Addressing the hard problems
of automotive Linux: networking and IPC

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Android · Nucleus · Linux
Mobile & Beyond · 2D/3D User Interfaces · Multi-OS · Networking

Outline

- Status of Linux in automotive

- GENIVI and AF_BUS IPC

- V2V and V2I networking

- New stakeholders for Linux

- Summary

Housekeeping: IVI Jargon

- *"OEM":* a car manufacturer

- *"Tier 1":* a vendor who sells directly to OEMs

- *"Tier 2":* a vendor to Tier 1s, who bundle components

- *"ECU":* electronic control unit, 32- or 16-bit MCU running an RTOS

- *"AUTOSAR":* ECU protocol incl. design methodology

- *"ADAS":* advanced driver assistance system

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Linux won:

- on servers and on handsets.

Linux lost:

- on desktops.

*Linux **could lose** in automotive:*

- QNX and Windows have the largest automotive base.

- QNX has fast IPC and works well on smaller MCUs.
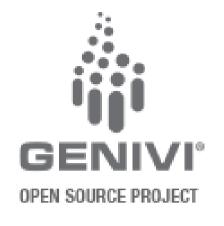
- Most car CPUs run proprietary RTOSes.

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Current <u>Public</u> Status of Automotive Linux

<u>OEM</u>	<u>Confirmed Operating system</u>
Fiat-Chrysler Blue&Me (500, Delta), Kia Uvo	Microsoft Windows Embedded Automotive
Ford (all?)	MyTouch/Sync-Microsoft (OpenXC-Android)
General Motors/Cadillac User Experience	Linux
Geely (China); Hawtai (China)	Linux: Moblin (MeeGo-Tizen precursor)
Renault R-Link	Android
Jaguar Land-Rover	Tizen (Linux)
Honda (Accord, Odyssey, Pilot), Audi (A8L, Q5, A6), BMW (7-series and M models), Chrysler, Daewoo, GM (OnStar), Hyundai, Land Rover, Porsche, Saab (9-3), Renault (SM7), Mercedes (S- and C-class)	QNX

Linux Foundation members: Toyota, Pelagicore, Symbio, Tieto

GENIVI Alliance: 160+ members including 11 "OEMs"

GENIVI Alliance

- *Goals*:

  - reduce lock-in by Tier 1 vendors.

  - reduce cost and TTM of new models.

- *Methods*:

  - Promote code reuse via standard interfaces.

  - Grow the size of contributor community.

  - Focus on middleware: not a distro.

- *Projects with released code*: Audio Manager, IVI Layer Management, Diagnostic Log and Trace, AF_BUS D-Bus Optimization, LXCBENCH; more on the way.

- Mailing lists and #genivi on FreeNode.

TRUE:

01 February 2013, 09:07

What's the next big platform for Linux?

by Glyn Moody

Glyn Moody wonders whether the car – a currently undeveloped yet important platform with great potential – can provide the inspiration for the next generation of Linux coders.

How about the car?
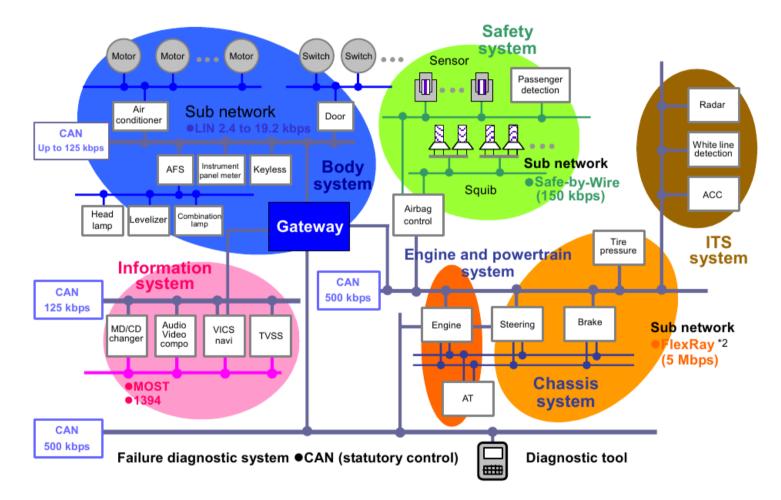Developing on Android

FALSE:

