

Ethernet – A Survey on its Fields of Application

Fachtagung ITG FA 5.2 "Zukunft der Netze"

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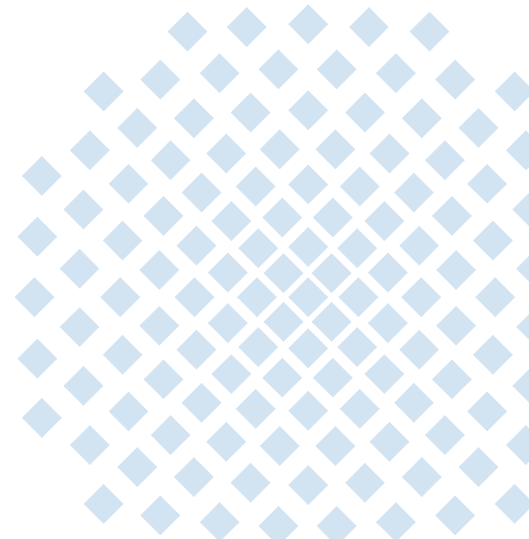
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Question: "What is Ethernet today?"

Ethernet's story of success

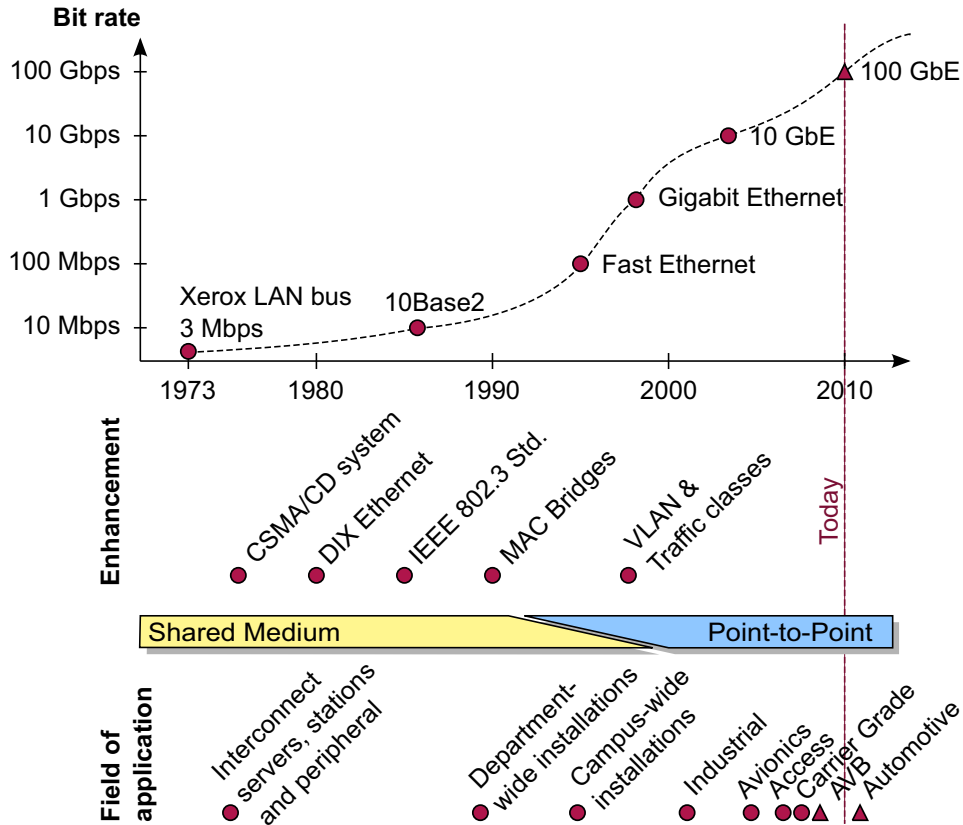
Ethernet LAN technology

Ethernet's fields of application

Comparison

Summary

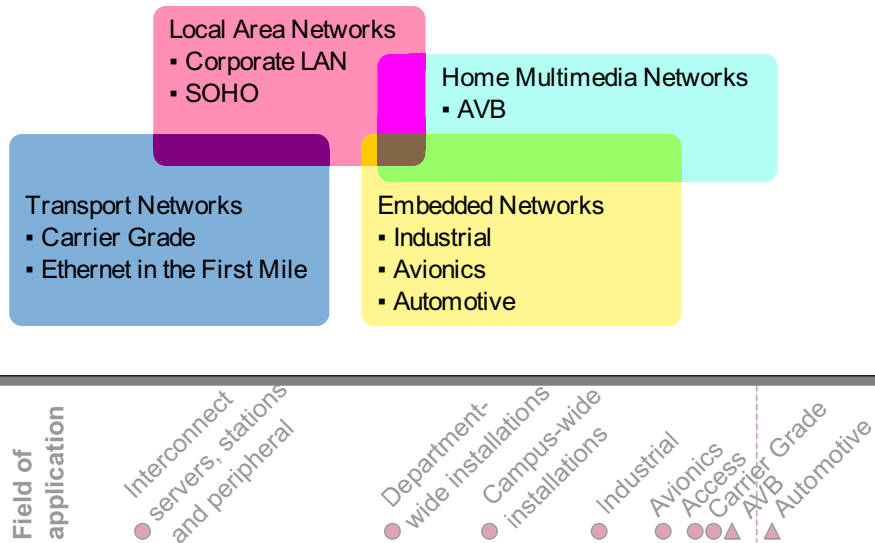
Ethernet's story of success



Ethernet's story of success

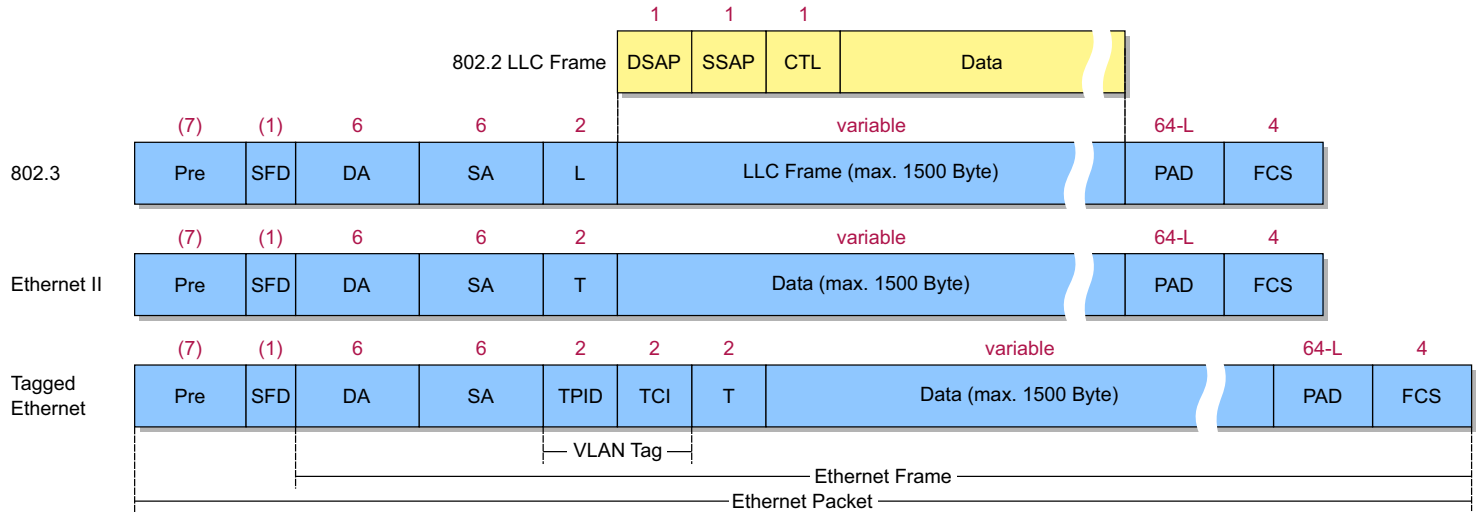


Classification of Ethernet's fields of applications



Ethernet LAN technology

