

# Electrical architecture, the new challenge of automotive lighting



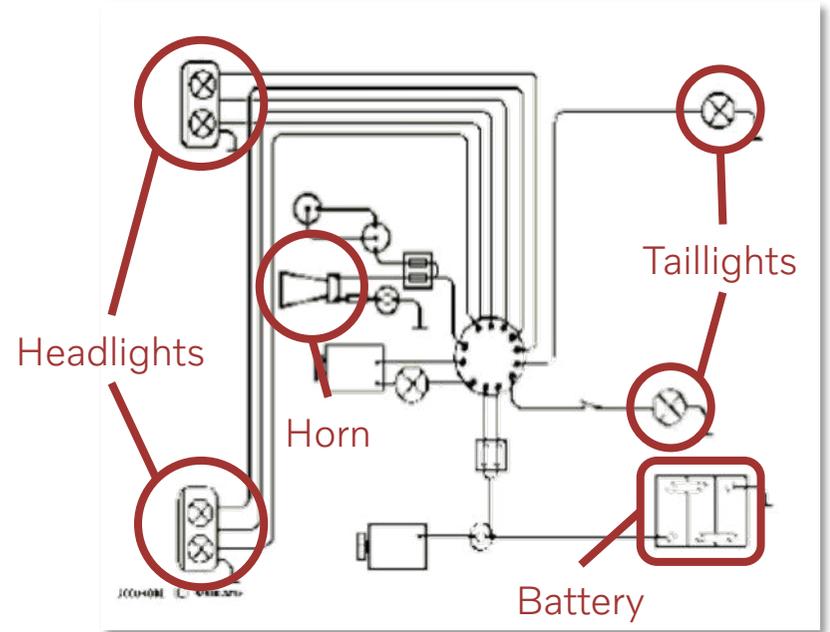
Paul-Henri MATHA  
DVN COO, General Editor Lighting  
2023-08-29

# Where do we come from ?



Example Volvo ÖV4 (Jakob)