Since then, Genivi has moved even closer to Linux: for example, the Linux Foundation now hosts key Genivi projects. However, Genivi is only about IVI – "in-vehicle infotainment". That's an important part of a vehicle's operations, but doesn't involve the fundamentals – things like the engine or braking systems – that are arguably closer to its heart. That's what made this announcement last year noteworthy:

http://www.h-online.com/open/features/What-s-the-next-big-platform-for-Linux-1794404.html
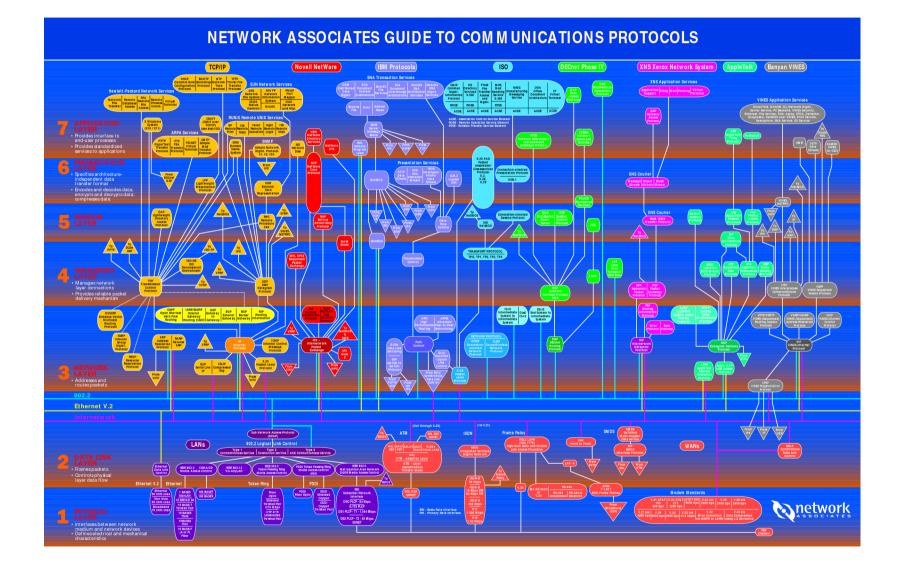
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The *strange* case
of
AF_BUS

Mixture of time-critical and best-effort networks

Copyright Renesas, "*Introduction to CAN*", with permission.
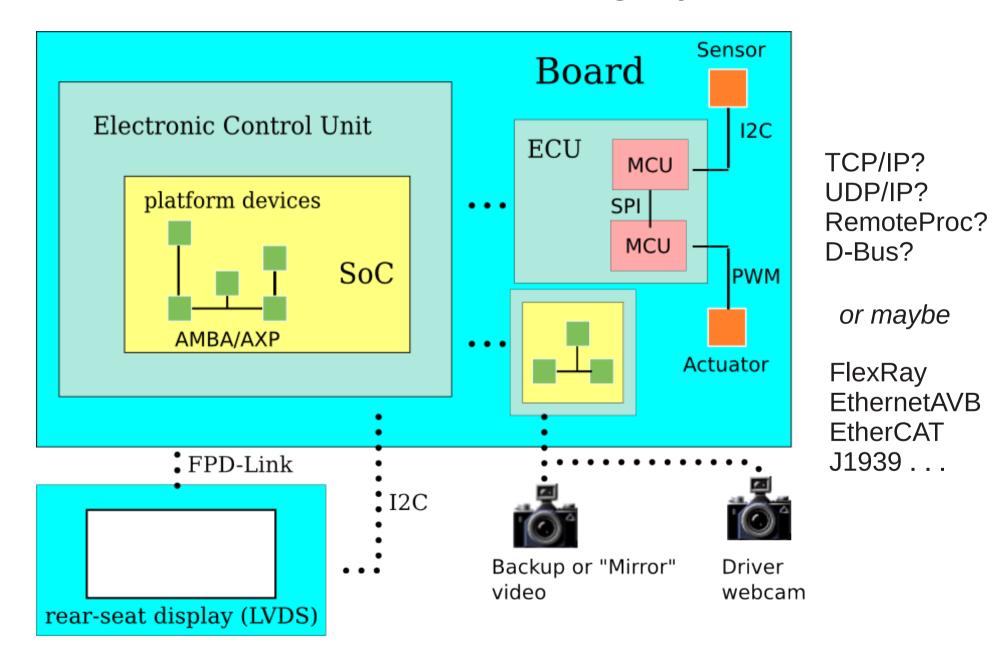
Anyone reminded of this Babel?