Ethernet IEEE 802.3 frame formats



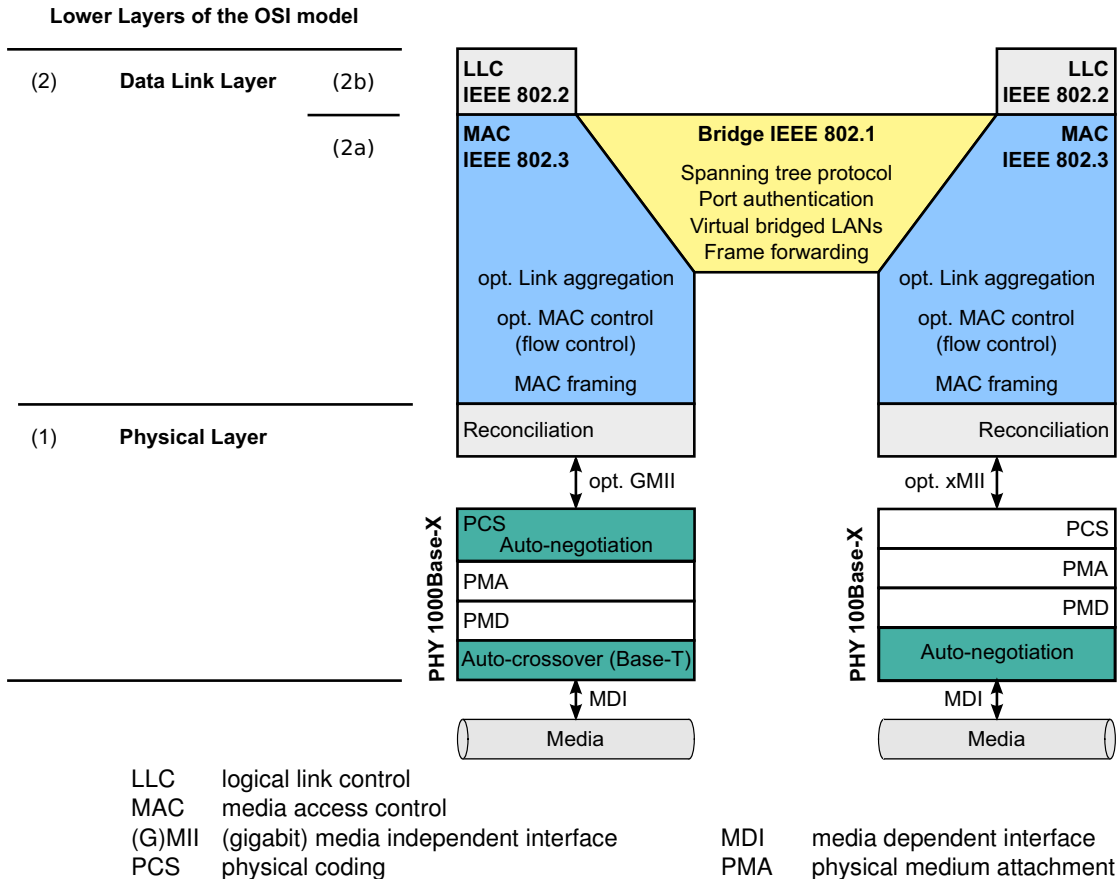
DSAP destination service access point
 LLC logical link control
 DA destination address
 L length
 TPID tag protocol identifier

SSAP source service access point
 SFD start of frame delimiter
 SA source address
 T type
 TCI tag protocol information

