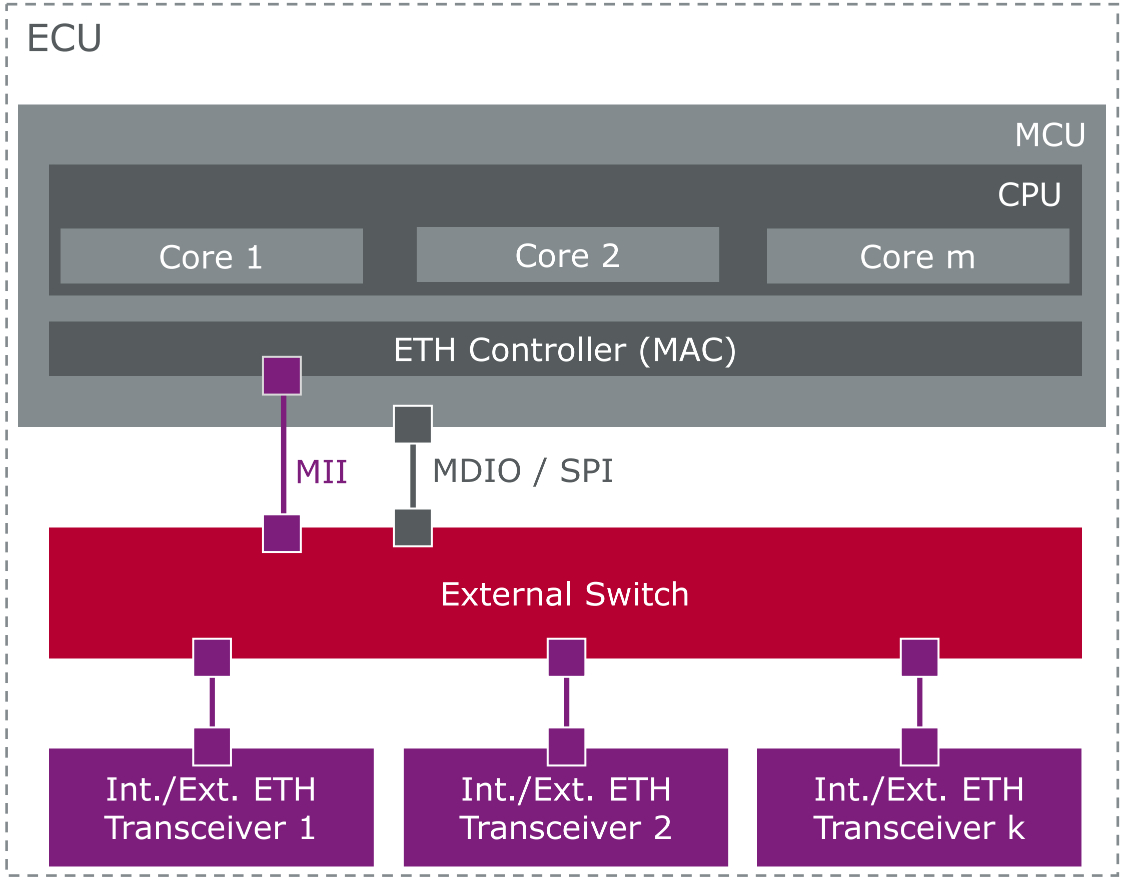
? Open questions

- How does the HW and SW architecture look like?
- Which SW features will be necessary on the switch?
- How do we ensure overall configuration consistency?
- How is switch SW updated?