NETWORK ASSOCIATES GUIDE TO COMMUNICATIONS PROTOCOLS

Diverse IPC mechanisms, Legacy Protocols

TCP/IP?
UDP/IP?
RemoteProc?
D-Bus?

 or maybe

FlexRay
EthernetAVB
EtherCAT
J1939 . . .

Challenges to Standards for Linux IPC

- "IP is the narrow waist of the Internet" *BUT*

- TCP/UDP, even IP headers are too large for AUTOSAR.

  - 6LoWPAN header compression offers a solution?

- *Event-driven* and *timer-based* traffic coexist on same network.

  - Will asynchronous networking provide QoS?

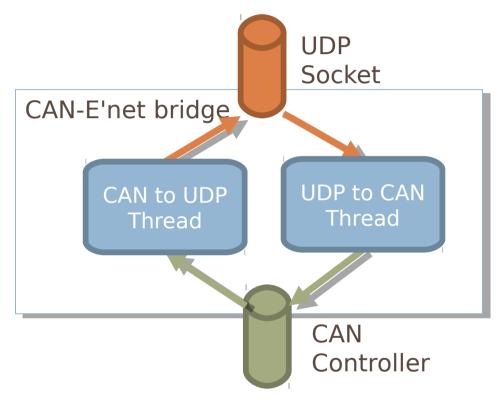- AudioManager, LayerManager, AF_BUS define *policies* to enable *whole-system-level* interrupts and priorities.

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CAN-Ethernet Gateway Demo

From "SAE J 1939 Over Real Time Ethernet: The Future of Heavy Duty Vehicle Networks," Ruggeri et al., Imamoter, 2012

- ARM Cortex A8
- Linux Ångström v 2.6.28
- Stack "SocketCAN"
- Can and Ethernet on chip

UDP Socket

CAN-E'net bridge

CAN to UDP Thread

UDP to CAN Thread

CAN Controller

Two independent threads.
Uses socket paradigm as an abstraction to transparently copy messages on different physical layers

GENIVI meets kernel: AF_BUS

- Problem: D-Bus scales poorly, is resource-intensive and slow.

- Recent history of contention around IPC: binder in 2009

- AF_BUS is created by Collabora with GENIVI-funding.

- Implements a new socket interface based on AF_UNIX but with multicast capability.

- Rejected from mainline with rationale that IP sockets can provide needed performance.

    – Real-time IPC guarantees possible with IP?

