Smart Ethernet Switch Architecture

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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

- **Ethernet Backbone Ring**
  - Switches in a hierarchical structure

- **Ethernet Extended Star**
  - Switches in a radial structure

Centralized Star Architecture (Network in a box)

- **Performance CPU**
- **Gateway**
- **Mgmt CPU**

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Switches in the E/E Network Architecture

Zonal Architecture

[Diagram showing the zonal architecture with switches and ECUs for various zones.]
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

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

**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**

AUTOSAR Stack for Switch configuration and control
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 Synchronization
  – 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!!

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