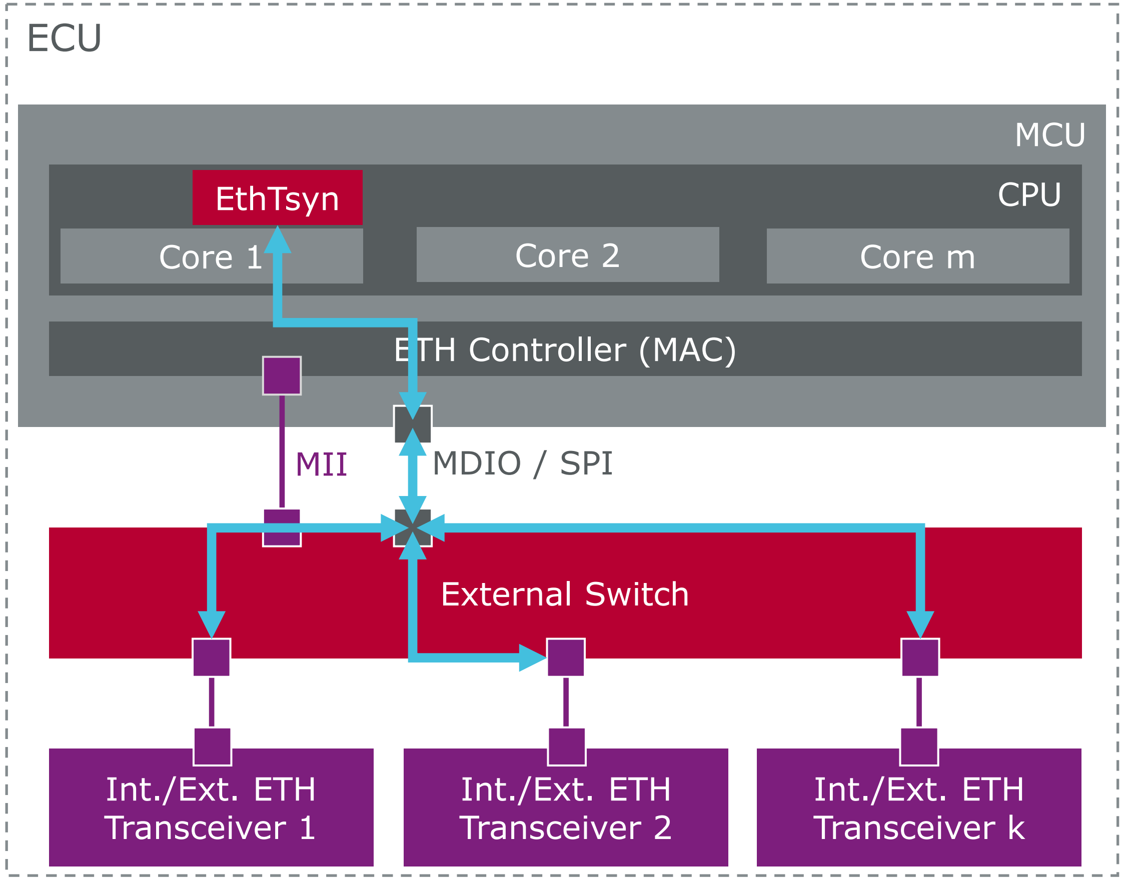
Switch ECU HW Architecture

- Typically, a **switch is a subsystem of an ECU** attached to an MCU on the same PCB
- "Traditional" AUTOSAR approach:
  - MCU manages the switch including its PHYs as **external peripherals** of the MCU
  - using AUTOSAR drivers
  - via **management interfaces** e.g. MDIO or SPI


ECU
MCU
CPU
Core 1
Core 2
Core m
ETH Controller (MAC)
MII
MDIO / SPI
External Switch
Int./Ext. ETH Transceiver 1
Int./Ext. ETH Transceiver 2
Int./Ext. ETH Transceiver k

