Addressing the hard problems of automotive Linux: networking and IPC

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Outline

- Status of Linux in automotive
- Automotive InterProcess Comms (Intranet)
- V2V and V2I networking (Ravi)
- Summary

Current Public Status of Automotive Linux

Carmaker	*Confirmed* Operating system
Fiat-Chrysler Blue&Me, Kia Uvo	Microsoft Windows Embedded Automotive
Ford (all?)	Microsoft MyTouch/Sync (+ OpenXC Android dongle and SmartPhoneLink)
General Motors “Cadillac User Experience”	Linux
Geely (China); Hawtai (China)	Linux: Moblin (MeeGo-Tizen precursor)
Renault R-Link	*native* Android
Jaguar Land-Rover, Tata, Toyota	Tizen (GNU/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 automakers

GENIVI Alliance

- *Goals*:
  - reduce lock-in by suppliers.
  - reduce cost and TTM of new models.
- *Methods*:
  - Promote code reuse and attract outside contributors.
  - Focus on middleware: not a distro.
- *Mailing lists and #genivi on FreeNode.*
- *10 projects with released code* including AUTOSAR (Diagnostic Log and Trace) and IPC (AF_BUS D-Bus Optimization)

OSI Networking Stack

Layer	Function	Questions for this layer	On a PC's Ethernet
1. Physical	Provides the electrical and physical specification	How many wires connect your processor to a peripheral? At what voltage? At what speed?	Ethernet cable
2. Data link	Describes how bytes flow over the physical wires	Do the bytes have parity checking? How many bits are sent and received in each frame?	Ethernet (802.xx)
3. Network	Gets a variable length of information (packets) from one place to another	How is each system addressed? How does the layer break up (and re-form) big blocks of data into amounts that can go over the communication pathway?	IP
4. Transport	Moves blocks of data in a reliable manner, even if those blocks are larger than the lower levels can handle	How do you count on data being received even when there is a glitch in the wires? How are errors recovered from?	TCP
5. Session	Manages a connection between the local and remote application	How to send this data from here to there?	Sockets
6. Presentation	Provides structure to the data, possibly encryption	How is the data organized when it is sent?	TLS and SSL
7. Application	Takes user interaction with the software and formulates a communication request	What command to send when a button is pressed?	HTTP

From
Making Embedded Systems
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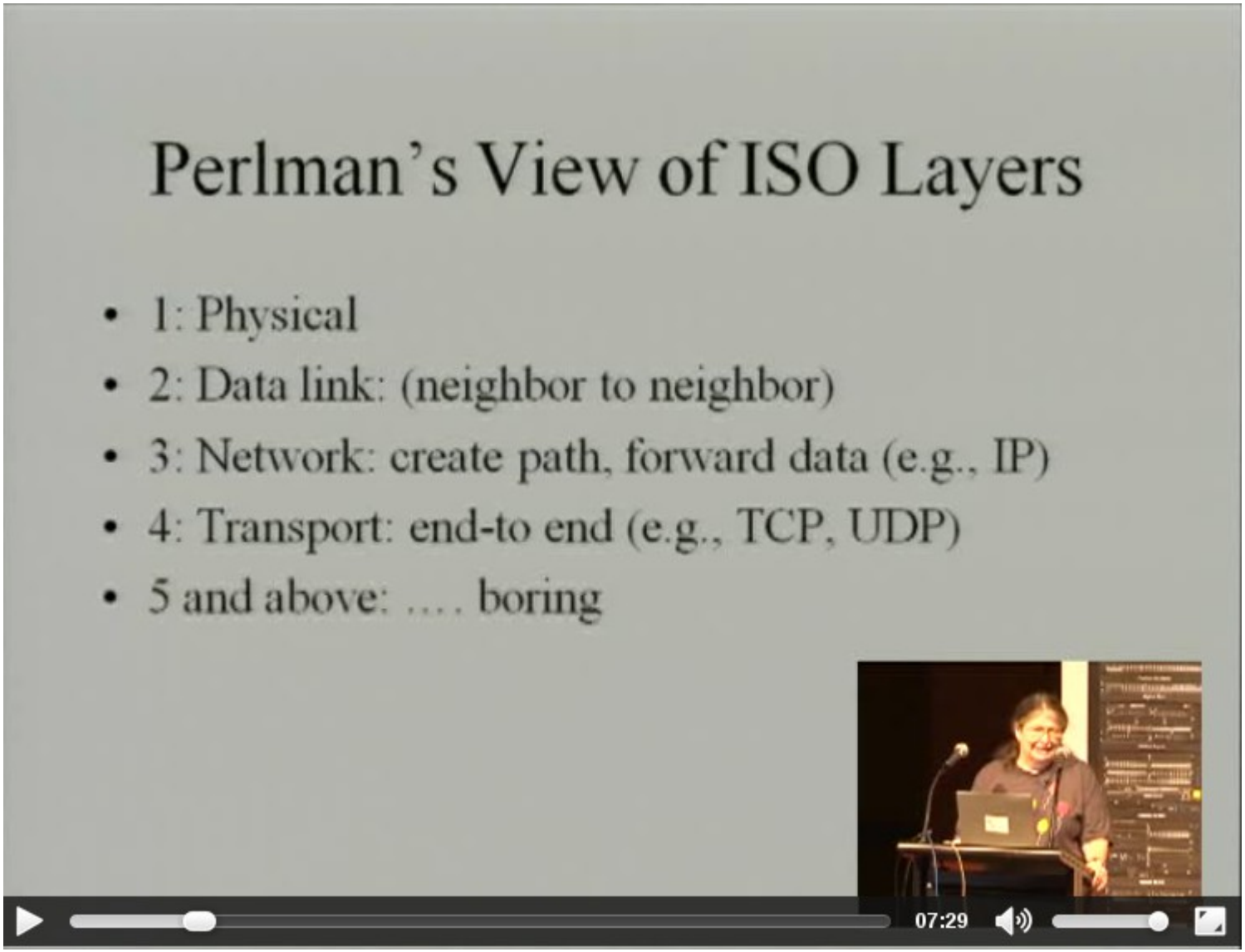
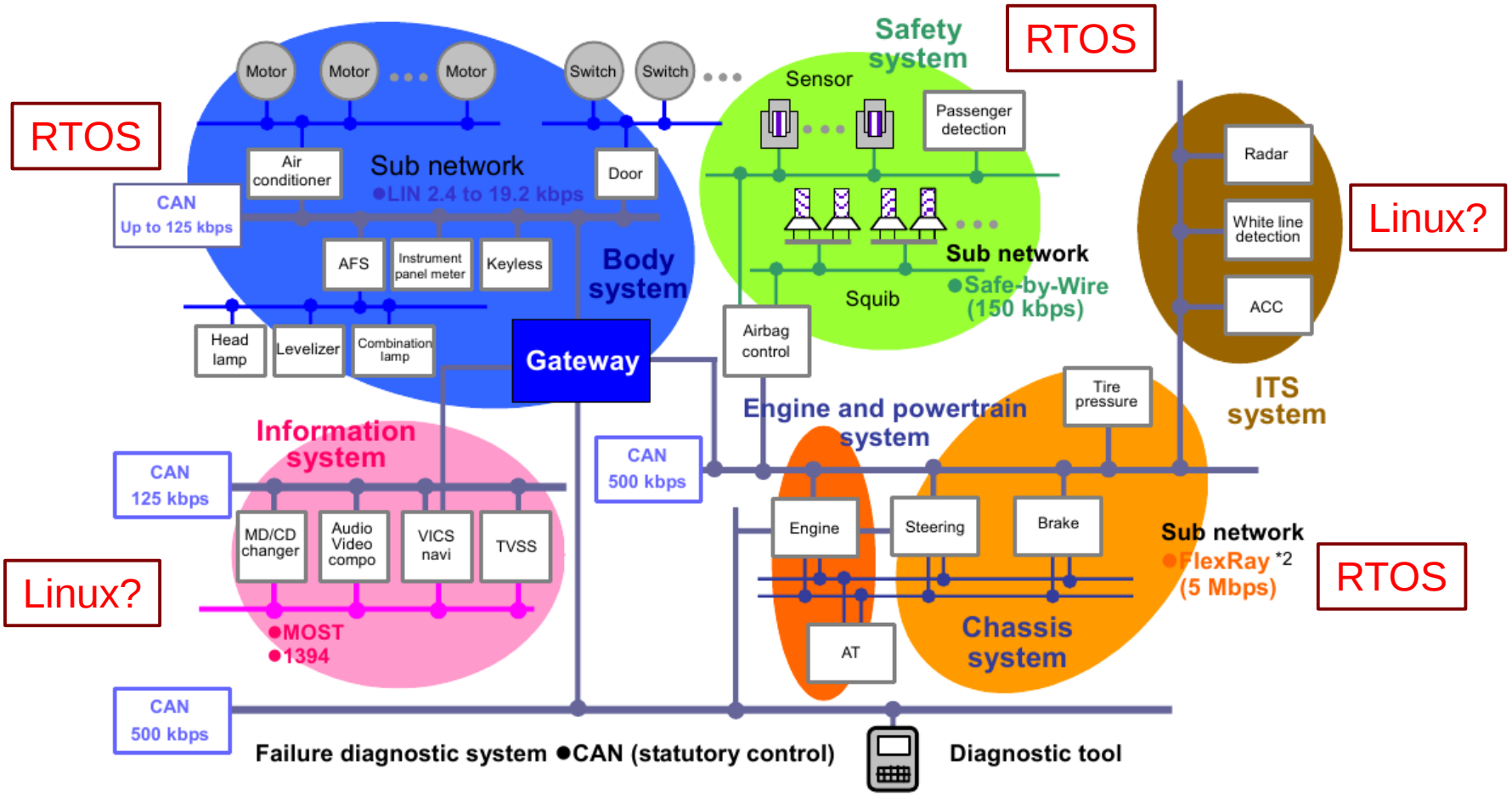


