Advanced Vehicle Networking

AMF-AUT-T0502

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September 2013

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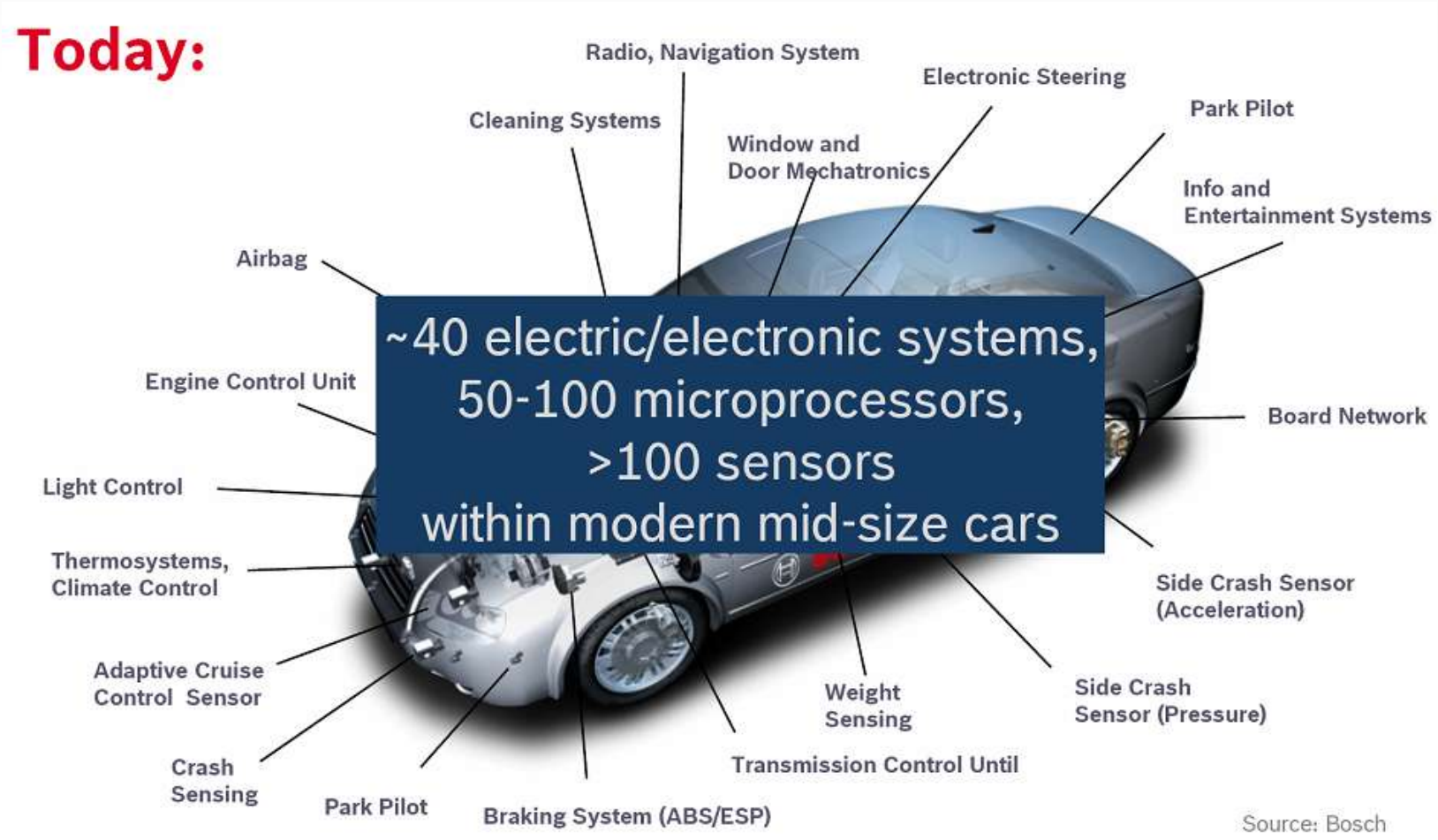
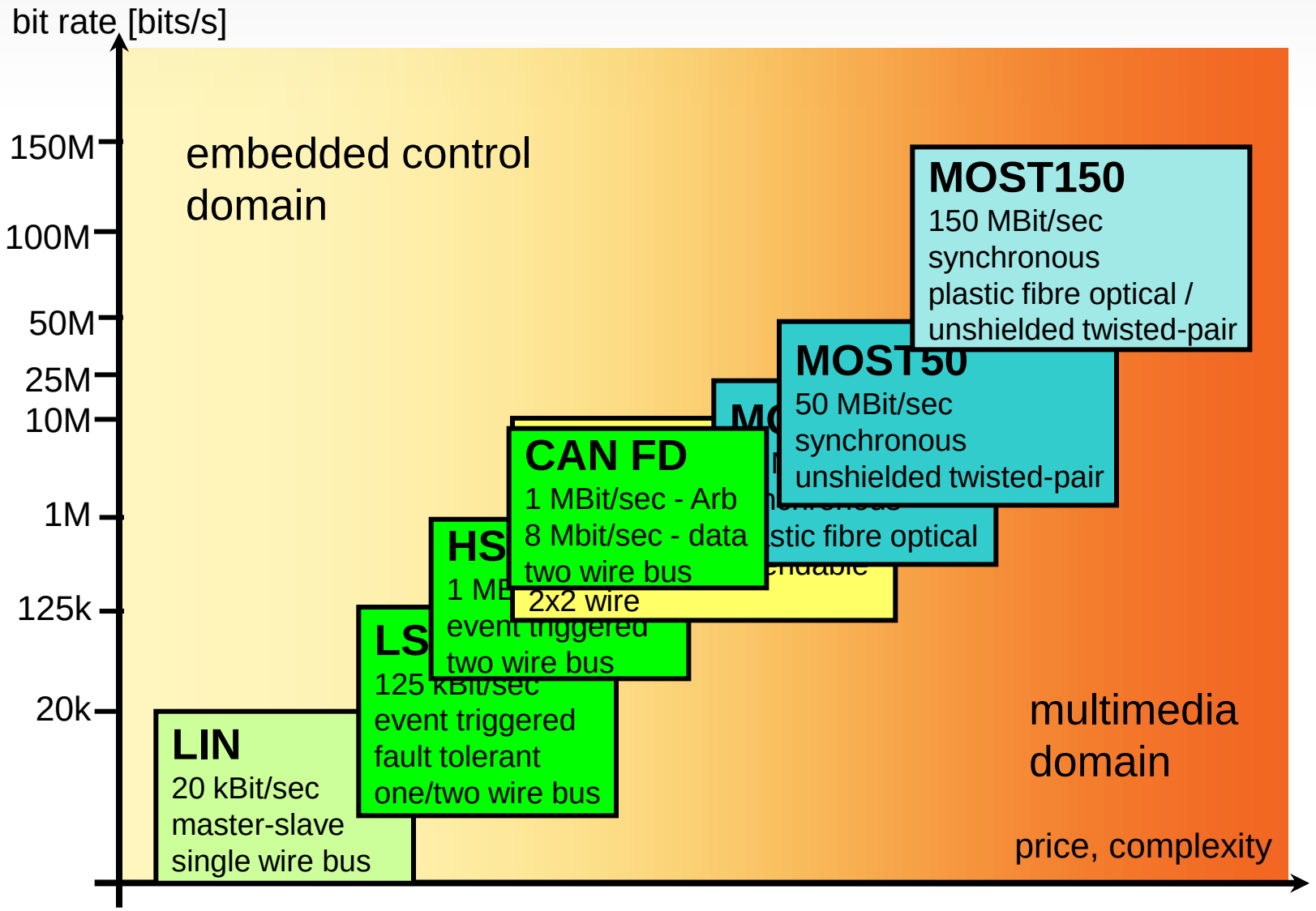
- Introduction
- Networking Protocols
- Networking future trends
- Roadmaps
- Competitive advantage
- Conclusions