Source : DVN Tokyo June 2022, Volvo cars presentation

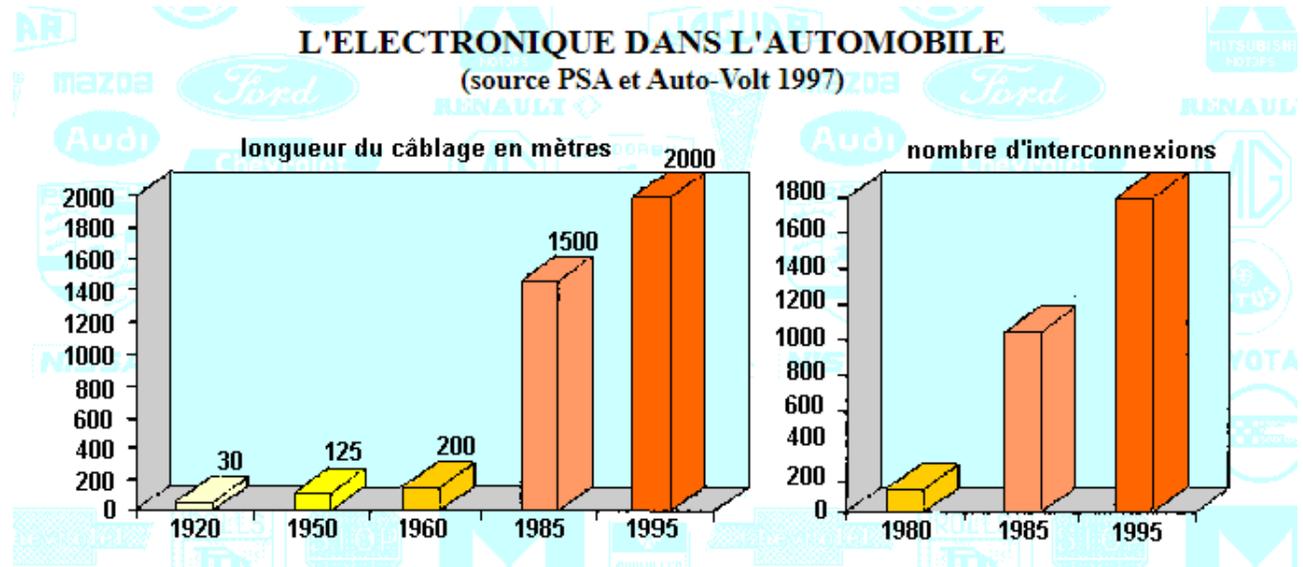


# What did we faced ?

In 1980, already increasing of cable hardness lenght and connexion

- ABS
- Air conditionning system
- Radio
- Side mirror

Addition of complexity

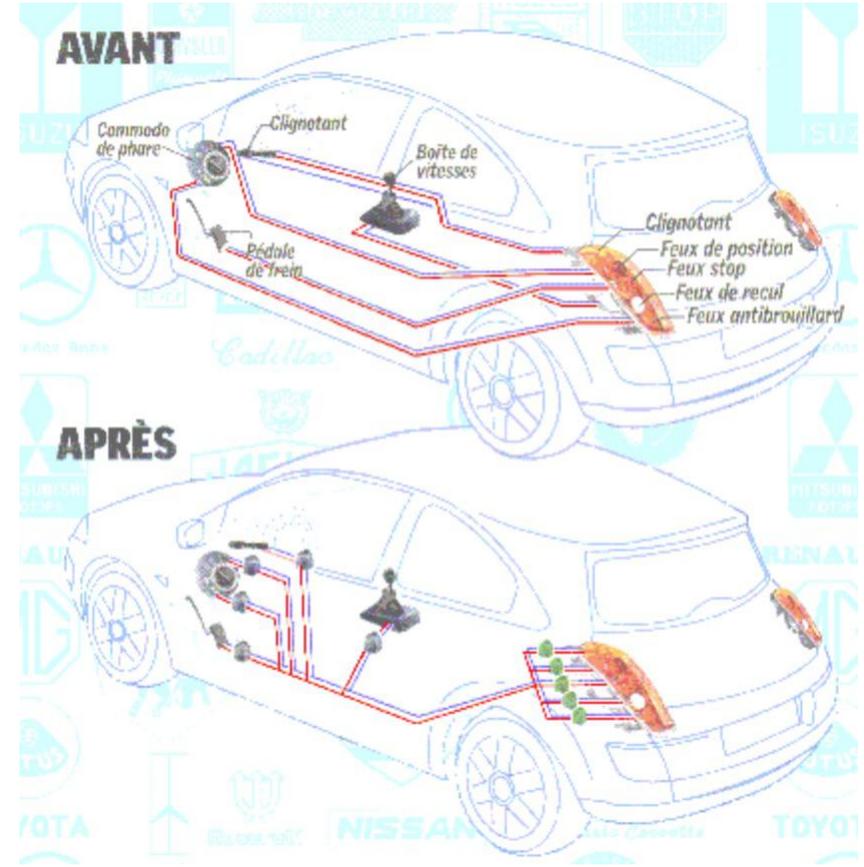
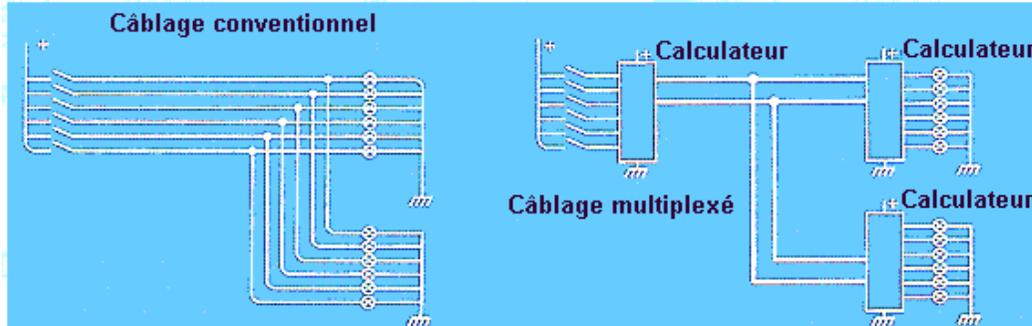


Example PSA

Source : [Philippe B. de l'Arc - Automobile \(free.fr\)](http://Philippe B. de l'Arc - Automobile (free.fr))

# What did we do ?

## 1) Multiplexing



Example Renault Megane, 2000

Source : [Philippe B. de l'Arc - Automobile \(free.fr\)](http://Philippe B. de l'Arc - Automobile (free.fr))

## What did we do ?

2) Definition of a protocol for multiplexing

First vehicle with CAN from Bosch : BMW 850 in 1986,  
in competition with other protocol ( *VAN (Vehicle Area Network)*), *SCP*, *ECP*, *ABUS*, *K-BUS*, *P-BUS*, *I-BUS*...)