CTL control field
 FCS frame check sequence
 PAD padding

Ethernet LAN technology

Ethernet protocol stack including its functions

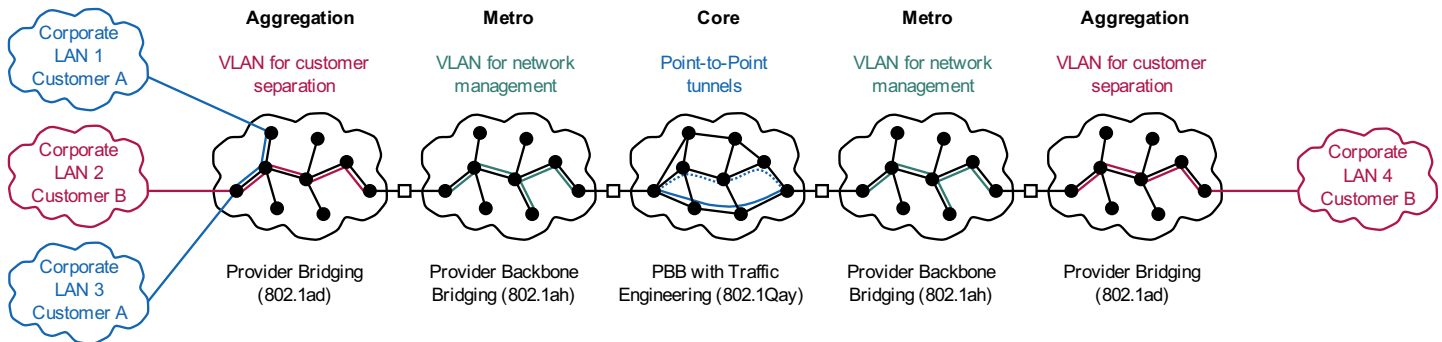
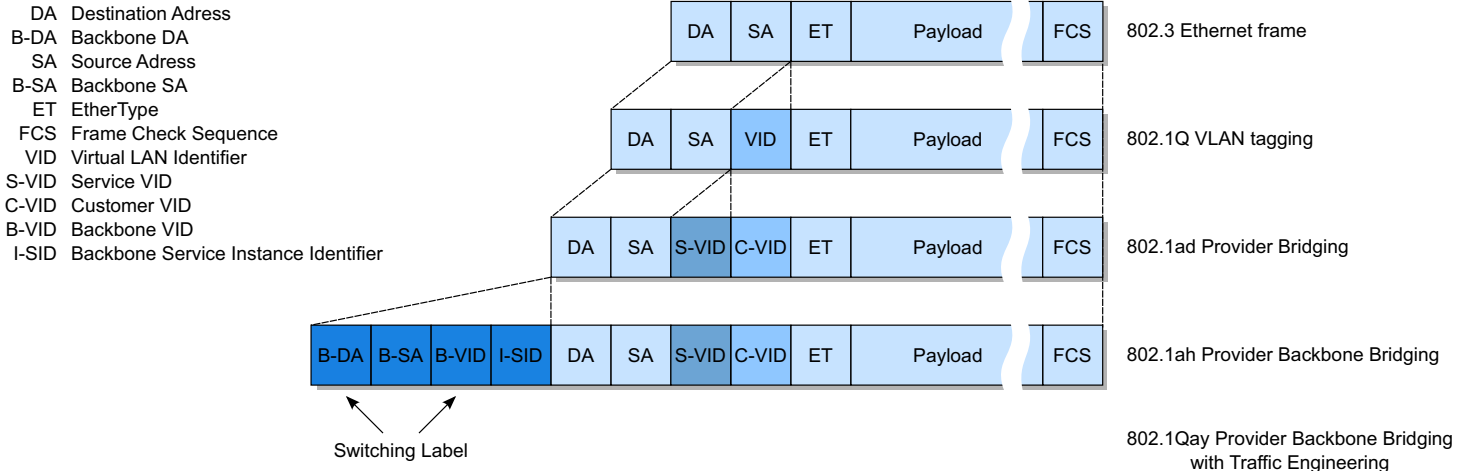


Carrier Grade Ethernet

- Synonymously *Metro Ethernet* and *Carrier Ethernet*
- Two approaches to introduce Ethernet into carrier networks
 - Ethernet services (interface to corporate customers)
 - Ethernet transport as new packet-oriented transport technology
- Differences between traditional LAN Ethernet and Ethernet transport
 - Scalability (large spatial extensions and a huge number of devices)
 - Avoiding flooding (due to save transmission capacity)
 - QoS and SLA (guarantees to corporate customers)
e.g., 99.999% availability and 50 ms for restoration in case of a failure
 - Basic principles of Ethernet are inappropriate to fulfill these requirements
- Ethernet PHYs with high data rates (40 and 100 Gbps)
- OAM and control
 - Centralized management
 - Connectivity fault management messages (value 0x8902 in type/length field) and alarm messages
 - Traffic shaping at network edge enables QoS guarantees
- Extensions to the Ethernet frame format