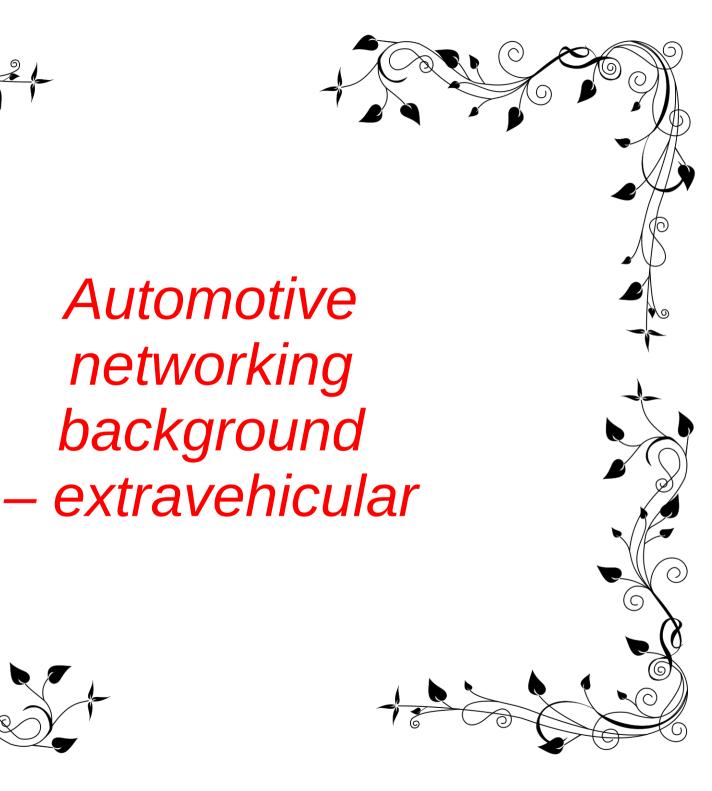- AF_BUS subsequently merged in LTSI kernel 3.4.21.

Feb 2013: Gnome Hackfest

- New *in-kernel* D-Bus-based IPC is broached.

  - Will support Binder userspace API as well as D-Bus.

  - And others (0MQ, RabbitMQ, *etc*.)?

- Endorsed by D-Bus (Pennington) and kernel (GKH) contributors.

- *Victory* for GENIVI: in-kernel D-Bus optimization is coming!

- Not viewed that way by everyone . . .
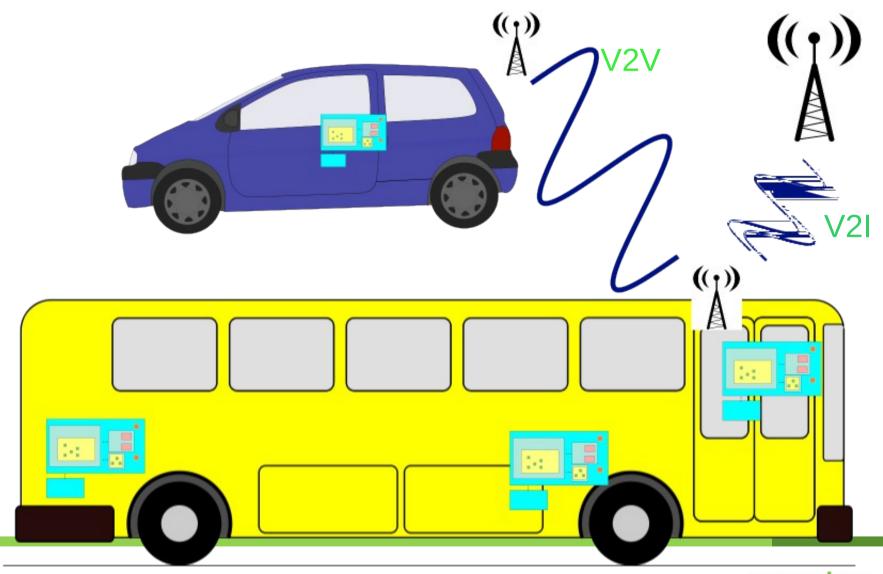
- brcmsmac vs. b43 (Broadcom) redux?