Limits of MCU managed Switch Approach

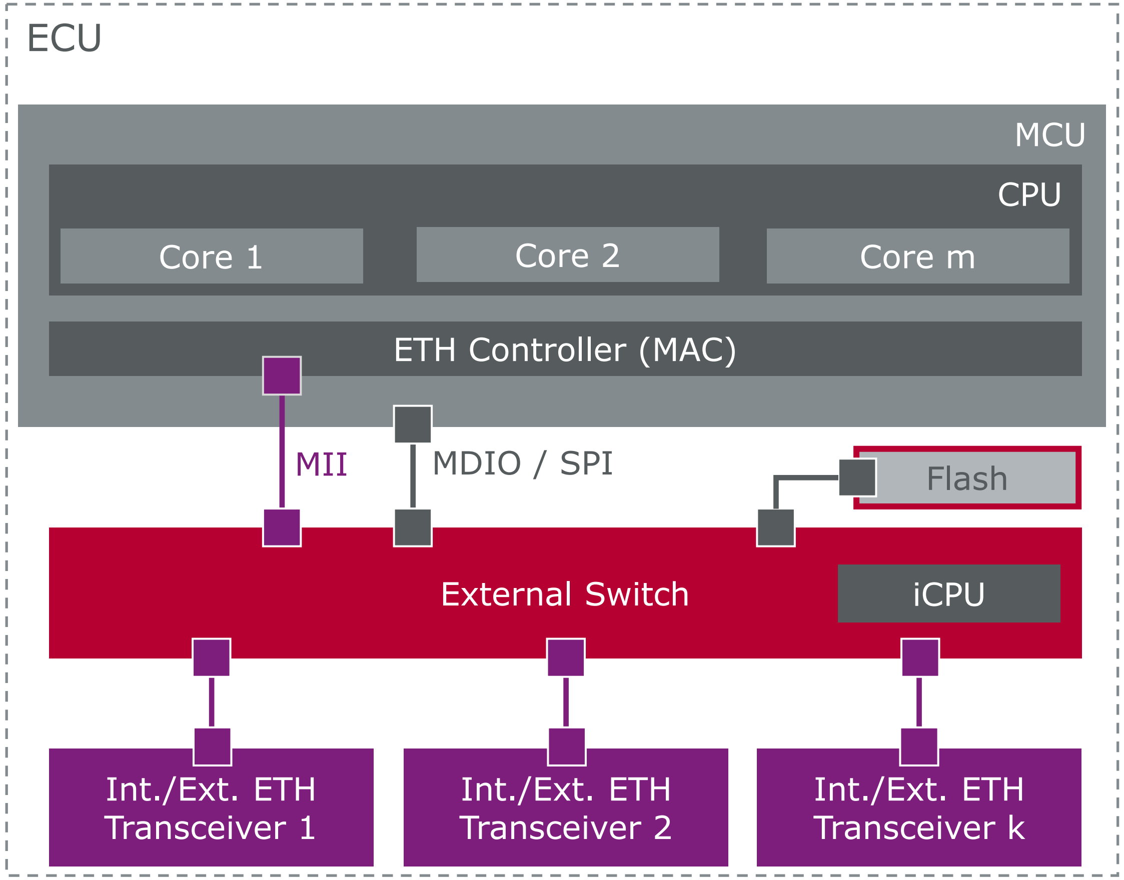
- The MCU based switch management **does not scale** for some use cases
  - e.g. handling of switches with many ports for PTP residence time compensation
- The MCU based switch management is **not feasible at all** for specific features
  - e.g. firewalling via an attached MCU will not provide the necessary throughput



ECU Hardware Architecture with Smart Switches

- Today's switch devices come along with an **own CPU subsystem** and allow – to some extend – an **independent operation** of the switch
- Switch devices with an **own CPU** can be used as a **"smart" switch subsystem** of the MCU and take over relevant network-specific tasks

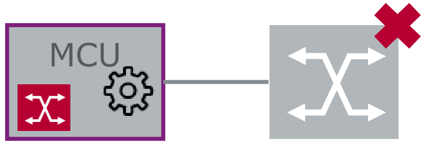
- **Offloading** of networking tasks from the MCU ➔ to the switch
- Other interesting use cases come to play…



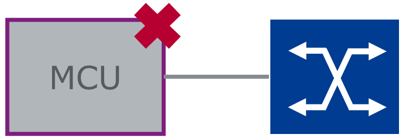
Status Quo: Common, but non optimal Approaches

- Following approaches are common:

1. "Downgrade the smart switch to a dumb peripheral" and run **AUTOSAR switch driver on MCU**
   - Perquisite: switch *must not* execute own firmware to avoid conflicting register access
   - Drawback: the switch resources cannot be used ➔ this is neither smart nor sustainable