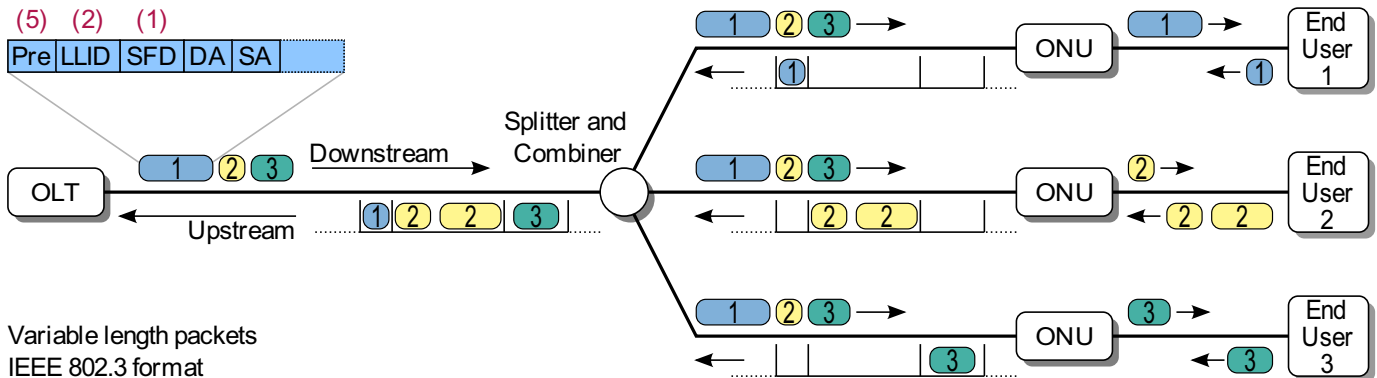
Carrier Grade Ethernet

Extensions to the Ethernet frame format



Ethernet in the First Mile

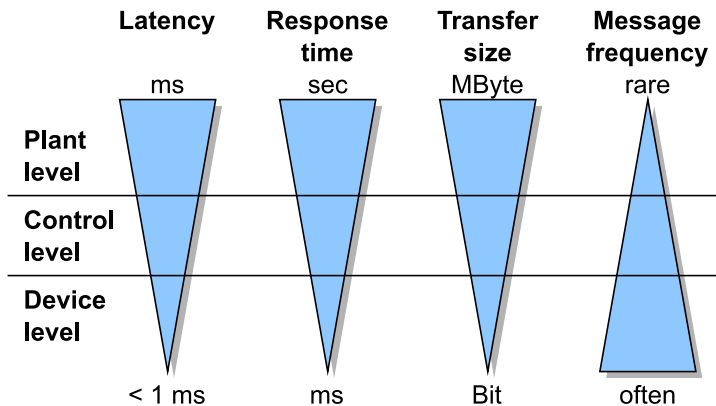
- In 2001, standardization of Ethernet in the First Mile (EFM) began (IEEE 802.1ah and Ethernet in the First Mile Alliance (EFMA) in parallel)
 - Copper and fiber based PHY interfaces (reflecting special requirements of outdoor cabling)
 - Copper interfaces which allow reusing installed voice-grade copper cables
 - Functions for management and monitoring links on PHY layer
- Ethernet PON (EPON) = full duplex single fiber network with point-to-multipoint and data rates up to 1 Gbps



OLT central optical line termination ONU optical network unit LLID logical link identifier

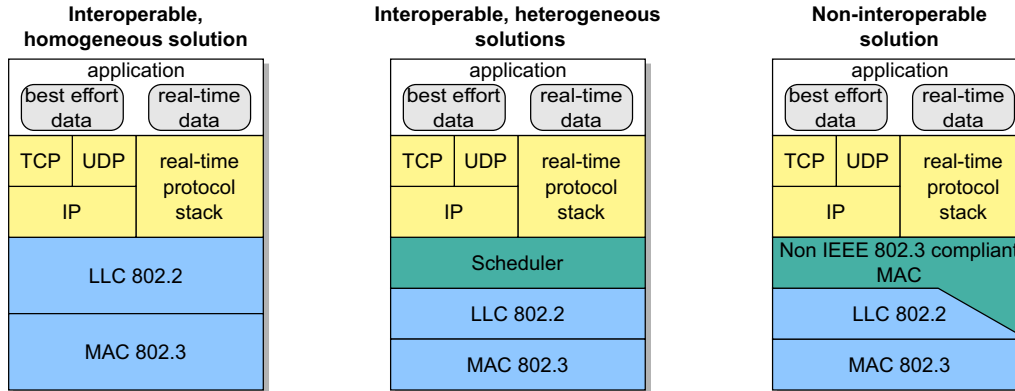
Industrial Ethernet

- Different vendors adopt Ethernet for industrial applications
→ Industrial Ethernet
- Drivers
 - Steadily increasing costs and complexity
 - Demand for interconnecting factory and outside world
- Fulfills enhanced requirements: (hard) real-time operations, time synchronization, ...
- Networking requirements