Introduction: Complex Electric/Electronic System



Car Network Protocols

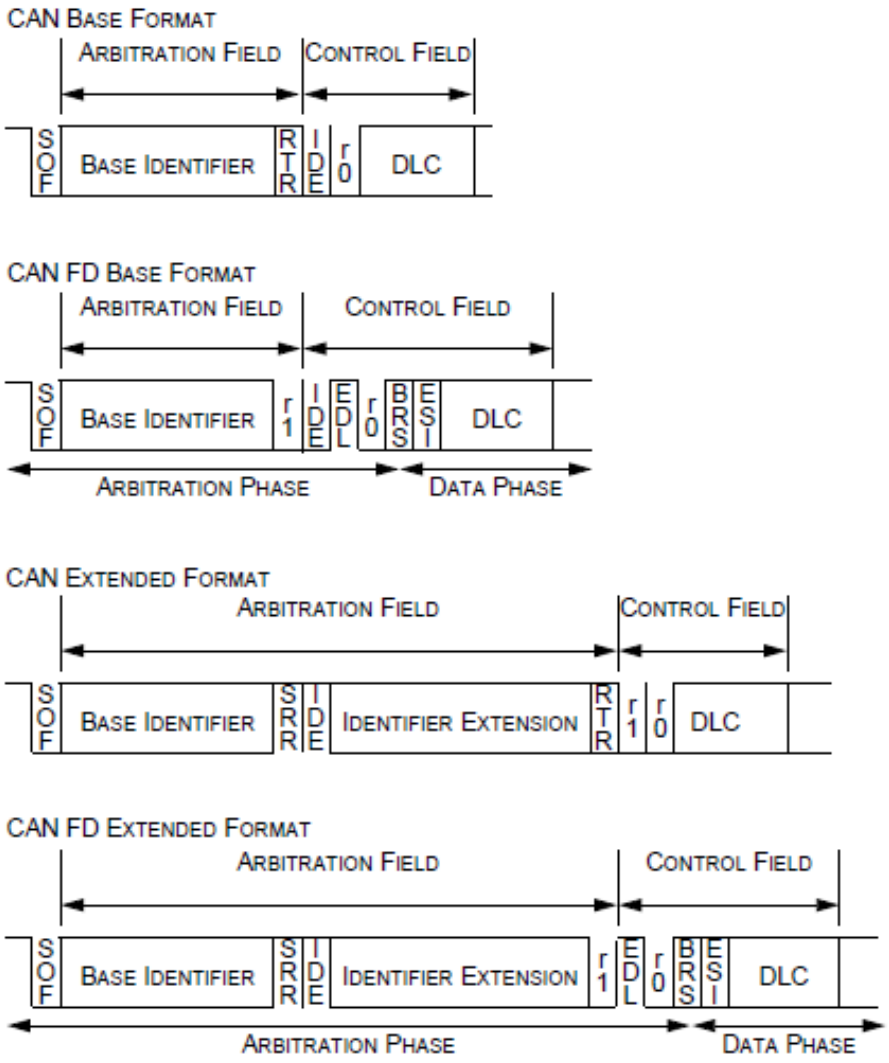
Communication Protocols Landscape



CAN FD Summary

- **Motivation**
  - Bandwidth need is on the increase
    - E.g. Future growth, functional safety
  - Increased demand for >8 byte message
    - E.g. Software authentication
  - Improve fault confinement
    - Notification of system bus degradation
  - Provide CAN upgrade path without major network re-design
- **New Features added**
  - Increase Bit Rate
    - Arbitration phase: up to 1Mbps; Data phase: up to 8Mbps
  - Increase Payload
    - Up to 64bytes
  - Error status indicator
- **Remote frames not supported**

CAN FD Summary



- EDL – Extended Data Length
  - EDL = recessive indicates CAN FD frame format
  - EDL = dominant indicates standard CAN frame format
- r1, r0 – reserved bits
  - RTR replaced by r1 in CAN FD base and extended frames
- BRS – Bit Rate Switch
  - BRS = recessive: switch to alternate bit rate
  - BRS = dominant: do not switch bit rate
- ESI – Error State Indicator
  - ESI = recessive: transmitting node is error passive
  - ESI = dominant: transmitting node is error active
- New DLC-coding and CRC

CAN FD Summary

Characteristic	CAN 2.0	CAN FD	Comments
Maximum payload length [bytes]	8	64	
Payload bandwidth for functional messages [bytes/ms at 50% bus utilization]	16 11-bit ID, 0.5 Mbit/s, 8 bytes payload	68 11-bit ID, 2 Mbit/s payload, 0.5 Mbit/s arbitration, 32 bytes payload	Approx four times higher functional bandwidth
Detection of bit errors and/or degradations	Medium	Good error status indicator flag, enhanced CRC polynomials	Improved detection and self diagnostics

- Note: Max payload bandwidth for CAN FD >>68 if full 64bytes used and data bit rate 8Mbps . Can achieve up to approx 10x improvement