Automotive networking background – extravehicular

Vehicles are a "network of networks"

V2V
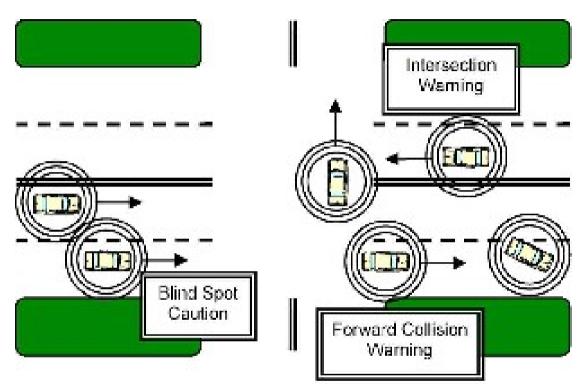
V2I

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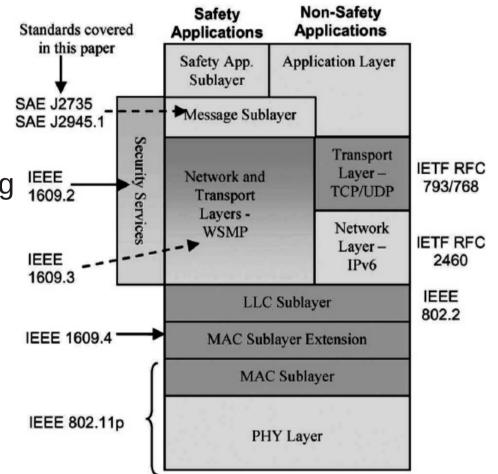# IEEE: DSRC and Basic Safety Message

J.B. Kenney,
Toyota ITC,
Proc. IEEE 99,
2011.

- Collision avoidance is primary motivation.

- USDoT had RFC on PKE for V2X in 2012.

- How to issue revocable keys w/o trackability?

802.11p & 1609: DSRC, WAVE and WSMP

- 802.11p has dedicated spectrum at 5.9 GHz.

- Unlike other 802.11, no BSS.

- New protocols, *e.g.* DNS Geocasting

- New use cases, *e.g.* mobile routers

- VIN == MAC? or is VIN private?

- Jouni Malinen, 2012 Linux Wireless Summit, "Not yet implemented."

Standards covered in this paper

	Safety Applications	Non-Safety Applications
	Safety App. Sublayer	Application Layer
SAE J2735 / SAE J2945.1	Message Sublayer	
IEEE 1609.2	Network and Transport Layers - WSMP	Transport Layer – TCP/UDP (IETF RFC 793/768)
IEEE 1609.3		Network Layer – IPv6 (IETF RFC 2460)
	LLC Sublayer	IEEE 802.2
IEEE 1609.4	MAC Sublayer Extension	
IEEE 802.11p	MAC Sublayer	
	PHY Layer	

Security Services

J.B. Kenney,
Toyota ITC,
Proc. IEEE 99,
2011.

802.11p V2X routers

Linux-based

StreetWAVE™ Roadside Unit: Supports V2X Safety and Mobility applications using DSRC, 3G

BSD-based?

Commsignia

Laguna is a multimodal communication device, software development and verification platform representing the state-of-the-art of Cooperative ITS communications (C-ITS)
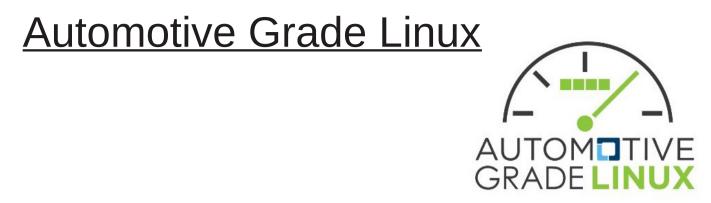
Automotive Grade Linux

- Initiated September 2012.

- An installable distro like Android (unlike GENIVI).

- Development in open (unlike Android or GENIVI).

- No CLA, but no GPLv3 (like Android and GENIVI).

- Mailing lists available but very quiet.

- So far, based entirely on Tizen.

Open source has new allies

Reflashing the ECUs: uprev.com

Conclusions

- Hardest problem of automotive Linux is *cultural*.

- The Linux community and kernel devs and "Tier n" software creators need to work together.