Industrial Ethernet

Real-time Ethernet solutions

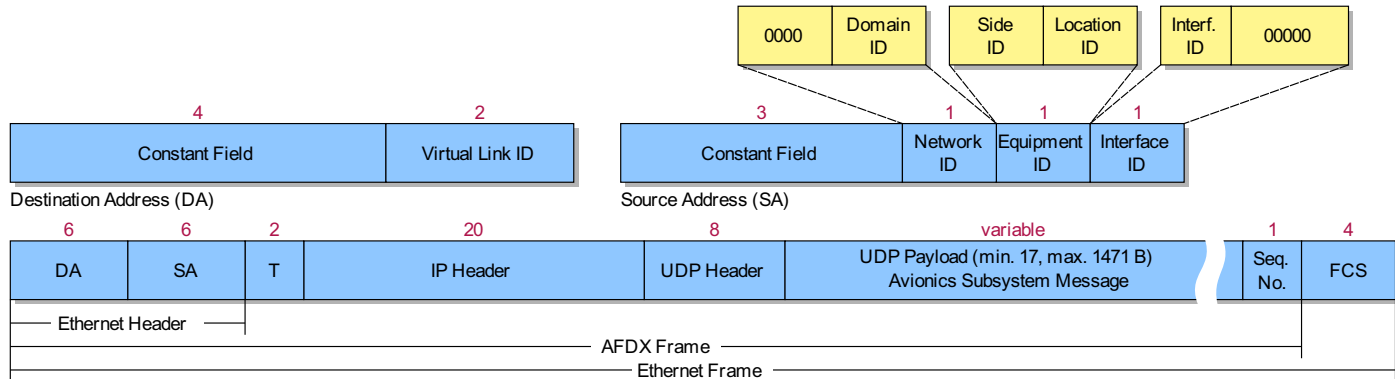


- Interoperable, homogeneous solutions
 - Build on IEEE 802 standards and thus compatible with IEEE 802.3 devices
 - QoS with full duplex links (no collisions) and traffic prioritization (VLANs)
- Interoperable, heterogeneous solutions
 - Communication with IEEE 802.3 compliant devices; but no real-time guarantees (for real-time capabilities exclusive use of modified switches)
- Non-interoperable solutions
 - Additional, deterministic MAC (TDMA, slot reservation,)
 - Isolated from regular Ethernet networks by bridges

- New trend: Using COTS technology to reduce development costs and facilitate the maintenance process
 - Specific aircraft implementation: Avionics Full Duplex Switched Ethernet (integrated e. g. Airbus A380)
- AFDX standard
 - Closed network topology
 - Defines protocol specifications for data exchange between avionics subsystems
 - Each end systems has two direct bi-directional connections to two redundant switches
 - Transmission of each frame via redundant connections (first valid frame is chosen)
 - Virtual link (VL) concept
 - Defines a logical unidirectional connection between one source and one or more destinations
 - Each end system can send data to multiple VLs
 - For each VL, transmission rate and maximal frame size are limited and defined
 - VL scheduler inside each end system
 - Traffic shaping
 - Statical configuration of the switches' forwarding tables (physical ports for each VL)

Avionics Ethernet

- Frame format



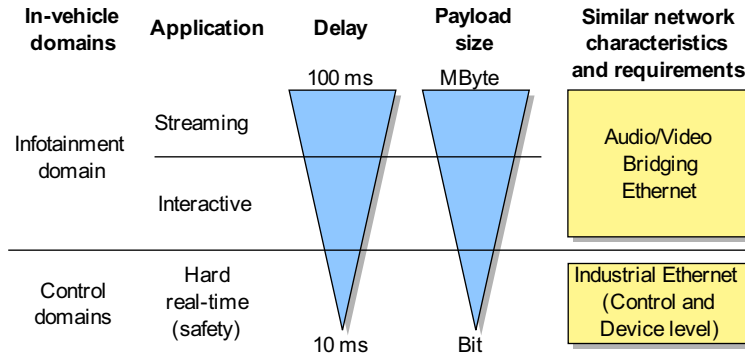
- Destination address is a multicast address with an embedded VL identifier
- Source address represents a unique end system
- Extensions to 802.3 standard
 - Traffic control in each source (VL concept and traffic shaping)
 - For each VL, a sequence number is added (before FCS)
- Extensions to 802.1D standard
 - AFDX switches are aware of VL characteristics and include policiers enforcing VL traffic contracts
- Extensions to Military Avionics