Can is now used by all OEM Nowadays



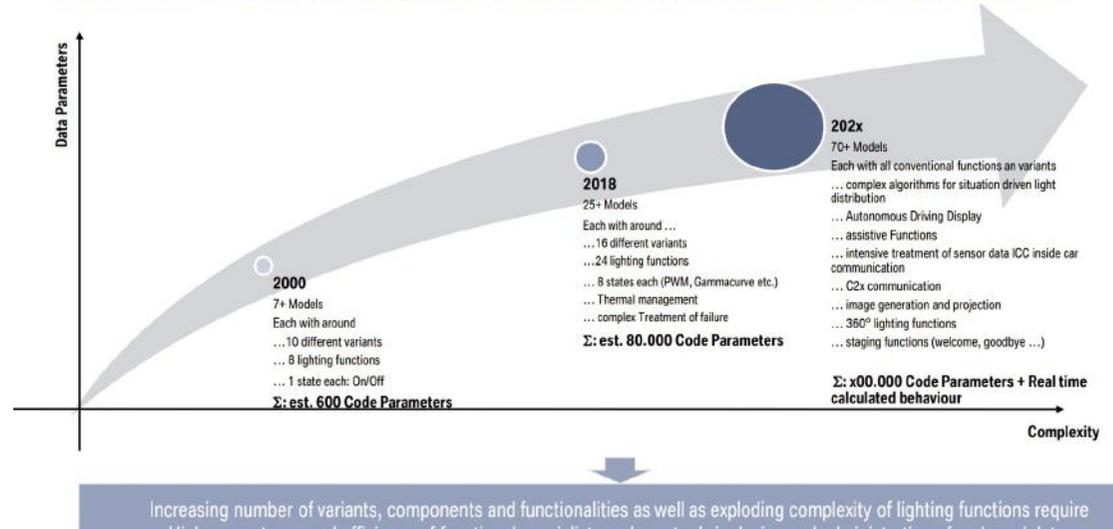
[Source : CAN in Automation \(CiA\): History of the CAN technology \(can-cia.org\)](http://can-cia.org)

# Status in 201x

Complexity has continued to grow

- New functions (Navigation, ADAS, Camera)
- New lighting feature :
  - ADB
  - Welcome
  - Automatic high beam low beam
  - Automatic light activation
  - Daytime running lamp
  - Adaptive rearlamp
  - Etc ...