CAN FD Summary

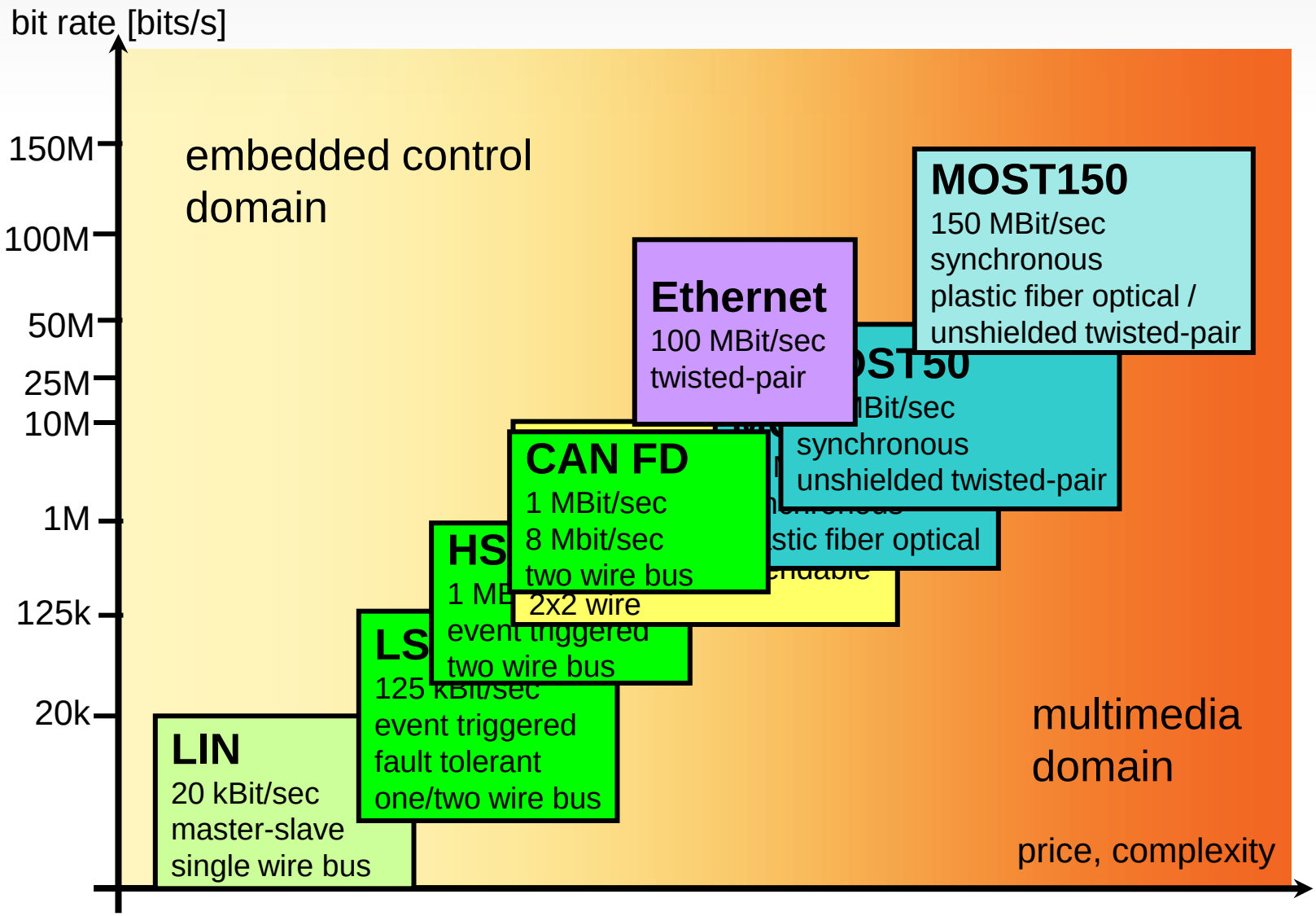
- **Use Case 1: Fast SW Download**

  Standard data rate – 500 kb/s

  FD data rate – 2 Mb/s

  - Time to transmit 4 standard CAN message with 8 data bytes and 15% stuff bits - 1021 µs
  - Time to transmit 1 CAN FD message with 32 data bytes and 15% stuff bits - 229 µs
  - CAN FD message allow greater transfer data rates than CAN2.0. Thus, reducing re-programming time
- **Use Case 2: Longer message support - Avoid Splitting of long messages**
  - Secure 8 Byte CAN message by additional MAC (Message Authentication Code)
  - Example (2): Transmission of acceleration sensor data in x,y,z-direction

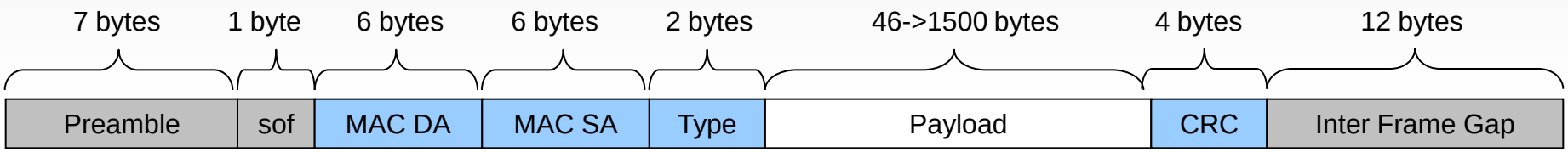
Communication Protocols Landscape



Ethernet Summary

- **Widely used network standard (IEEE 802.3) for LANs**
- **Several speed grades:**
  - 10 baseT, 100 baseT, 1000 baseT….
- **Auto qualified Physical layer based on Unshielded twisted pair (TP) wire**
- **Multiple Phy to MAC Interfaces**
  - MII, MII_Lite, RMII, GMII, RGMII, ...
- **Duplex and Half duplex communication**
- **Ethernet already established in vehicle**
  - Diagnostics, Ethernet camera
  - Ethernet AVB being introduced
- **Broad offering of software stacks, tools, expertise makes use of Ethernet cost attractive**

Ethernet (Layer 2)

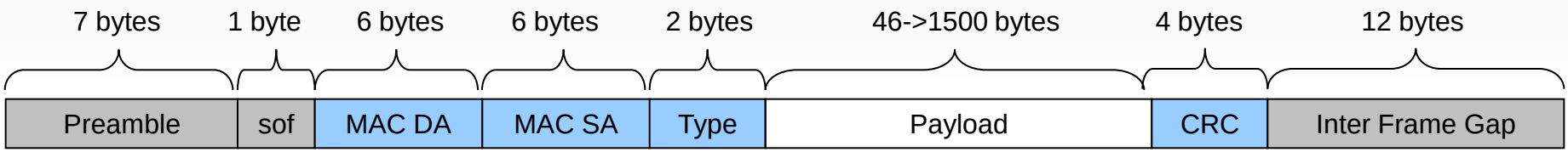


Type II Format

IEEE 802.3 Format

- **Type II Format**
  - Original format – Ethertype defines payload encapsulation
- **Type IEEE 802.3 Format**
  - 802.2 Header in payload to define frame type
- **Optional 802.1Q VLAN Tag after MAC SA**
- **Preamble and Start of Frame are identified by PHY**
- **Inter frame gap is enforced by PHY**
- **PHY detects and informs MAC of collisions**

Ethernet (Layer 2)