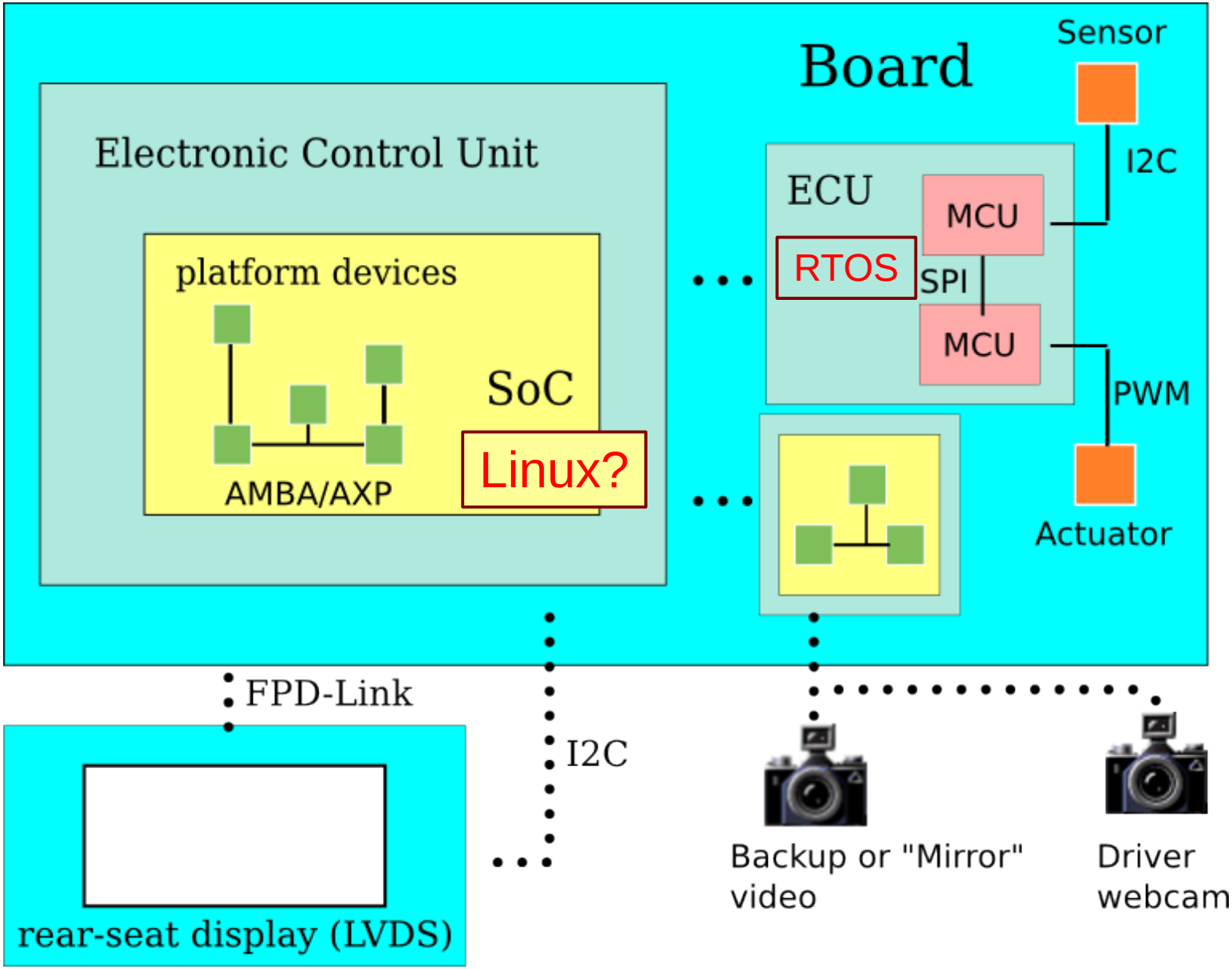
From LCA 2013

Mixture of time-critical and best-effort networks



Copyright Renesas, "*Introduction to CAN*", with permission.