Automotive Ethernet

- *Automotive Ethernet* is not a standardized term or technology
- Ongoing discussion
"Has Ethernet the potential for an in-vehicle communication technology?"
- Today, different in-vehicle networking technologies, e. g. CAN, MOST, LIN, ...
→ Become inflexible, complex, costly and (some of them) reaching their capacity
- Ethernet's drivers
 - Low cost, flexible, and suitable for both quickly changing platforms and different car series
 - Reducing development times by using standardized technologies and mass-market components instead of developing automotive-specific technologies
 - Availability of solutions that integrate Ethernet and higher-layer protocols such as TCP/IP on a single chip
 - Thanks to low-cost bridges, simple interconnection of Ethernet subnetworks
→ no need for complex gateways
 - Robust against future evolutions

Automotive Ethernet

Networking requirements



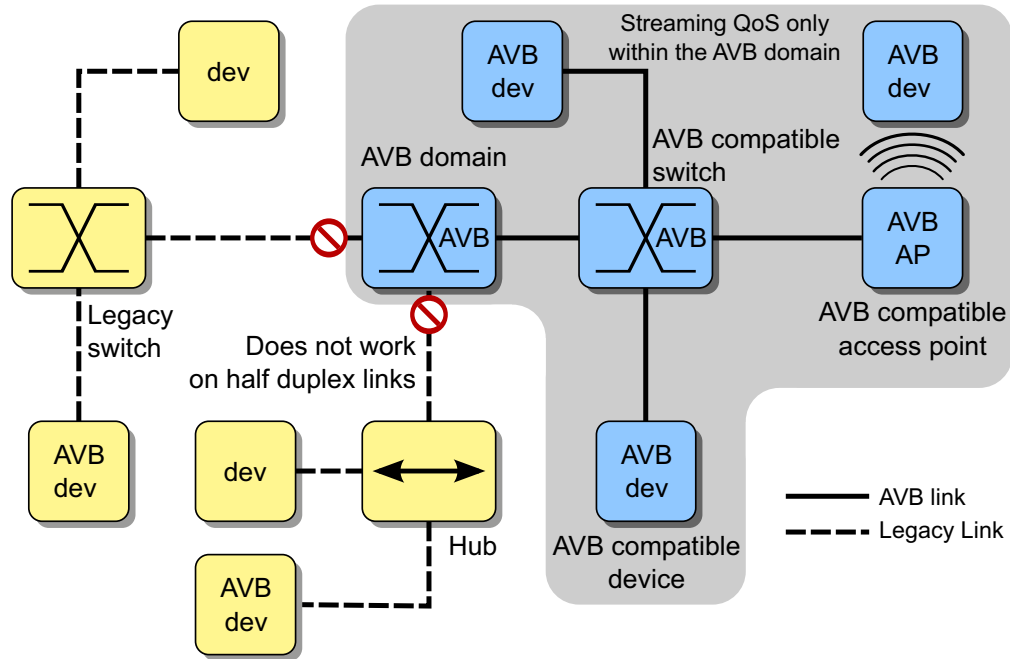
- Different traffic classes: hard real-time control data, real-time audio and video data, multimedia data, and best effort data
 - VLANs (see AFDX); also for "unknown" traffic (customers' personal electronic devices)
- Adopting existing AVB Ethernet and Industrial Ethernet solutions
 - Ethernet may fit for *nearly* all in-vehicle domains
- Degrees of freedom to design a Ethernet in-vehicle communication system (different media, different bit rates, different topologies, different switch locations, ...)