Type II Format

Preamble	sof	MAC DA	MAC SA	Size	Payload	CRC	Inter Frame Gap

IEEE 802.3 Format

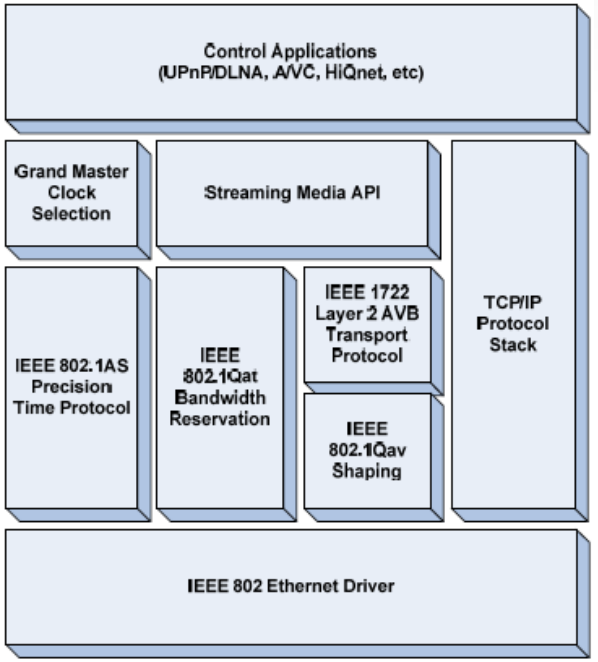
- **EtherType field used to identify higher layer protocols in payload**
  - 0x0800 = IPv4
  - 0x86DD = IPv6
  - 0x0806 = ARP
  - 0x8100 = VLAN
  - .....
- **CRC 32 validated over MAC header and payload**

Ethernet AVB Summary

- **IEEE 802.1 Audio/Video Bridging (AVB) standards enable time-synchronized low latency streaming services through 802 networks.**
  - Ensures interoperability between devices using AVB
- **AVB technology allows network to reserves the necessary bandwidth and resources**
  - Ensure that the signal reaches its destination in a precisely pre-determined amount of time synchronized across all outputs.
  - Aim is to minimise the amount of buffering to keep costs down
- **Four IEEE 802.1 AVB standards form the foundation of AVB technology**
  - IEEE 802.1AS (PTP): “Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks.”
  - IEEE 802.1Qat (SRP): “Virtual Bridged Local Area Networks - Amendment 9: Stream Reservation Protocol (SRP) .”
  - IEEE 802.1Qav (Qav): “Virtual Bridged Local Area Networks - Amendment 11: Forwarding and Queuing for Time- Sensitive Streams.”
  - IEEE 802.1BA: “Audio/Video Bridging(AVB) Systems”

AVB Ethernet stack summary

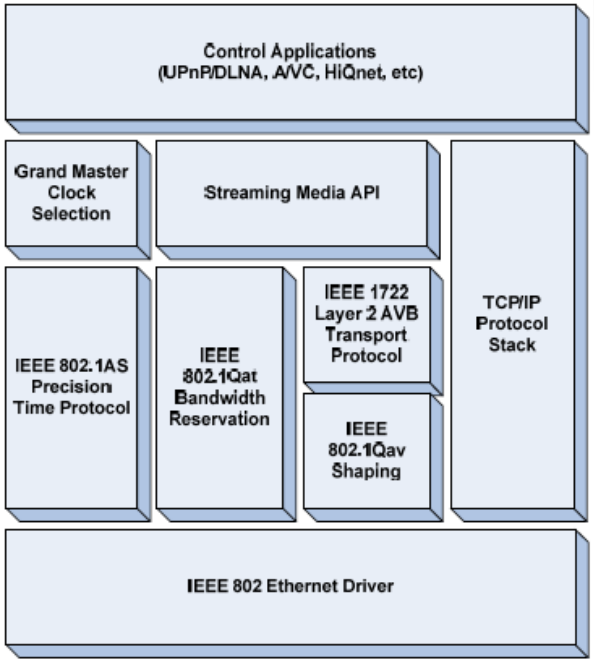
- IEEE 802 Ethernet Driver
  - Low level driver for MAC
- IEEE 802.1AS (PTP)
  - Used to synchronise network nodes to a common time reference
    - Defines clock master selection (BMCA) and negotiation algorithms
    - Link delay measurement, and compensation
    - Clock rate matching and adjustment mechanisms.
    - Specifies use of IEEE 1588
- IEEE 802.1 QAT (Bandwidth reservation)
  - Stream reservation protocol (SRP).
    - Used to guarantee QoS by ensuring end to end bandwidth availability before an AV stream starts.



Reference: Understanding IEEE 1722 AVB Transport Protocol – AVTP, March 9, 2009, Harman International

AVB Ethernet stack summary

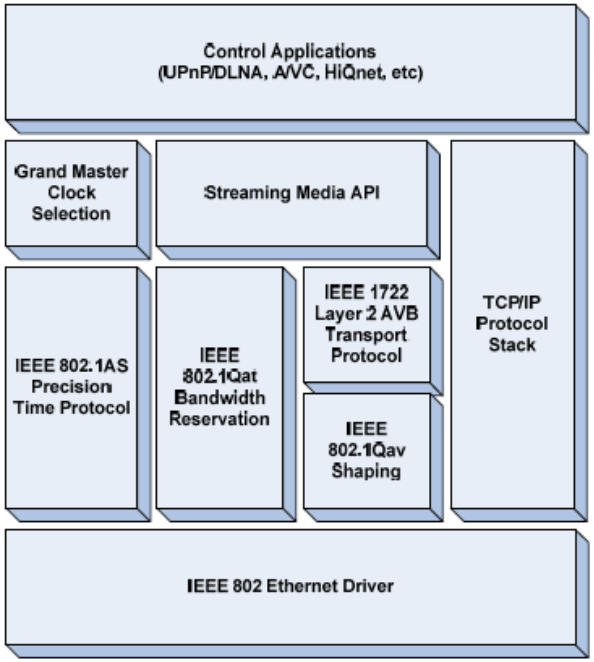
- **IEEE 802.1 QAV (Shaping)**
  - Queuing and forwarding protocol to ensure asynchronous Ethernet traffic does not interfere with steaming AVB traffic.
    - Allows bridges to provide guarantees for time-sensitive (i.e. bounded latency and delivery variation), loss-sensitive real-time audio video (AV) data transmission (AV traffic).
    - Standard uses the timing derived from IEEE 802.1AS
- **IEEE 1722 AVTP (Time sensitive streaming)**
  - AVTP specifies methods to transport audio/video data and timing information so that audio/video content sent by a Talker can be reproduced.



Reference: Understanding IEEE 1722 AVB Transport Protocol – AVTP, March 9, 2009, Harman International

AVB Ethernet stack summary

- **IEEE 1722.1**
  - IEEE P1722.1 defines the higher layer protocol for IEEE P1722 based devices. It specifies an application procedure for the AVB network systems. This standard covers
    - Service discovery – Identifies other 1722.1 capable nodes
    - device enumeration
    - connection management
    - Connects/disconnects virtual links between media sources/sinks
    - device control protocols:



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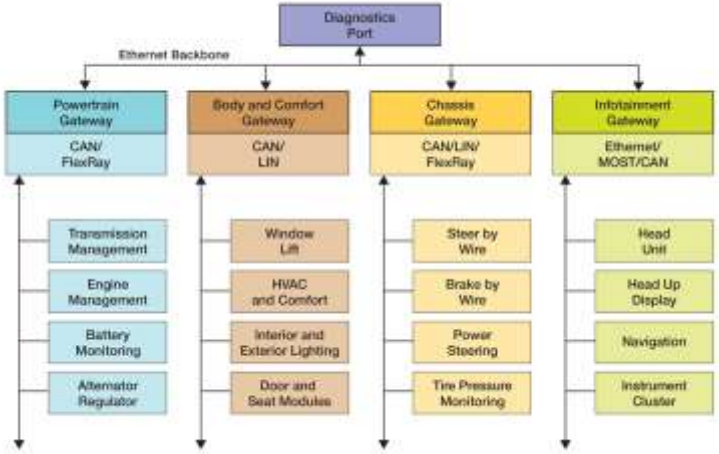
Future trends