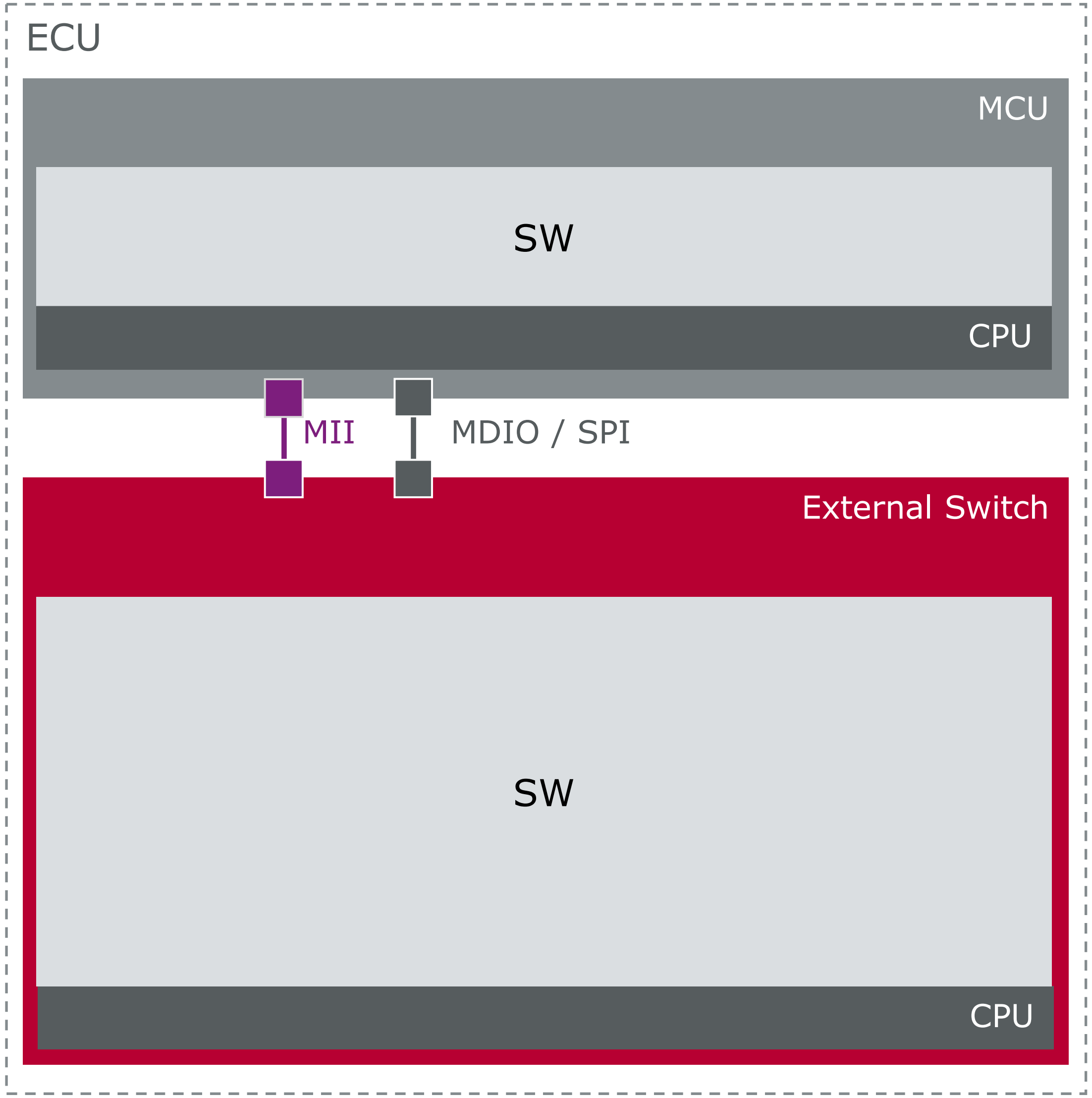


2. Alternatively, the **switch driver is removed** on the MCU; switch executes **proprietary firmware**
   - Drawback: Switch is **decoupled from the AUTOSAR** configuration and update workflow and MCU is **not "switch aware" anymore**
   - Questions left open to be solved in project scope:
     - How do we achieve configuration consistency?
     - How does the software update and UDS diagnostics concept look like?
     - What about automotive specific protocols or extensions to be supported on the switch subsystem?



Switch ECU: Multi–Processor System with distributed Feature Set I

- The switch **ECU system** consists of an
- **MCU** typically running **AUTOSAR** based software and a connected
- **Switch** with an **integrated CPU** which could run own software too