## KOMPLEXITY AND AMOUNT OF CODE AND DATA SEEMS WITHOUT LIMIT.



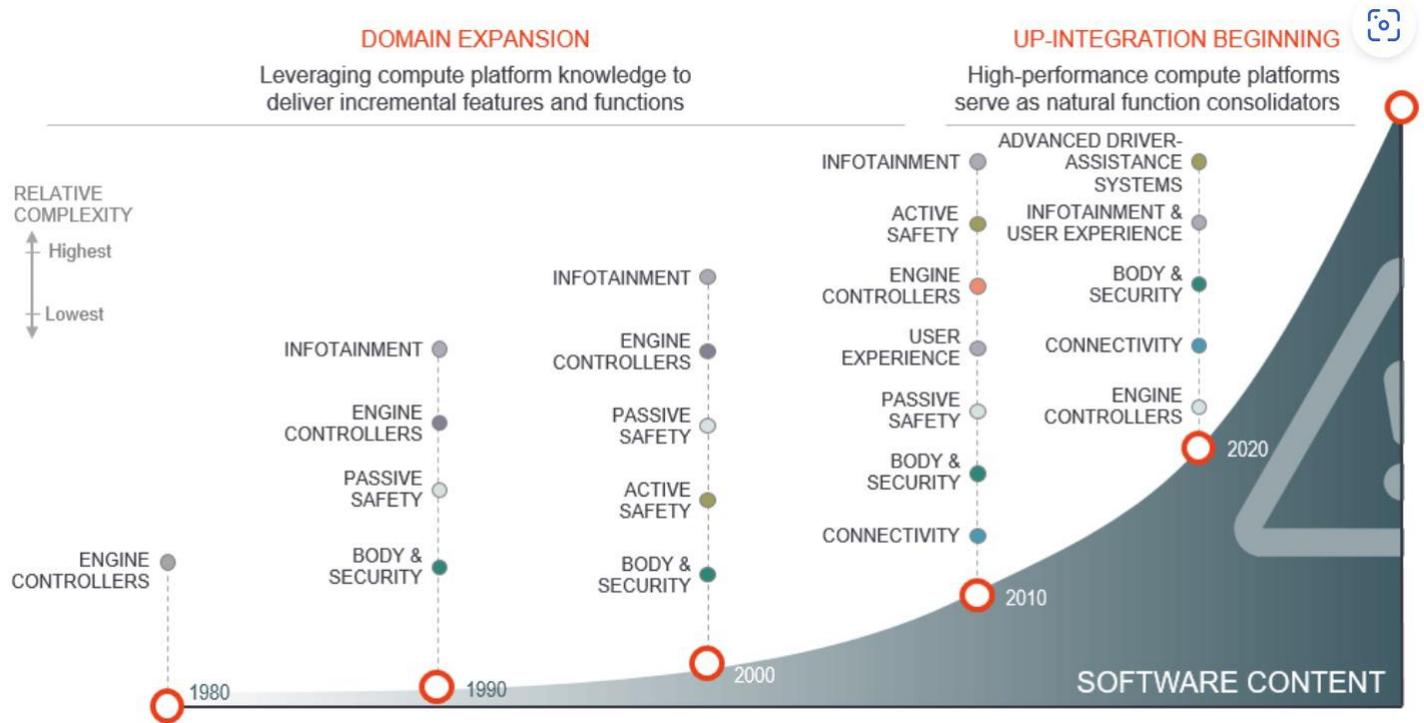
Example BMW, 2018  
Source : DVN 2018, Munich

DVN Workshop Munich 2018  
Christian Amann, BMW Group Head of Lighting Systems



# Status in 2023

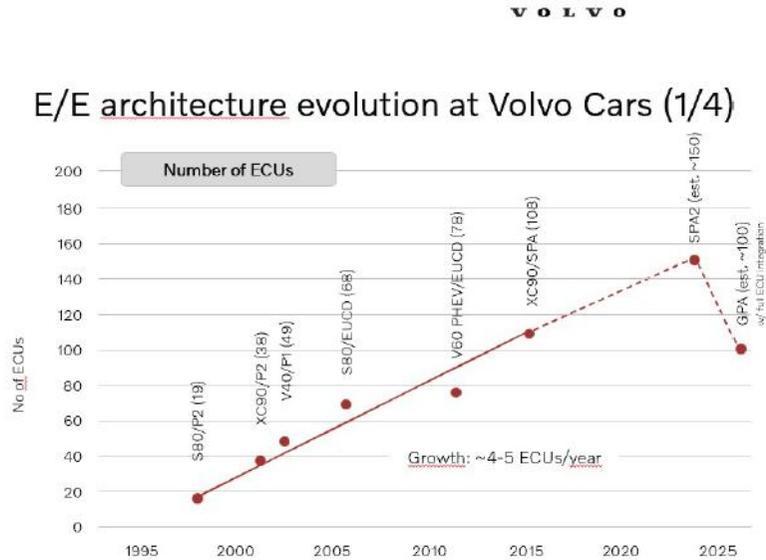
Continue to grow



Source APTIV : [What Is a Software-Defined Vehicle? \(aptiv.com\)](https://www.aptiv.com/what-is-a-software-defined-vehicle/)