  – Make accomodation for mutual benefit, as with Android.

- Kernel quality standards must be maintained

  BUT

  OEMs need to ship reliable, safe cars every year.

- Drivers, transit planners, insurance companies, home mechanics are stakeholders, too.

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Related automotive presentation

John Mehaffey, Mentor Graphics,

Security Best Practices for Embedded Systems

Friday at 3:15 in Cyril Magnin

Special thanks

Massimiliano Ruggeri of Imamoter, *John Kenney* of Toyota,
Ravi Puvvala of Savari Networks, *Christie Dudley* of Santa Clara
University Law School, *Mentor Embedded and GENIVI colleagues*

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Resources

- GENIVI open-source projects, mailing lists, #genivi IRC

- Automotive Grade Linux

- ITSSv6, CALM, Imamoter, ETSI, ISO C-ITS

- SAE, IEEE, AUTOSAR, ISO, IETF, W3C standards

- IETF-ITS mailing list; Telematics News and Telematics Update, Wired Autopia

- Reverse-engineering legions: scantool.net, mp3car.com, diyefi.org, Team Wikispeed, righttorepair.org

- LWN and H-Online (as always!)

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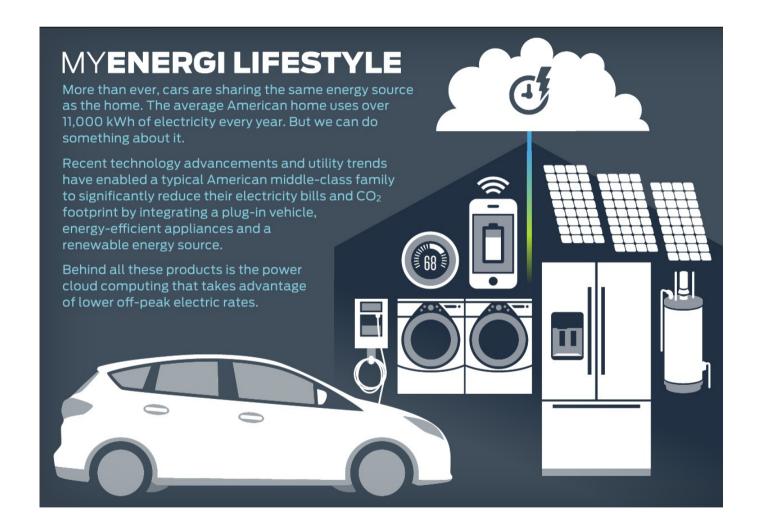
Early backup video and v4l2

- NHTSA proposed a requirement for annotated, composited backup video 2s after boot.

  – Announced for 12/2012: nothing yet.

- Likely solution for fast-boot: a dedicated camera ECU or CPU.

  – What network architecture optimizes BW, cost and reliability?

- Jaguar Land-Rover: 8 cameras in new ADAS systems.

- Cameras will also be used for gesture recognition.

  – Now possible with specialized IP cores (Samplify *et al.*).

Cars talk on the Internet of Things

MYENERGI LIFESTYLE

More than ever, cars are sharing the same energy source as the home. The average American home uses over 11,000 kWh of electricity every year. But we can do something about it.

Recent technology advancements and utility trends have enabled a typical American middle-class family to significantly reduce their electricity bills and CO_2 footprint by integrating a plug-in vehicle, energy-efficient appliances and a renewable energy source.

Behind all these products is the power cloud computing that takes advantage of lower off-peak electric rates.