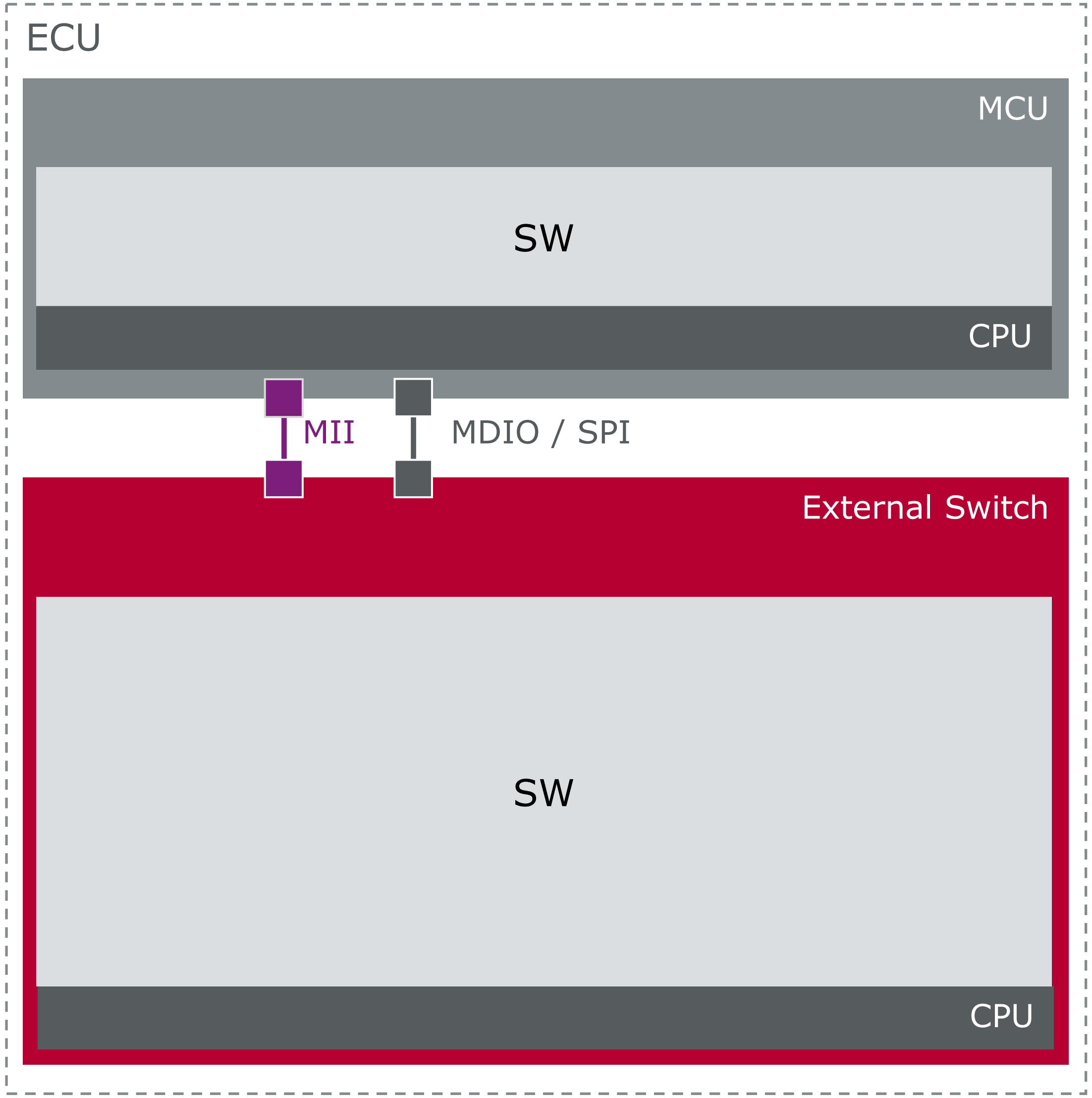
Switch ECU: Multi–Processor System with distributed Feature Set II

- Vision: distributed software architecture MCU and switch CPU
  - Quick **startup** / **wakeup** (incl. TC10)
  - Basic **switch configuration**
  - **GTS (PTP)**