Diverse IPC mechanisms, Legacy Protocols

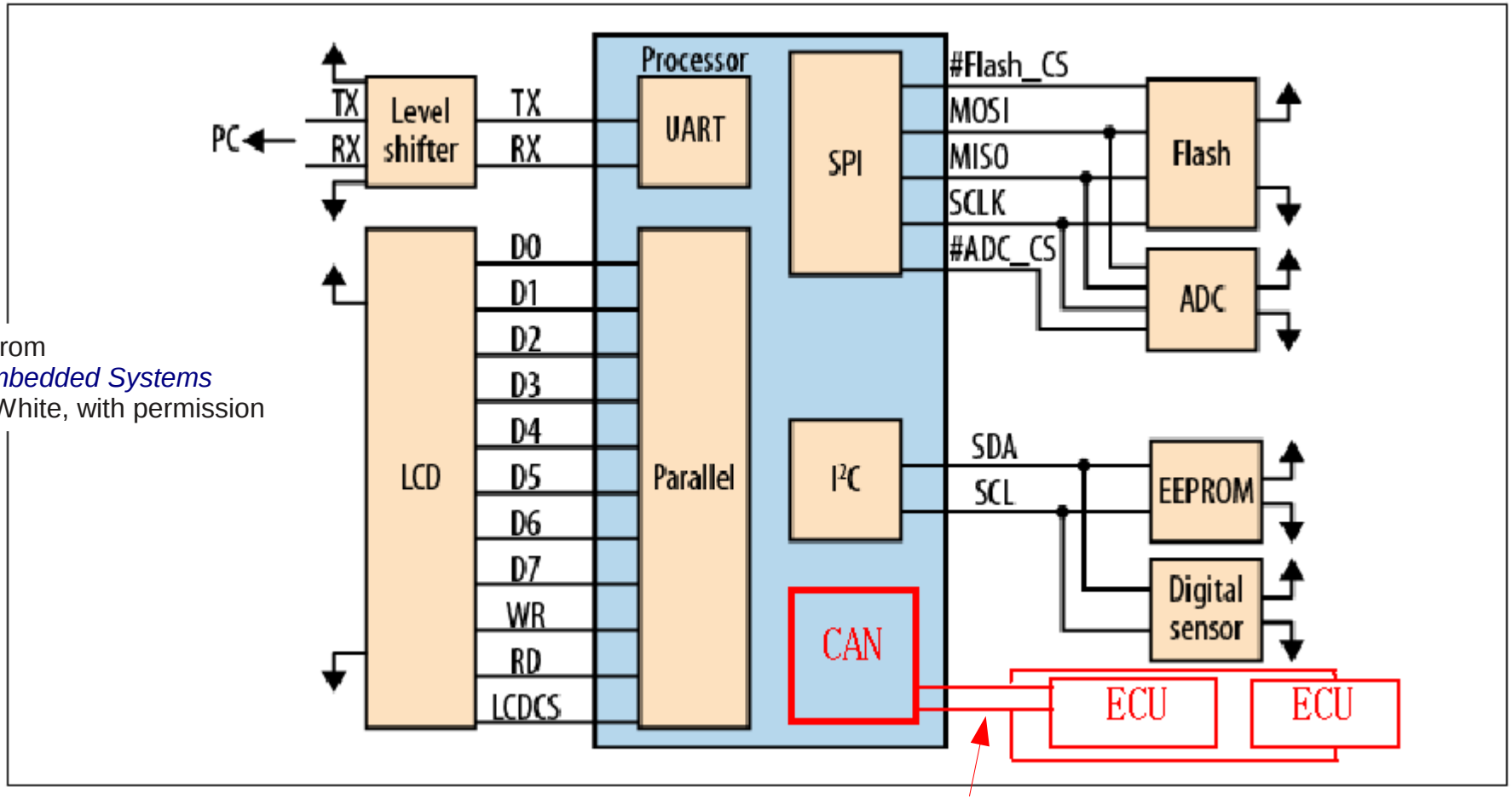


TCP/IP?
UDP/IP?
RemoteProc?
D-Bus?

or maybe

FlexRay
EthernetAVB
EtherCAT
J1939 . . .

Controller Area Network is 2-wire serial like I2C



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CAN Bus has security problems at Data Link Layer

Remote wireless exploit against stock vehicle:
U. Wash. and UCSD collaboration

CAN will (eventually) phase out.