Future Trends

- Cross-domain car communication
  E.g. increasing safety enabled by data interaction between active safety and advanced driver assistance functions
- Networking of Cars and Environment
  Car2car communication for efficient organization of traffic flow
- More comfort and safety features in the car
  - Camera's, TFT displays, connectivity, functional safety
  - Example for average car
    - ~40 electric/electronic systems
    - 50-100 MCUs
    - >100 sensors
- Memory and performance on the increase
  - Modern car up to 50Mbyte (excludes infotainment)

Future Trends

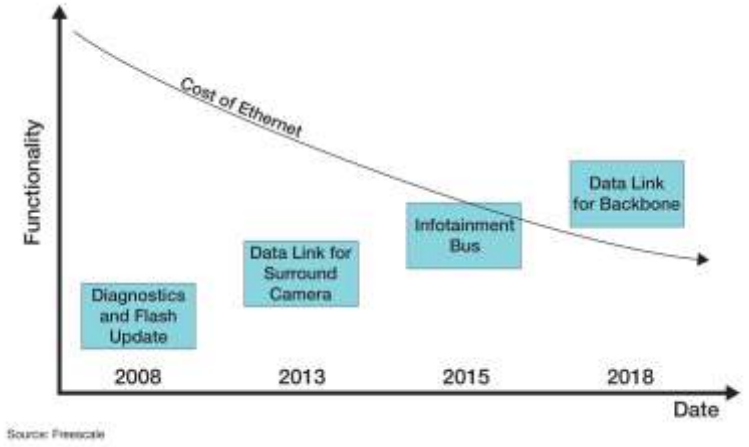
- **Move to integrate more functions into larger “domain controllers”**
  - Reduce costs, integration complexity and wiring harness weight



- **High bandwidth backbone interconnect network needed**
  - Manage the network complexity to reduce the development effort and increase fault tolerance and robustness of the network
  - Higher demand on bandwidth and quality of service

Future Trends

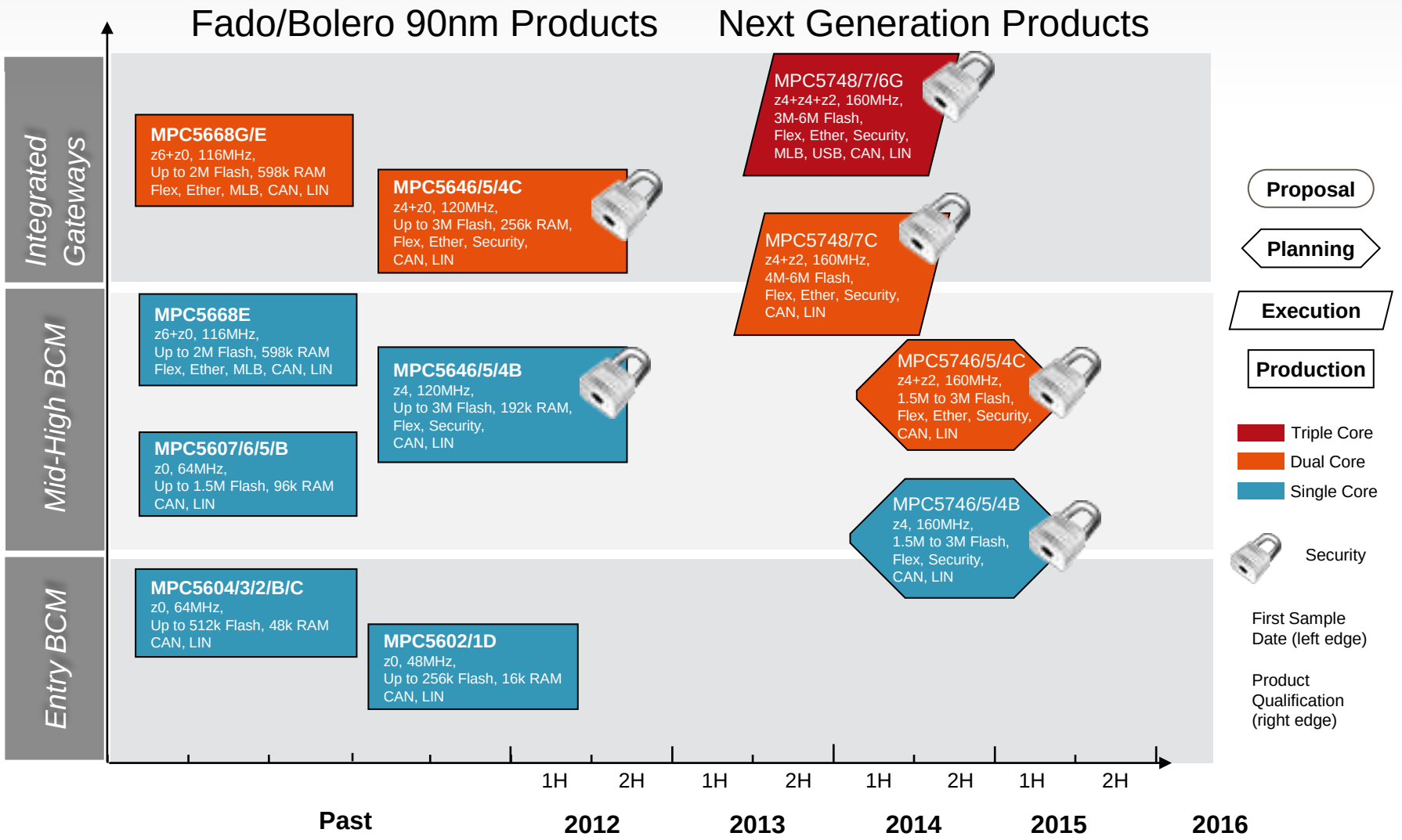
- **Ethernet for Automotive**
  - Ethernet already introduced into vehicle
  - Cost of Ethernet reducing
  - Increased bandwidth options (scalability)
  - Possible to stay below electromagnetic compatibility (EMC) emissions limit with low cost UTSP
  - Ethernet is a well-known and mature network structure
  - Many developers have Ethernet experience
  - Simple integration of consumer devices
  - Availability of hardware, software and low-cost and freeware tools