  - **Software-** and **configuration update**
  - **UDS diagnostics**

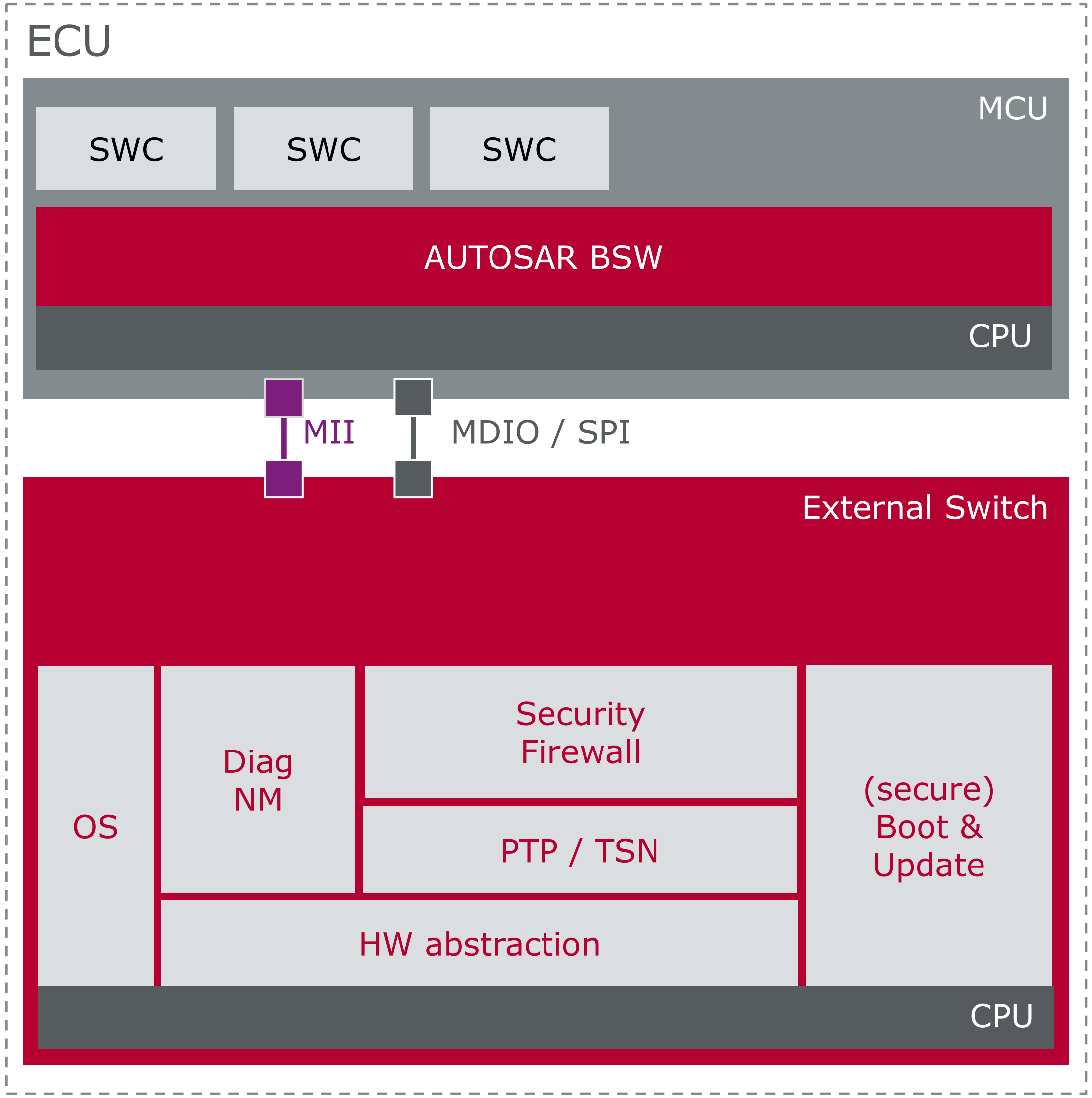
  - Network management (**PNC**)
  - **AVB / TSN** features

  - **Firewalling**
  - Other use cases / OEM specific software
    - **e.g. variant provisioning**
  - Close future: **MACsec**