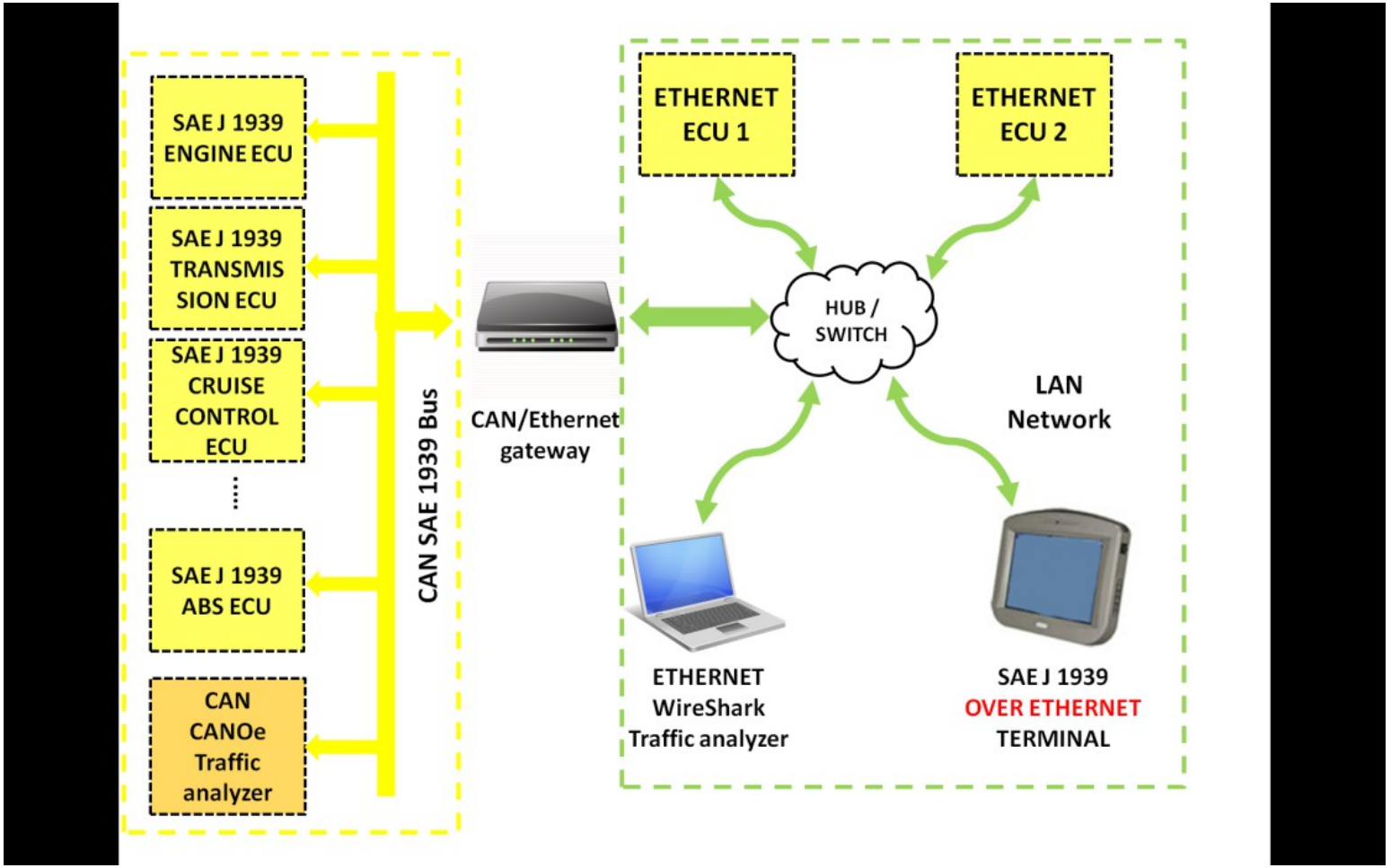
Linux security (SELinux, LXC, cgroups) offer limited help.

Challenges for Linux InterProcess Communication

- New for Linux: systems like cruise control incorporate both *safety-critical* and *driver-facing* components.
- *Event-driven* and *timer-based* traffic coexist on same network.
  - Will asynchronous networking provide QoS?
- "IP is the narrow waist of the Internet" *BUT*
  - TCP/UDP, even IP headers are too large for AUTOSAR.
  - Header compression (6LoWPAN) offers a solution?
- Many SAE, IETF, IEEE standards lack Linux support.

Linux (Ångstrom) CAN-Ethernet Gateway

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



Conclusions

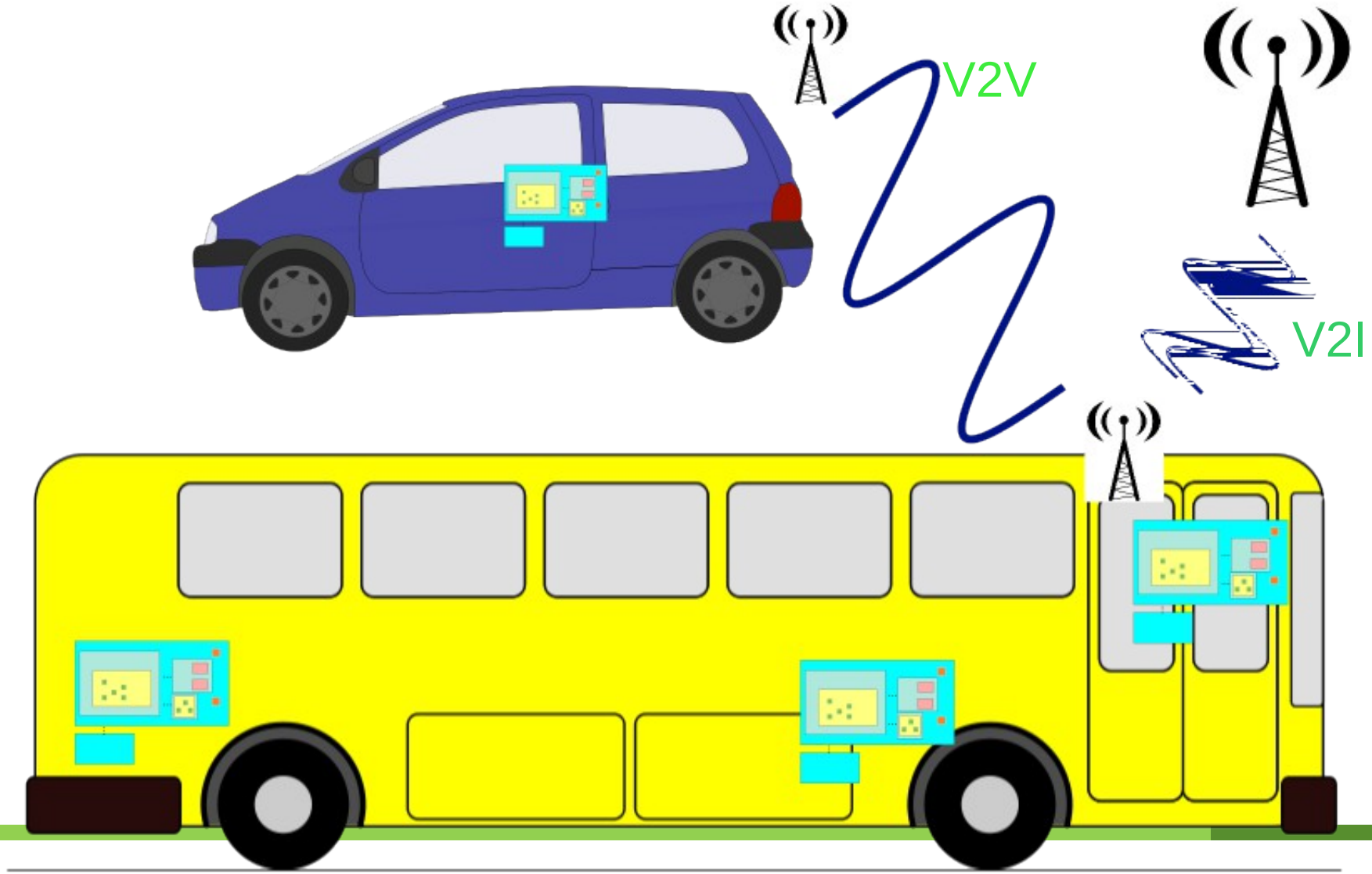
- Linux ships in a small fraction of vehicles.
- Growing rapidly, helped by GENIVI.
- Problem: integration of legacy and modern networks.
- Security, safety and reliability remain a challenge.
- Headed incrementally towards autonomous vehicles:
  - much work left to do.
  - field is expanding rapidly.