# Status in 2023

Continue to grow

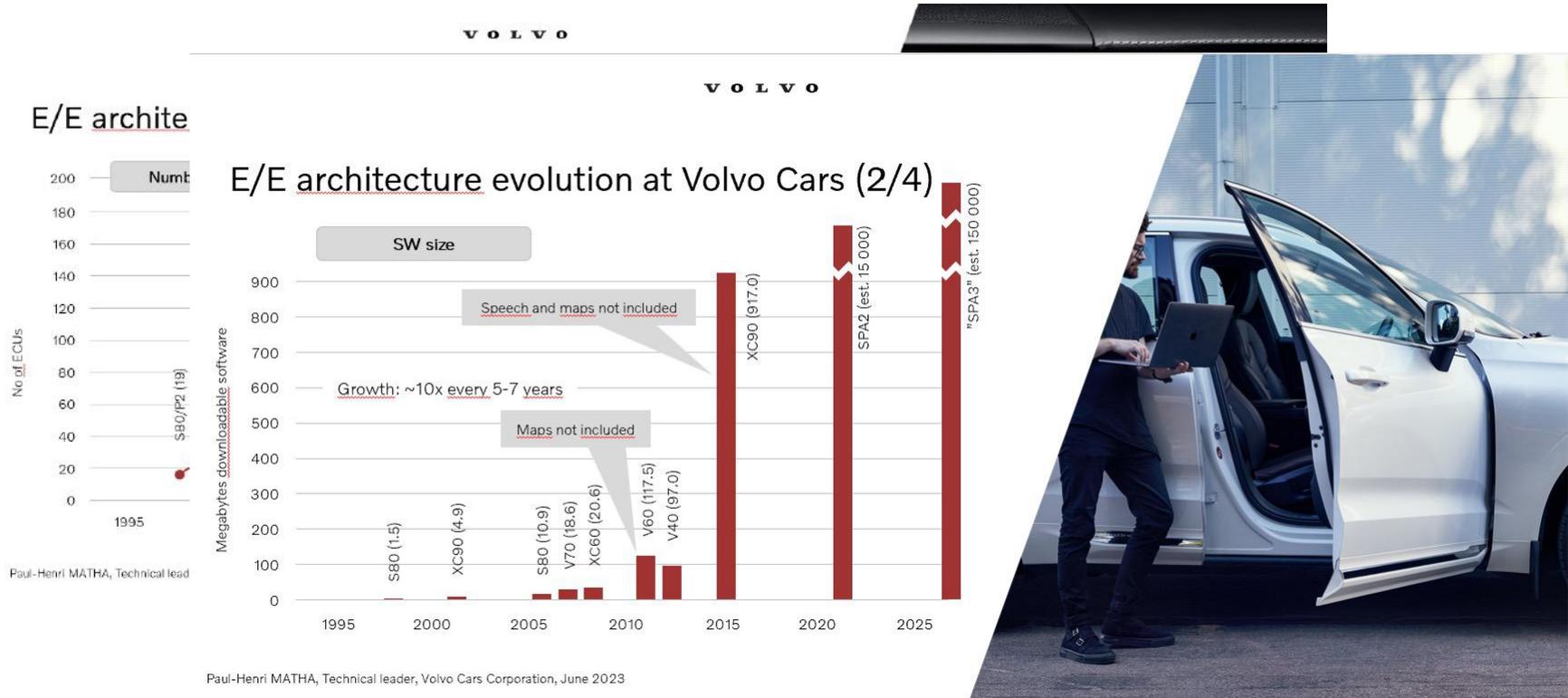


Paul-Henri MATHA, Technical leader, Volvo Cars Corporation, June 2023



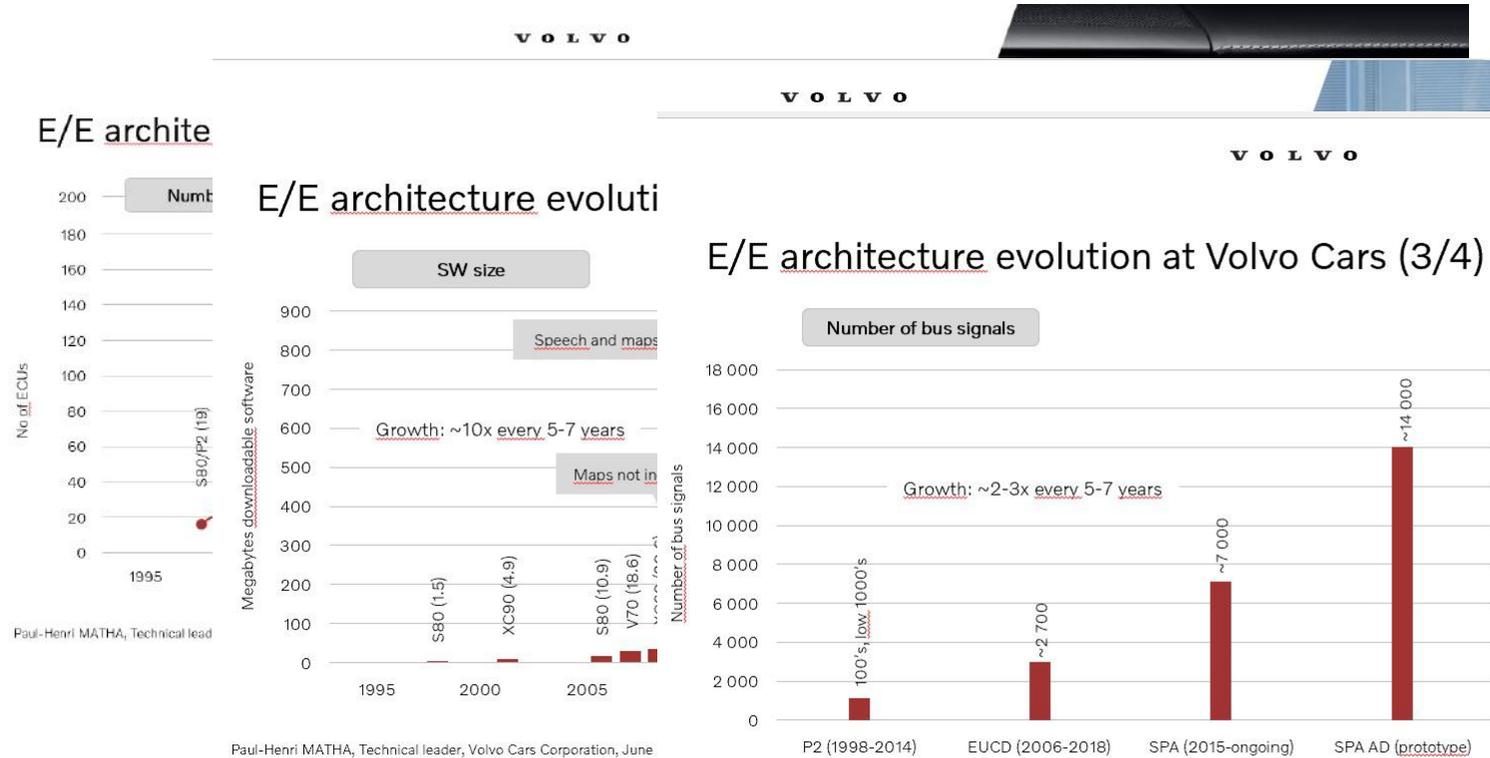
Source : DVN Tokyo June 2022, Volvo cars presentation

# Status in 2023



Source : DVN Tokyo June 2022, Volvo cars presentation

# Status in 2023

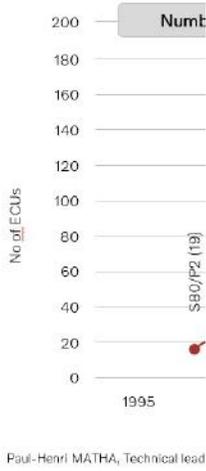


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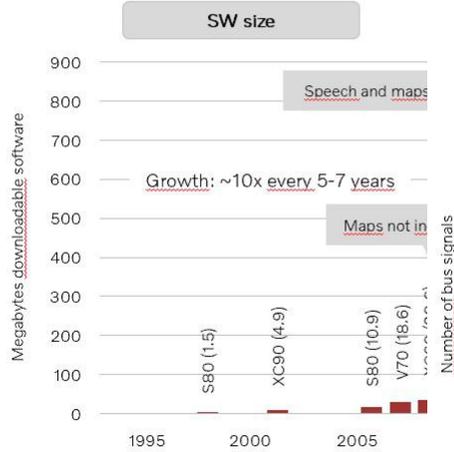
# Status in 2023