High-Bandwidth feasible buses overview

|	IEEE 802.3	Ethernet Field busses	CAN-FD	Flexray	MOST
Openness	Open standard, high availability of PHYs and MACs	Usually open standard, some have custom PHYs and MACs	Under ISO standardization ISO-11898-2/6 transceivers	Under ISO standardization (or flexray.com) Expensive controllers	Closed Standard. Expensive Fiber wiring
Band width	1000/100 Mbit	100 Mbit (not every fieldbus Gigabit ready)	Up to 8x CAN datarate→2Mbit for ISOBUS (theoretical)	Up to 10 Mbit	Up to 138Mbit (MOST 150)
Hotplug capability	YES	Depends on the field bus	YES	NO (attempts were made to enable)	YES
Topology	Star, Logical Bus, daisy chain, …	Ring, Daisy chain, Star in some topologies	Physical Bus	Star	Ring or doubled ring, star feasible
Safety certified	NO (OpenSafety)	Many fieldbuses have IEC-61508 SIL3 certified Layer	??	NO	??
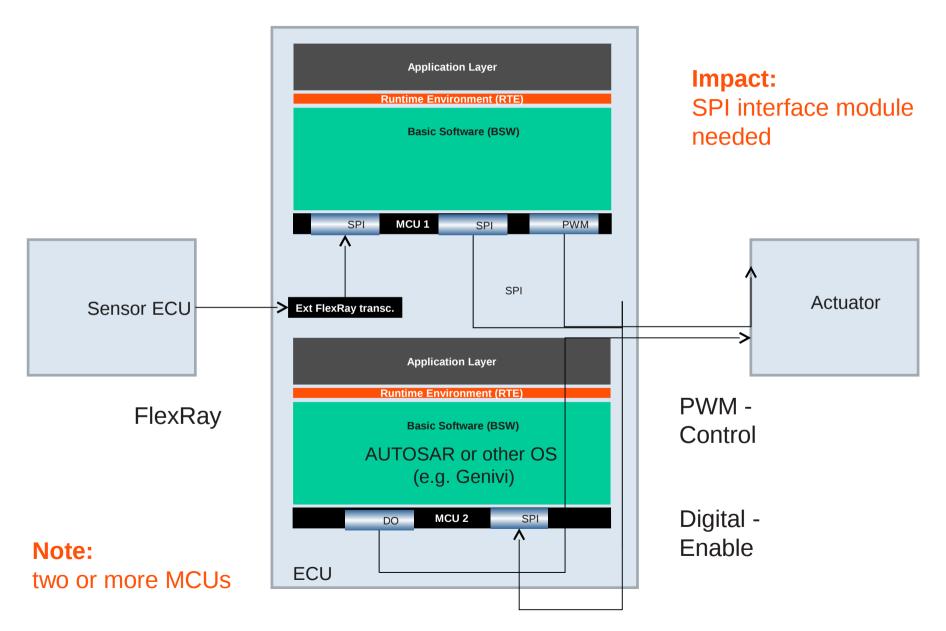
From "SAE J 1939 Over Real Time Ethernet: The Future of Heavy Duty Vehicle Networks," Ruggeri et al., Imamoter

Another view of automotive networks

courtesy AUTOSAR

SPI used as communication stack

Application Layer

Runtime Environment (RTE)

Basic Software (BSW)

SPI **MCU 1** SPI PWM

Impact:
SPI interface module needed

Sensor ECU

Ext FlexRay transc.

SPI

Actuator

FlexRay

Application Layer

Runtime Environment (RTE)

Basic Software (BSW)

AUTOSAR or other OS
(e.g. Genivi)

DO **MCU 2** SPI

ECU

PWM - Control

Digital - Enable

Note:
two or more MCUs

Courtesy of AUTOSAR Consortium

Phasing in autonomous operation

- *Prediction:* in U.S., incentives to buy cars with V2X radios.

  - Usage-based insurance motivates driver acceptance.

- *Prediction:* congestion pricing everywhere all the time.

  - Drivers get discounts for travelling off-peak.

- *Prediction:* stop signs and traffic lights disappear.

- Optimization at the whole transport-system level is enabled by vehicles talking on the Internet of Things.

  - Pollution, energy usage and travel times can be jointly managed

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CAN-Ethernet Gateway Demo

*From "SAE J 1939 Over Real Time Ethernet: The Future of
Heavy Duty Vehicle Networks," Ruggeri et al., Imamoter, 2012*