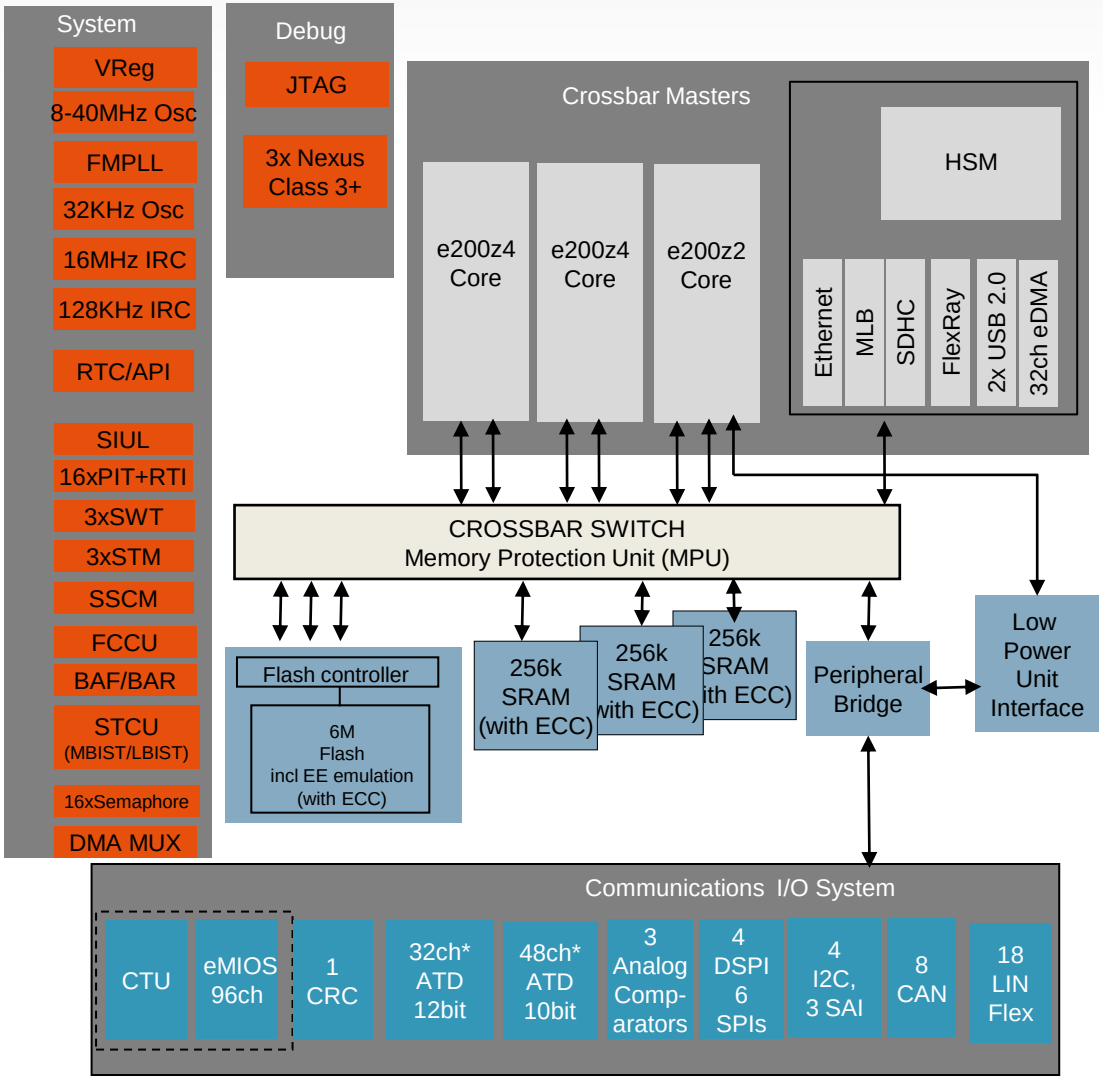
Source: Freescale

Roadmap

32-bit Body Electronics MCU Roadmap



MPC5748C/G - High End Gateway/BCM Solution



Applications:

- High end Gateway and Body Modules

Key Characteristics:

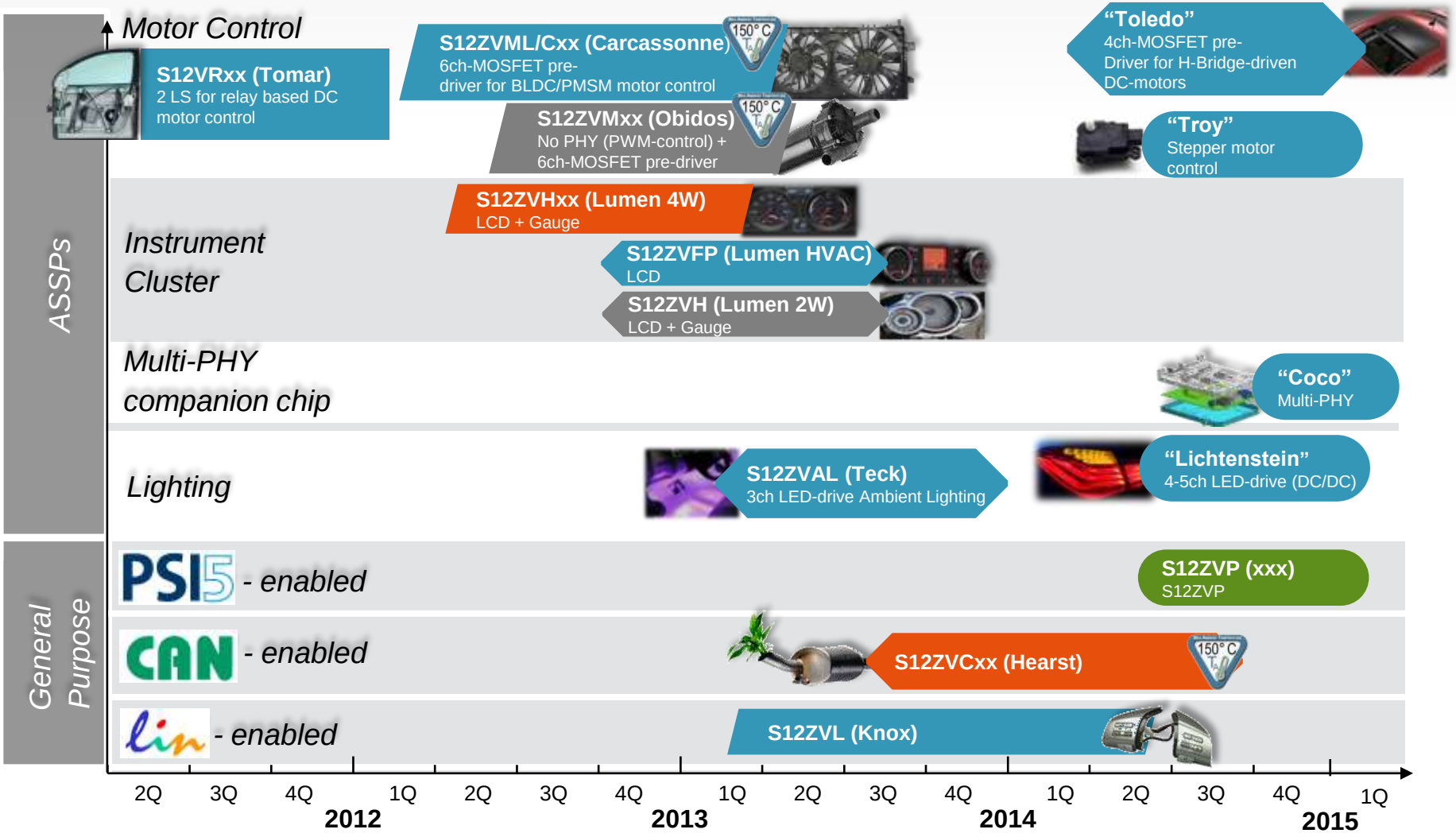
- 2x e200z4 + 1x z2 cores, FPU on z4 cores
- 160 MHz max for z4s and 80 MHz on z2
- HSM Security Module option supports both SHE and EVITA low/medium standard
- Media Local Bus supports MOST communication
- 2 x USB 2.0 (1 OTG and 1 Host module) support interfacing to 3G modem and infotainment domain
- Ethernet 10/100 Mbps RMII, MII, +1588, AVB
- CAN module optionally supports CAN FD
- SDHC provides standard SDIO interface
- Low Power Unit provides reduced CAN, LIN, SPI, ADC functionality in low power mode
- Designed to ISO26262 process for use in ASIL B
- -40 to +125C (ambient)
- 3.0V to 5.5V