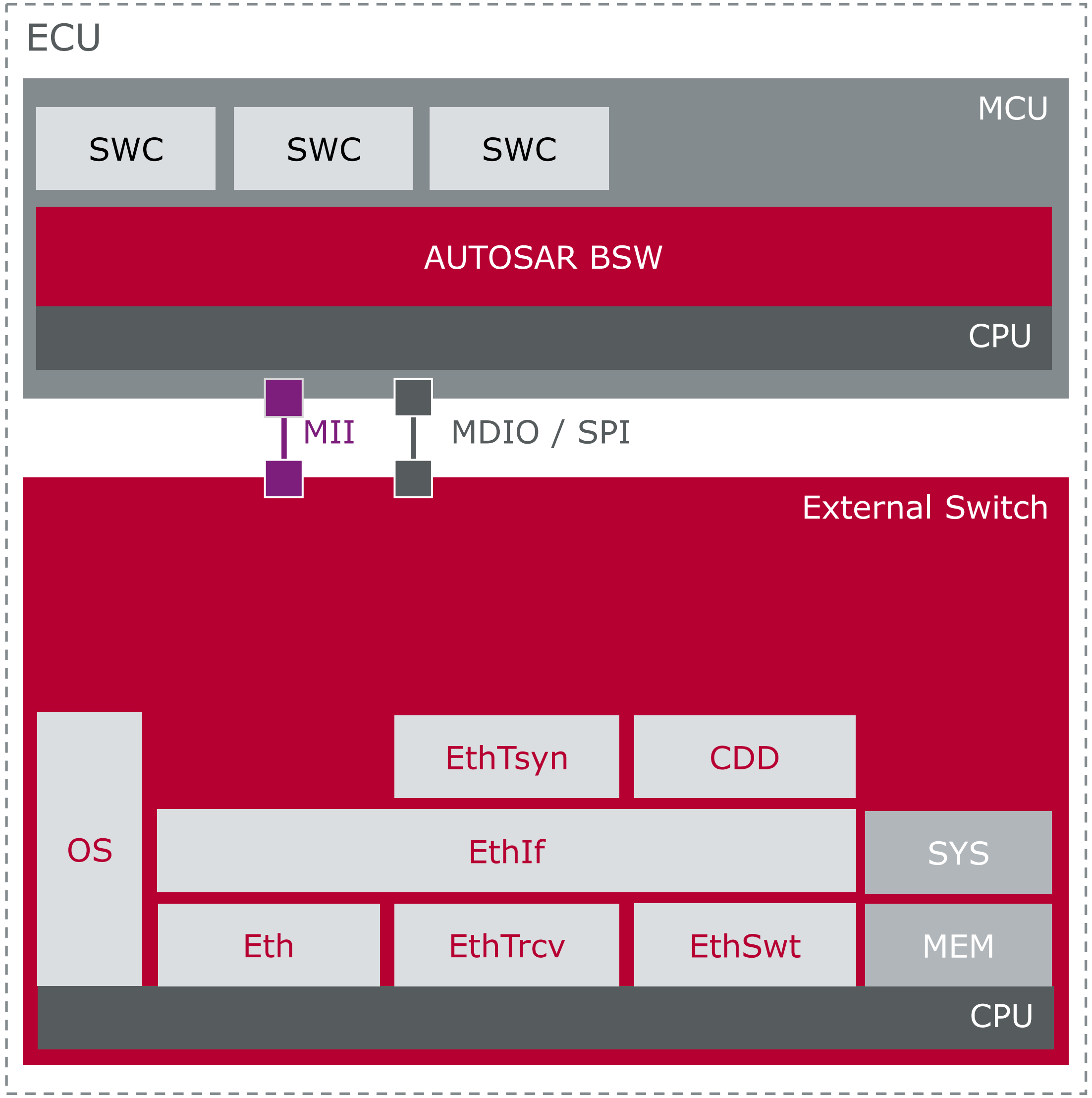
Switch ECU: Software Distribution between MCU- and Switch Sub System

- What kind of software do we need on the switch?
- Which pieces are meaningful to be offloaded from the MCU to the switch subsystem?
- Switch-local OS and hardware abstraction layer are perquisites
- Relevant functional clusters are
  - Switch initialization and basic configuration
  - PTP handling and further TSN features
  - Extensions to allow a software update and diagnostics via the MCU
  - Network management
  - Security features