Resources

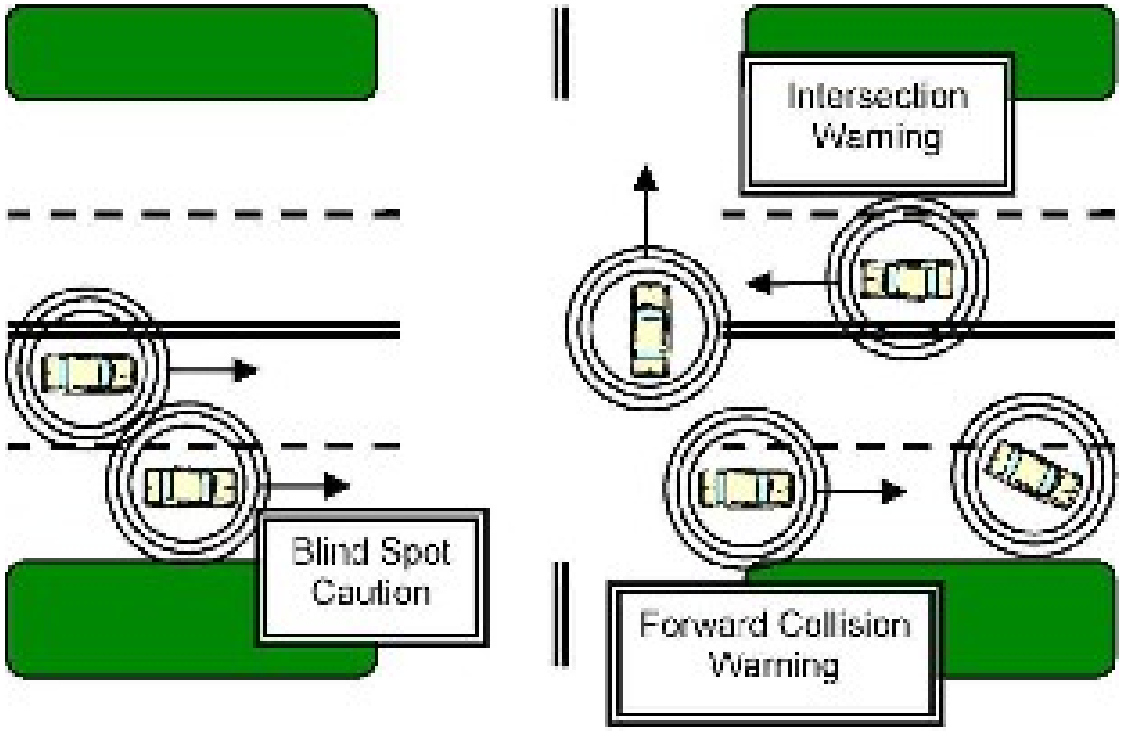
- GENIVI open-source projects, mailing lists, #genivi IRC
- *Making Embedded Systems* by Elecia White
- IETF-ITS mailing list, Telematics News, Wired Autopia
- autosec.org and Ruggeri SAE paper
- LWN and H-Online (as always!)
- Mentor's AUTOSAR and Embedded Linux platforms

Automotive extravehicular networking: Ravi Puvvala, Savari Networks

Vehicles are a “network of networks”



IEEE: DSRC and Basic Safety Message

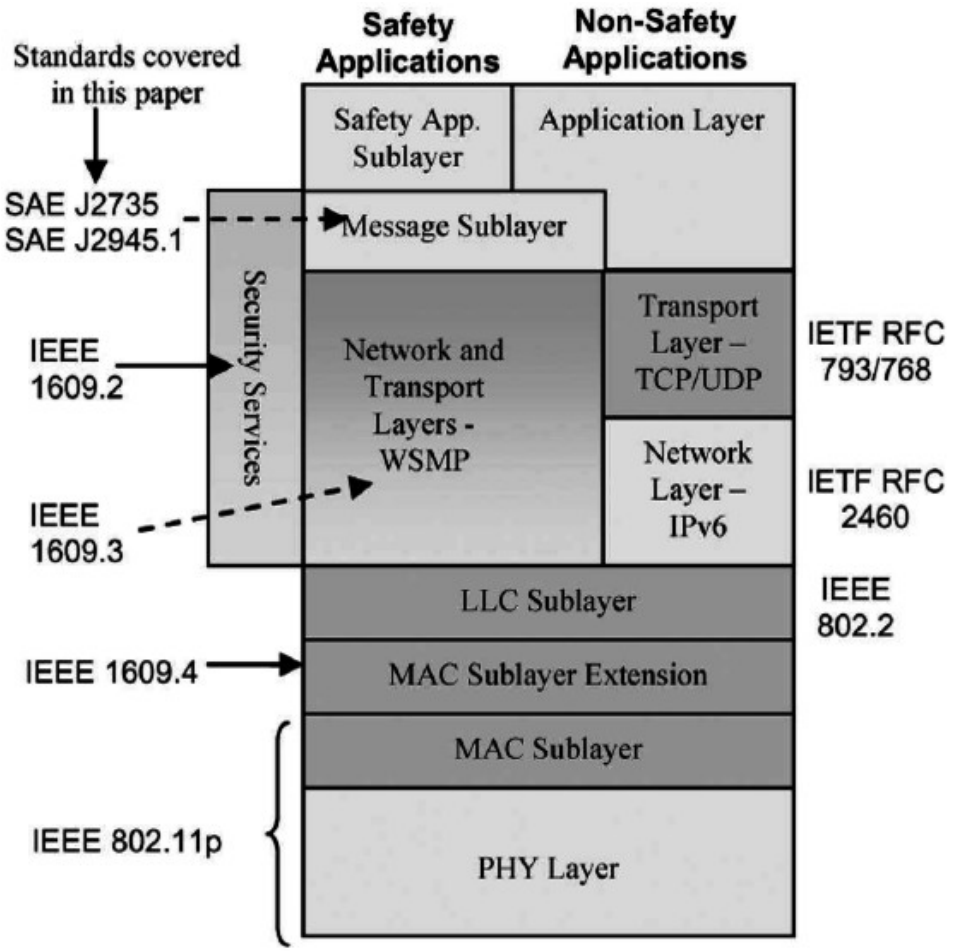


J.B. Kenney, Toyota ITC, Proc. IEEE 99, 2011.