Packages:

- 176 LQFP, 256 BGA, 324 BGA

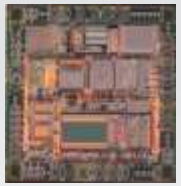
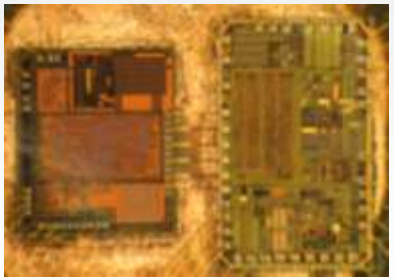
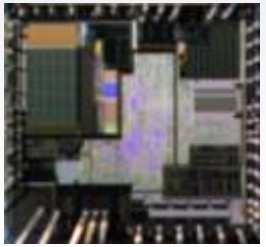
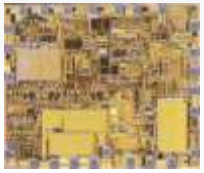
	5747C	5748C	5747G	5748G
Cores	2	2	3	3
Flash	4M	6M	4M	6M
RAM	512k	768k	768k	768k
MLB	N	N	Y	Y
USB	N	N	Y	Y

S12 MagniV Roadmap



What's S12 MagniV?

SiP = System in Package

Semi-Discrete Solution (Multi-Chip)	Multi-die SiP	Monolithic SiP
• Standard MCU 	• Single package • Die-to-die bonding  	• MCU and Analog on the same die  
• Application Specific Analog IC (ASIC) 		

S12 MagniV Benefits

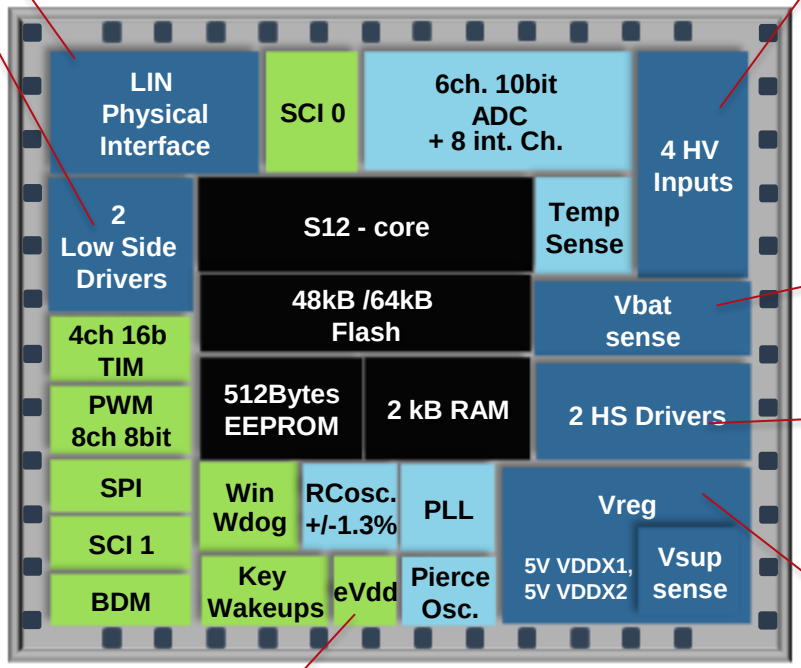
		Tomar	Carcassonne	Knox
Product specific benefits	Bill of material reduction	LIN phy VREG + Vsense 2xLS for relays 2xHS	LIN phy VREG + Vsense Gate Driver 2xOp-amps	LIN phy VREG + Vsense
	PCB Space	2-3cm2	2-6cm2	1-2cm2
	Manufacturing cost	- Fewer components to mount (pick & place) - Less testing required for individual ICs		
General benefits	Quality/Reliability	- Fewer solder joints → fewer points of failure - Pre-tested “sub-system”		
	Logistics	Fewer parts to qualify, source, store, track, etc…		

S12 CPU with an integrated Voltage regulator, LIN physical layer and HS/LS-drivers for Relay-driven Windowlift-motor