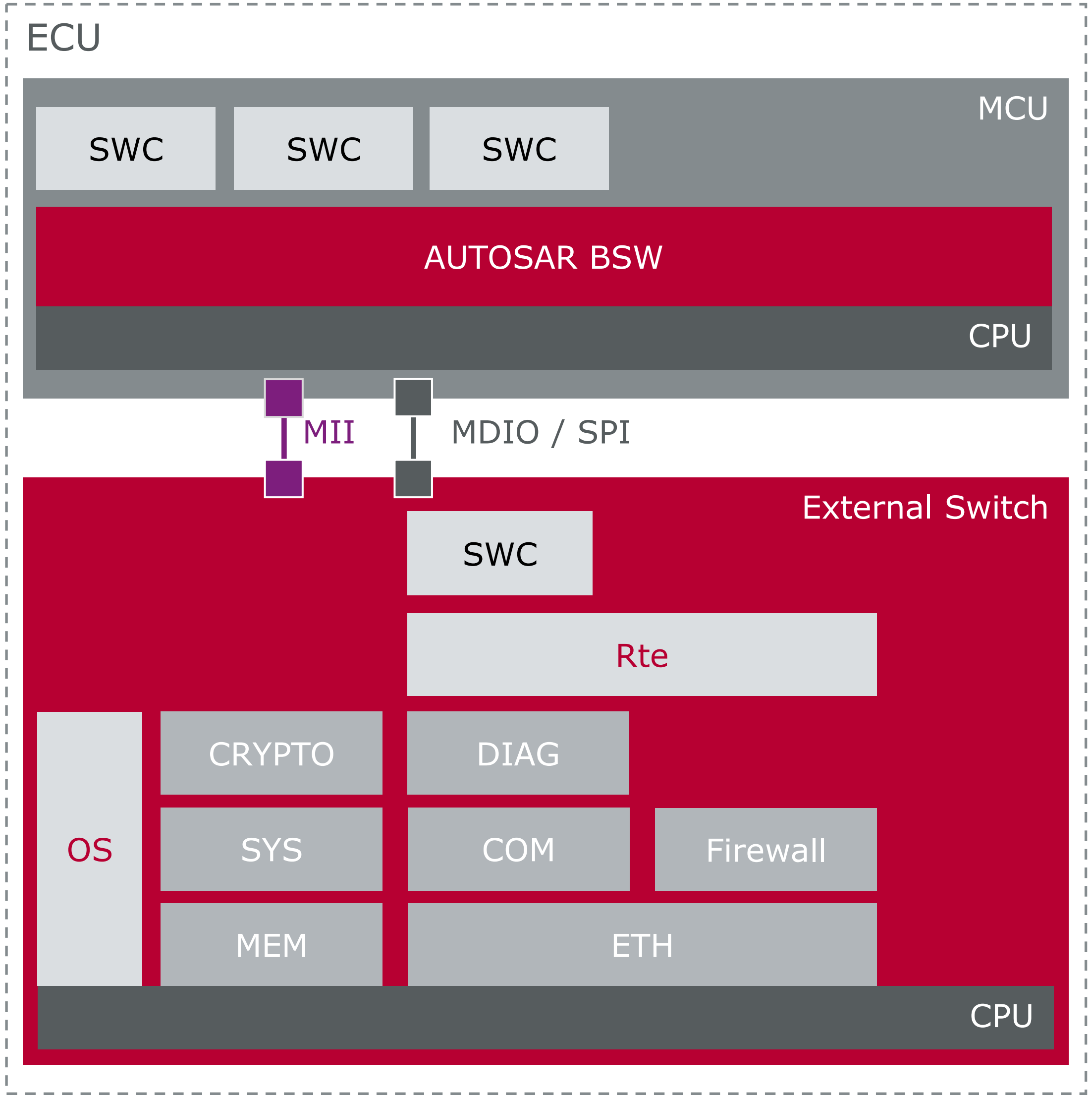
Switch ECU: AUTOSAR aware Switch Software – minimal Configuration

- AUTOSAR aware switch software running on the switch allows a standalone boot and - operation
- Porting of further standard AUTOSAR software to the switch subsystem can be done with small effort
- Configuration **workflow** and - **tooling** is **identical** to the AUTOSAR stack running on the attached MCU
- Example of automotive specific implementation: PTP (IEEE 802.1AS) with AUTOSAR extensions covered with EthTsyn module



Switch ECU: AUTOSAR aware Switch Software – A Scalable Approach

- Today's switches already allow far more extensions than just a switch-local PTP handling
- With an AUTOSAR aware smart switch solution we can get the best out of smart Ethernet switches:
  - add further production approved software available in the AUTOSAR eco system e.g. for network management or diagnostics
  - increase the overall system performance
  - shorten the time to marked with qualified software and a proven architecture
  - gain time with one solution, tooling and workflow



Challenges To be Overcome

- The software executed on the switch today is limited by available hardware resources
  - Future use cases e.g., firewalling and IDS will require significant resources
  - Features like MACsec will require a switch-local key storage and crypto an acceleration

- Mindset change in the automotive industry necessary:
  Switches are complex subsystems rather than **“simple peripherals”**
  - Switches are active components with own communication needs
    - Hence, switches require own MAC -, IP - and even diagnostic addresses
  - Software share and feature set on switches will play an important role
    in future ECU projects to be considered by the ECU “component responsible” on OEM side
  - Transport formats and workflows need to be discussed
    - AUTOSAR XML may be a solution or at least a basis for many OEMs

Outlook: Future Extensions in Smart Switches

- Software share on switches will increase
- Integrated software architecture is needed to meet the time to market – AUTOSAR may be a solution

- Next:
- Stringent functional safety concepts will be required for automated driving
- Introduction of MACsec and further TSN features is on the way

- Already more than a “vague vision”: **The switch as a fully independent single chip device!**

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