- 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."



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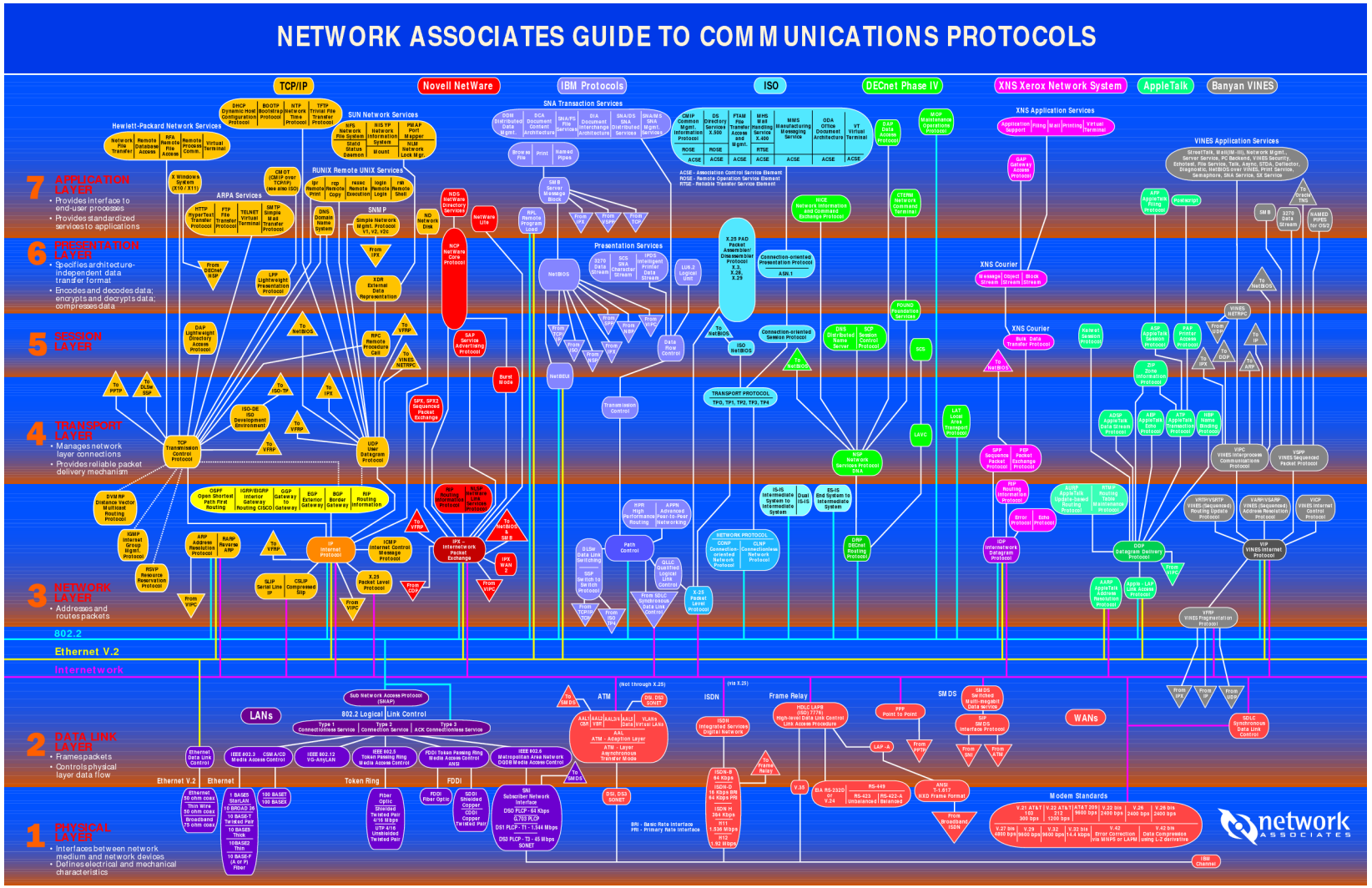
802.11p V2X routers

Linux-based

BSD-based?

Commsignia

Anyone reminded of this Babel?



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

Linux won:

- on servers and on handsets.

Linux lost:

- on desktops.

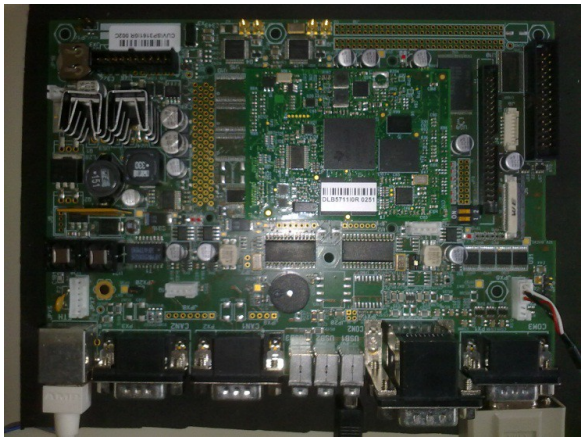
*Linux **could lose** in automotive:*

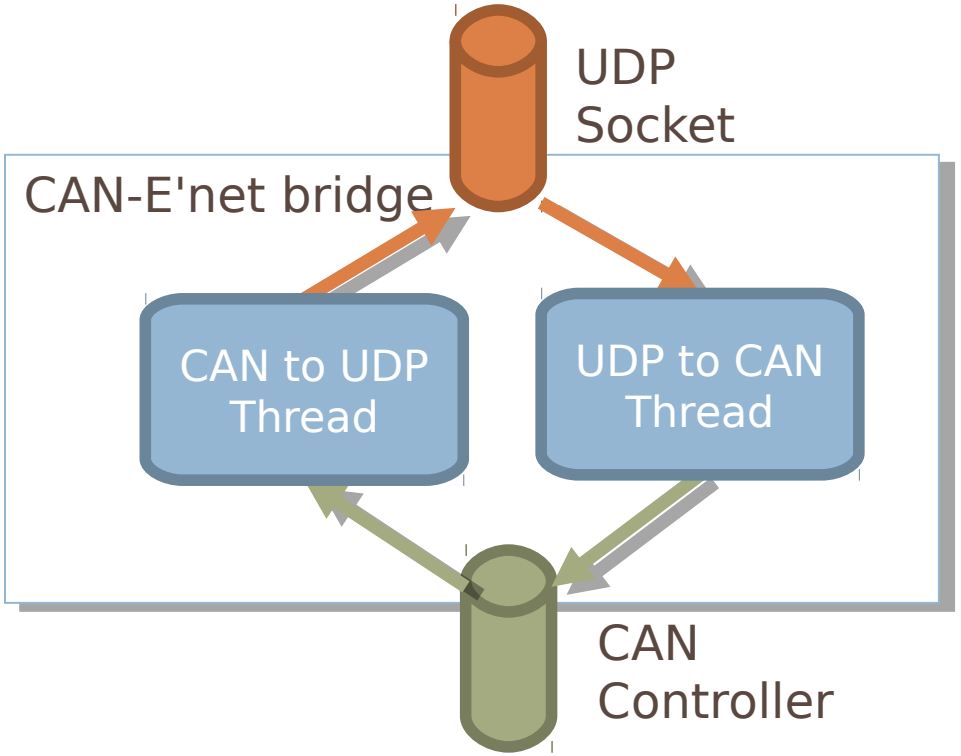
- QNX and Windows have the largest automotive base.
- QNX has fast IPC and works well on smaller MCUs.
- Most car CPUs run proprietary RTOSes.