## E/E archite



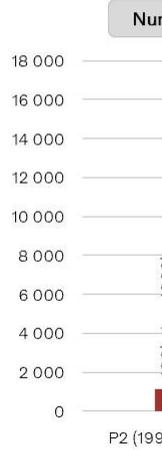
Paul-Henri MATHA, Technical lead

## E/E architecture evoluti



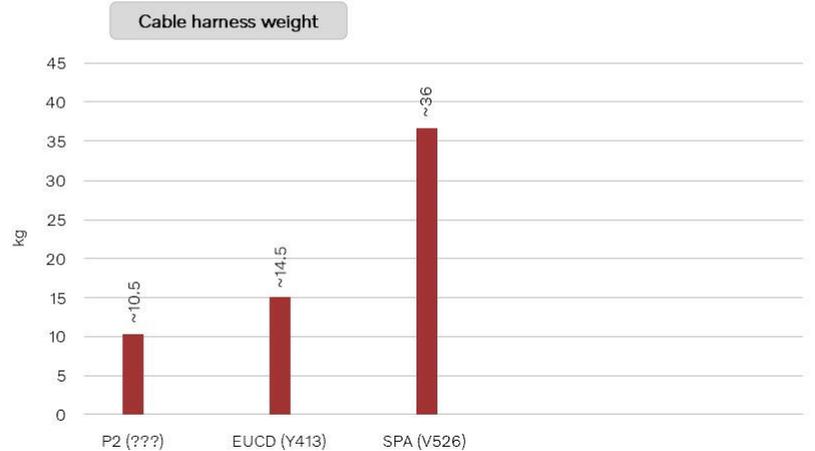
Paul-Henri MATHA, Technical leader, Volvo Cars Corporation, June

## E/E arch



Paul-Henri MATHA, Technic

## E/E architecture evolution at Volvo Cars (4/4)



Paul-Henri MATHA, Technical leader, Volvo Cars Corporation, June 2023

## OEM answer to this major issue

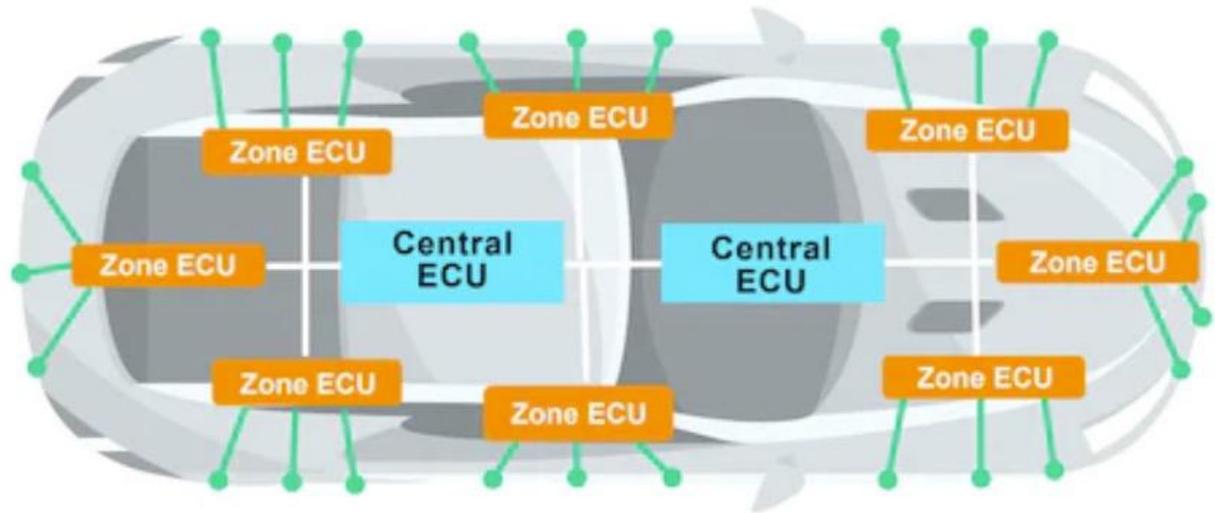
1) HW : Zonal architecture

Fast communication between each ECU with high bandwidth

Less hardness

Centralized SW

2) SW : Software defined vehicle



Example Siemens

Source : [Enable software-defined vehicles with Capital E/E Systems Development \(siemens.com\)](https://www.siemens.com/press/en/2019/04/enable-software-defined-vehicles-with-capital-e-e-systems-development)