S12VRx – "High Voltage" Integration

LIN Physical Layer
LIN 2.1 compliant
+/- 8kV ESD capability

2 Low-Side Drivers
Protected LS Drivers to drive brushed DC Motor Relays



4 High Voltage Inputs
12V Inputs for Switch Monitoring

Vbat and Vsup sense
Supply sense before and after protection diode

Up to 2 HS drivers
For LED and Switch supply

Voltage Regulator
No Ext regulator reqd
20mA to drive offchip components

Hall Supply
5V, 20mA,
Over curr. ctrl

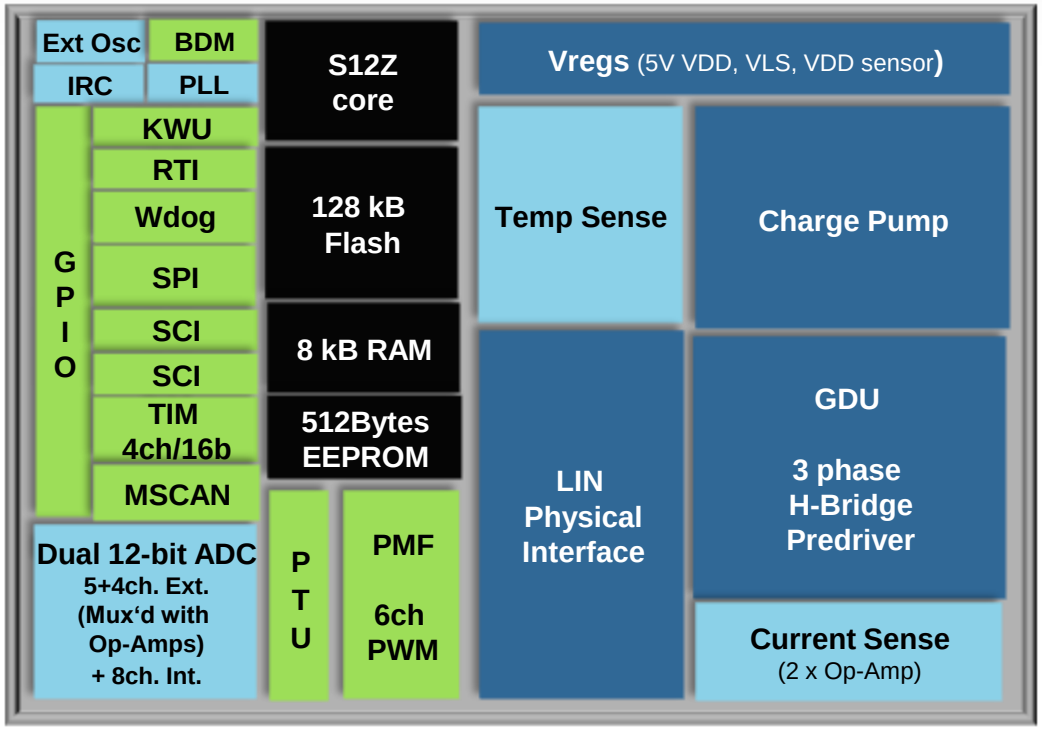
Digital Components	5V Analogue Components
MCU Core and Memories	High-Voltage Components

16-bit MCU with 12/5V voltage regulator, LIN physical layer, and MOSFET pre-drivers for DC and BLDC motors

Carcassonne – S12ZVML128

- **Target applications:**
  - BLDC motor control
  - DC motor control

- **Key Features:**
  - S12Z CPU @ 50MHz bus speed
  - Embedded VREG
  - LIN phy, LIN2.1 compliant
  - Embedded GDU for 3ph BLDC
  - Embedded EE
  - 1x MSCAN controller
  - 2xSCI, 1xSPI
  - Dual 12bit ADC, synch with PWM
  - 20mA/5V EVDD sensor supply pin
  - 2x Op-amp for current sense (each needs 3 pins mux'd with ADC inputs)
  - 64LQFP-EP 10x10/0.5mm



Digital Components | 5V Analogue Components | MCU Core and Memories | High-Voltage Components

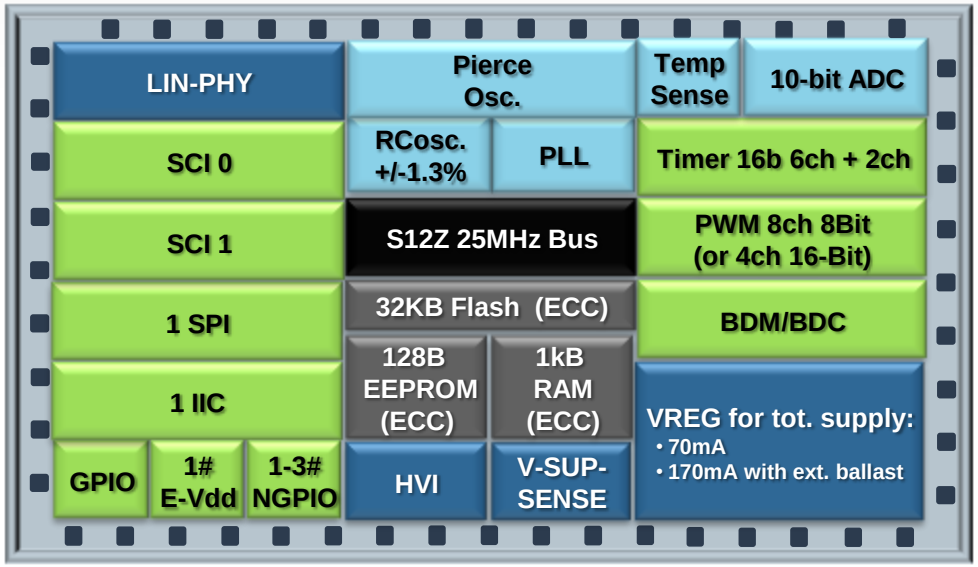
General Purpose S12 MagniV 16-bit MCU with 12/5V voltage regulator, LIN-physical layer

KNOX – *Sampling*

Integrated General Purpose LIN Node

Key Features:

- On chip 12V Vreg with Supply-capability:
- 70mA total (170mA with ext. Ballast)
- LIN-PHY, LIN2.1 compliant
- On chip RC Oscillator; trimmed to +/- 1,3% tolerance over full temperature range
- Robust 12V inputs Vsup-sense & HVI (with ADC)
- 1x E-Vdd (20mA source capability)
- 1-3x N-GPIO (25 mA sink capability)
- 10Bit ADC
- EEPROM 4-Byte-erasable
- Ambient temperature-range: -40°C … +125°C
- 5x5mm footprint 32QFN-package optional
- ASIL-A compliancy



	KNOX		
	S12ZVL		S12ZVLS
Application orientation	generic		small sensors
Package	48LQFP	32LQFP	32QFN
Flash Memory (ECC)	32/16/8 kB	32/16/8 kB	32/16 kB
NGPIO (GPIO with 25mA NMOS)	3	1	3
HVI	1	1	1
2nd SCI	y	y	y
SPI	y	y	y
IIC	y	y	y
10-Bit ADC	10ch	6ch	6ch
ASIL	A	A	A

Digital Components | 5V Analogue Components | MCU Core and Memories | High-Voltage Components

Freescale Competitive Advantage

Freescale Competitive Advantage

- Calypso 6M highest end gateway device on the market
- Knowledge of networking and G/W requirements
- Ethernet based products in series production
  - First Ethernet Gateway
  - Ethernet camera application based on Salsa product
- Comprehensive Ethernet roadmap
  - 10/100/1000 Mbit/sec
  - Leader in automotive AVB applications
    - Steaming software
    - Specific AVB features in Ethernet IP to offload CPU
- Active member of CAN FD working groups
- Early to market with CAN FD
  - Supports interleaving CAN 2.0 and CAN FD frames
  - Flexible buffer management

Freescale Competitive Advantage

- MagniV Roadmap
  - Monolithic HV technology built upon proven high volume standard CMOS process
  - Integration of high voltage (e.g. CAN Phy, LIN Phy, Vregs)
  - Improved reliability

Conclusion

- Automotive networking market is evolving with the introduction of new protocols
- CAN FD, Ethernet AVB
- Freescale provide support for all protocols in Automotive
- LIN, SENT, CAN2.0, CAN FD, FlexRay, Ethernet and Ethernet AVB, MLB, USB
- Freescale devices developed specifically for gateway market
- Calypso family
- Bolero Family
- Freescale devices support high voltage and power (Magniv)
- LIN Phy, CAN Phy, Vregs
- Lower BOM, higher reliability


freescale™