Audio and Video Bridging Ethernet

- IEEE audio/video bridging task group (AVB)
- Enhancements for streaming multimedia applications with real-time requirements in home multimedia networks (currently no QoS)
- Enhancements
 - Protocols and mechanism supporting services for streaming multimedia applications having time-synchronized, real-time requirements, and need high data rates at low latencies
- Isochronous service with less than 2 ms end-to-end latency and only 250 μ s (per hop), but only for 100 Mbps or faster
- Limitations of maximum number of bridges to 7
- IEEE amendment 802.1Qat: A stream reservation protocol (SRP)
- IEEE amendment 802.1Qav: Forwarding and queuing enhancements for bridges
 - Time sensitive frame forwarding for time-sensitive multimedia streams
 - Additional credit-shaper (similarities to industrial solutions)
- IEEE standard 802.1AS: Timing and synchronizing services on data link layer (both time-stamping and media coordination services)

Audio and Video Bridging Ethernet

Topology and interworking of an AVB domain



Comparison

Fundamentals (I)

	Corporate LAN	Transport networks		Embedded networks			AVB
		Carrier Grade	First Mile	Industrial	Avionics	Auto-motive	
Consortia	IEEE	IEEE, ITU-T, MEF	IEEE, MEF	IEEE, IEC, ISO	ARINC 664	consortium of OEM and suppliers	IEEE
Data rate	up to 10 Gbps	up to 10 Gbps	2 Mbps – 1 Gbps	100 Mbps, 1 Gbps	100 Mbps	100 Mbps	≥ 100 Mbps
Physical topology	mesh	mesh	point-to-point, tree	line, ring, tree	mesh	line, ring, tree	mesh
Logical topology	tree	mesh	point-to-point	tree or mesh	mesh	tree or mesh	tree
MAC protocol	dedicated channel	dedicated channel	dedicated channel, PON: TDMA	dedicated channel and additional MAC protocols	dedicated channel	dedicated channel	dedicated channel

Comparison

Fundamentals (II)

	Corporate LAN	Transport networks		Embedded networks			AVB
		Carrier Grade	First Mile	Industrial	Avionics	Auto-motive	
Switching Identifier	MAC addresses	path identifier (internal MAC & B-VID)	MAC addresses, PON: additional logical link ID	MAC addresses	VL identifier	MAC addresses	MAC addresses
Control philosophy	plug-n-play or fully managed	central management and resource provisioning	central management and resource provisioning	statically configured, isolated, and autonomous network	statically configured and autonomous network	statically configured, isolated, and autonomous network	plug-n-play and automatically configured
Fault management	STP or manual interaction	OAM and hard guarantee by protection switching	link level OAM, outage detection and recovery	manual interaction and proprietary solutions; partly redundant networks	two redundant networks	restoration, configuration only in workshops	STP

Comparison

Network QoS Capabilities

	Corporate LAN	Transport networks		Embedded networks			AVB
		Carrier Grade	First Mile	Industrial	Avionics	Auto-motive	
Bandwidth	relative	hard or statistical guarantee	hard guarantee	hard or statistical guarantee	hard guarantee	similar to industrial and/or AVB Ethernet	hard guarantee
Latency	no guarantee	statistical guarantee	no guarantee	hard or statistical guarantee	guaranteed	similar to industrial and/or AVB Ethernet	hard guarantee (end-to-end 2 ms)
Jitter	no guarantee	statistical guarantee	no guarantee	hard or statistical guarantee	guaranteed or bounded jitter	similar to industrial and/or AVB Ethernet	low jitter
Mechanisms	traffic classes (802.1D) and VLANs	resource reservation and traffic engineering	resource reservation	traffic schedulers, additional MAC protocols and resource reservation	VL concept, policers	similar to industrial and/or AVB Ethernet	traffic classes (802.1D) and resource reservation

Summary

- Question: "What is Ethernet today?"
- Starting as LAN technology, Ethernet diffused in a large number of fields of application
- All fields claim to rely on Ethernet technology
- In all fields, Ethernet has adapted (or is on the way) to specific requirements
 - Differences on OAM support and QoS capabilities, switching principle, and frame format
 - A **unique definition** of the term Ethernet **is not possible!**
- Usage of some frame structure being the only similarity in all fields
- After > 30 years only two attributes remain common
 1. **Framing**
 2. The **name** (or brand) – **Ethernet**