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
- Ethernet Extended Star

Centralized Star Architecture (Network in a box)
Zonal Architecture

Switches in the E/E Network 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

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
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)
**Smart Ethernet Switch Architecture**

2017 IEEE-SA Ethernet & IP @ Automotive Technology Day – San Jose

**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

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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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