CAN-Ethernet Gateway Demo

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

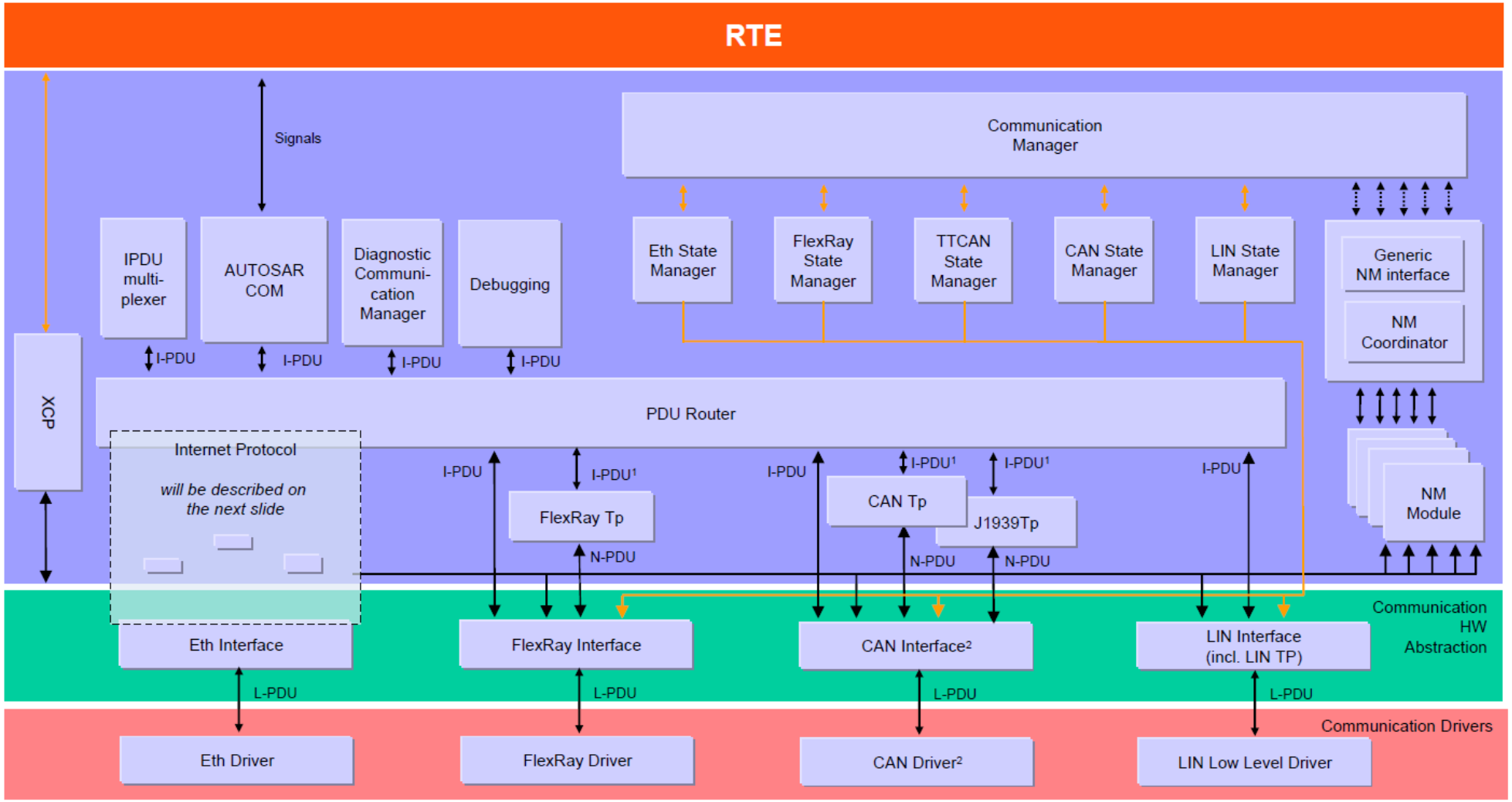
- ARM Cortex A8
- Linux Ångström v 2.6.28
- Stack "SocketCAN"
- Can and Ethernet on chip





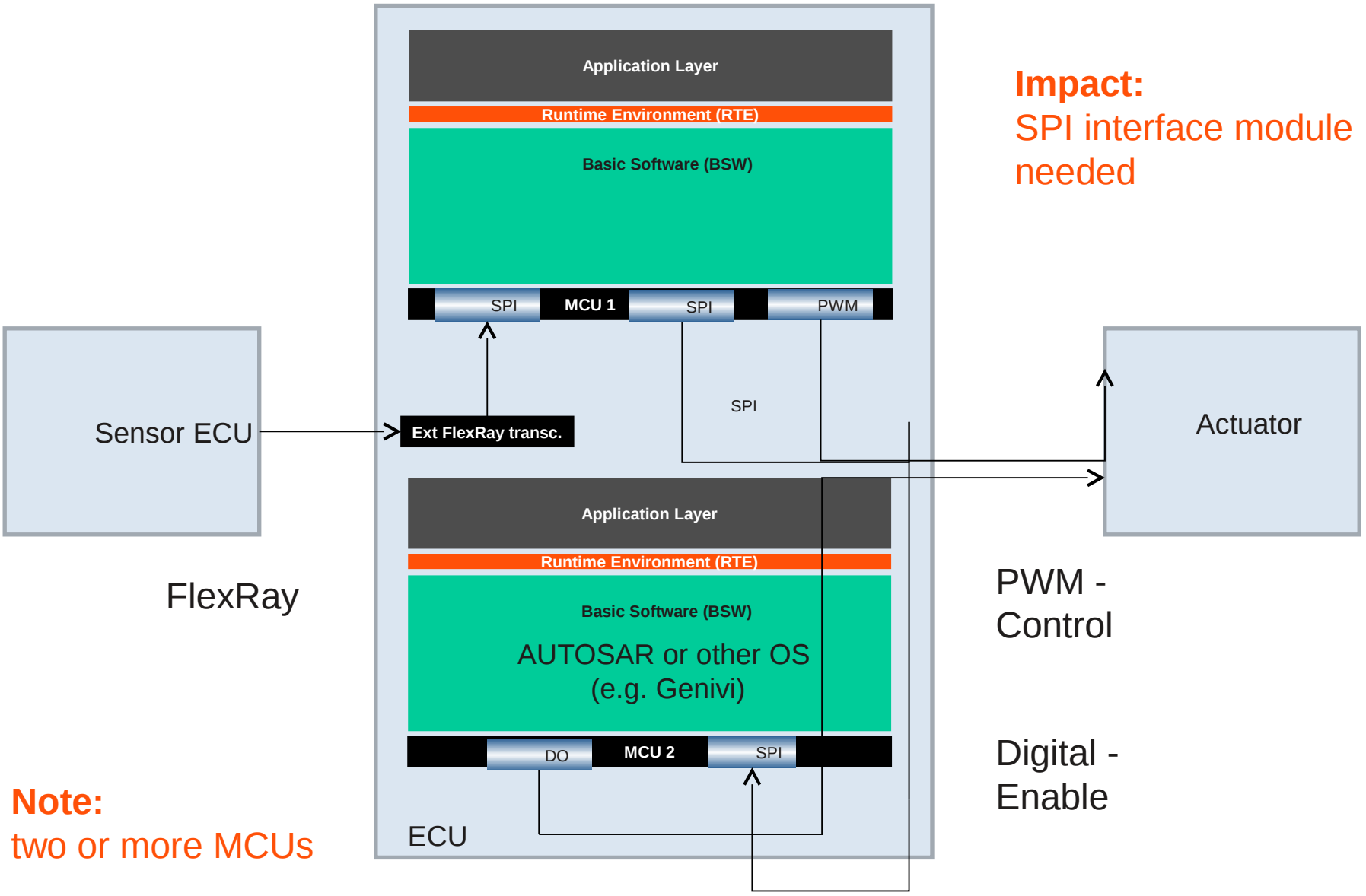
Two independent threads.
Uses socket paradigm as an abstraction to transparently copy messages on different physical layers

Another view of automotive networks



courtesy AUTOSAR

SPI used as communication stack



Impact:
SPI interface module needed

Note:
two or more MCUs

Courtesy of AUTOSAR Consortium

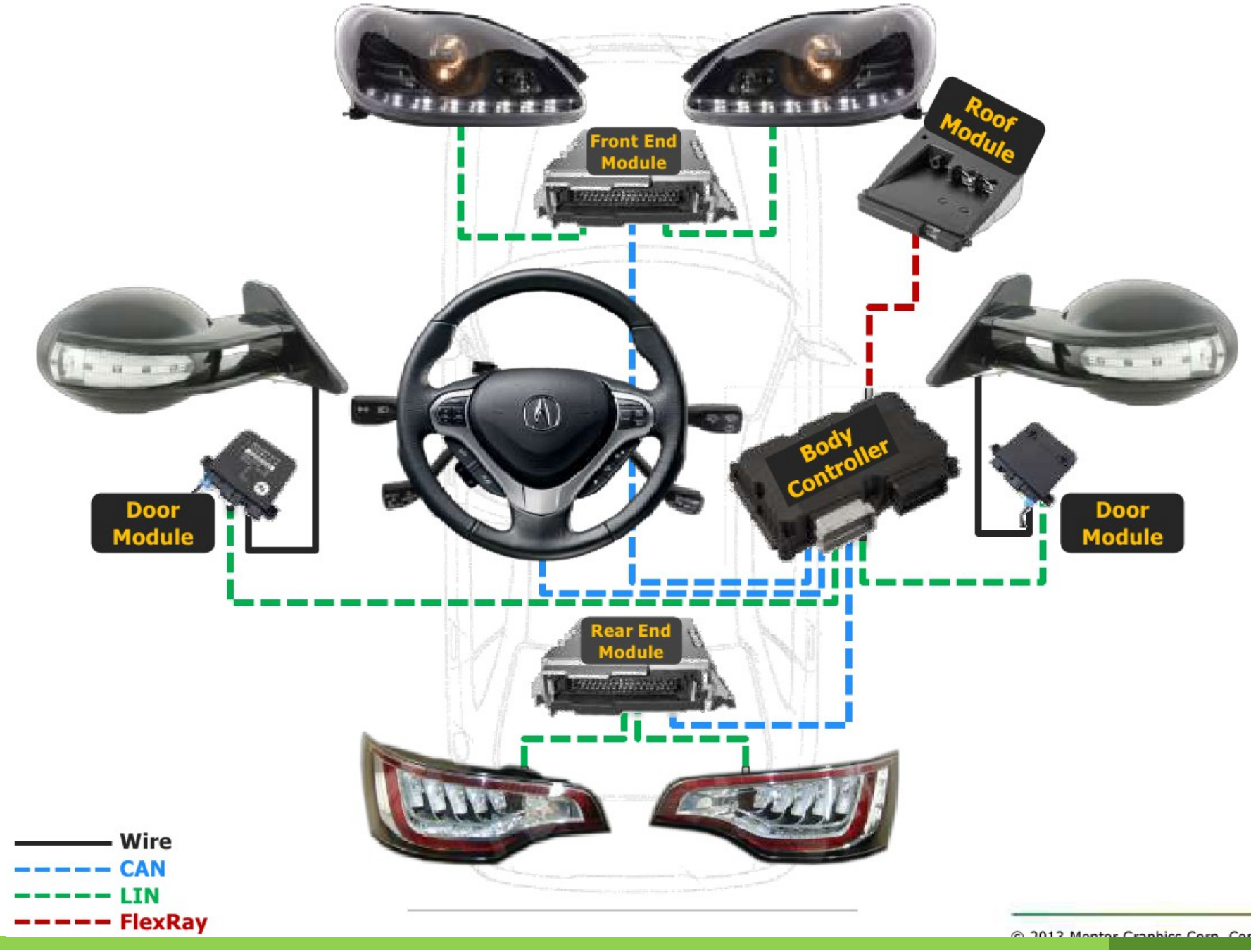
High-Bandwidth feasible buses overview

	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

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.



Automotive Architecture (H.-J. Mantsch, Mentor Automotive Networking)

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?