## Example 1 : Volvo cars corporation, SPA2 architecture

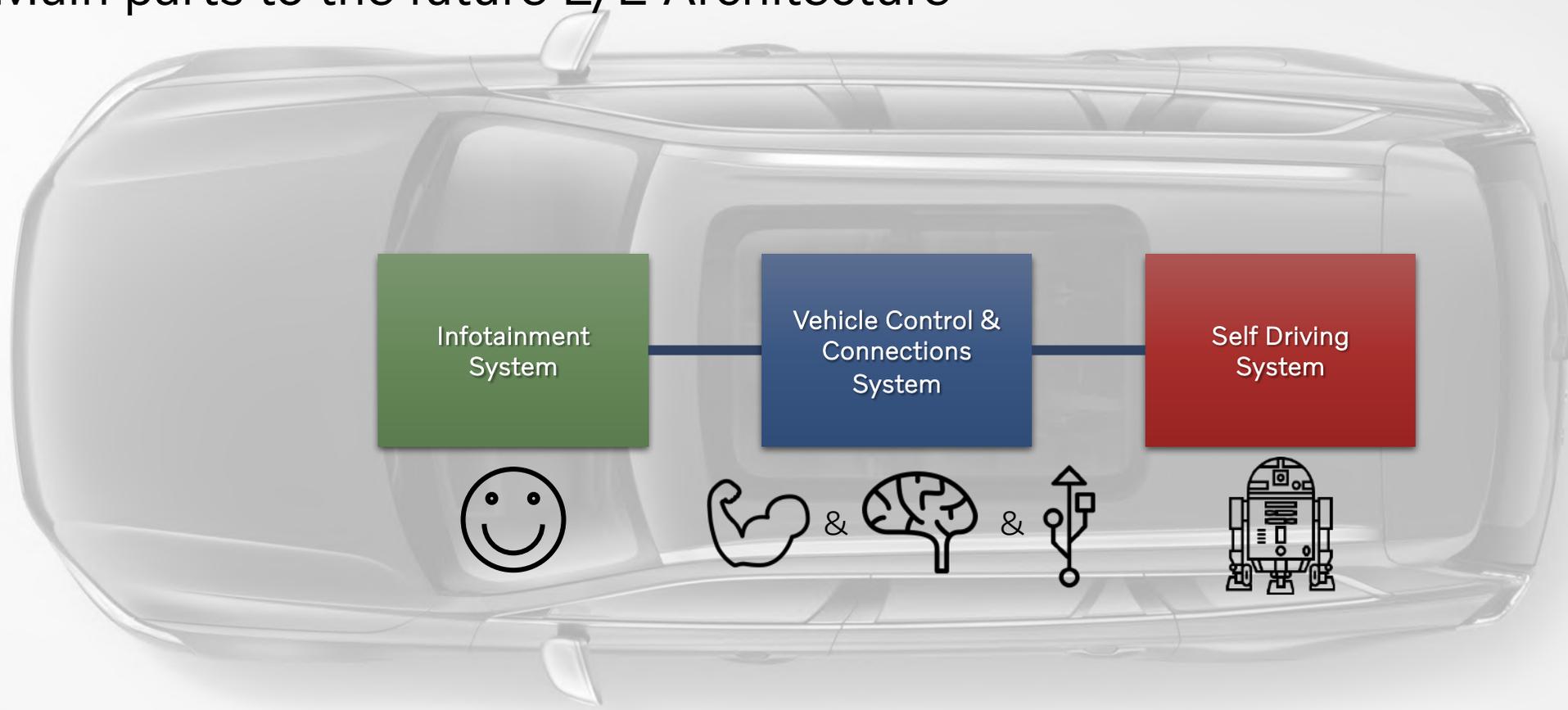
Polestar 3

Volvo EX90



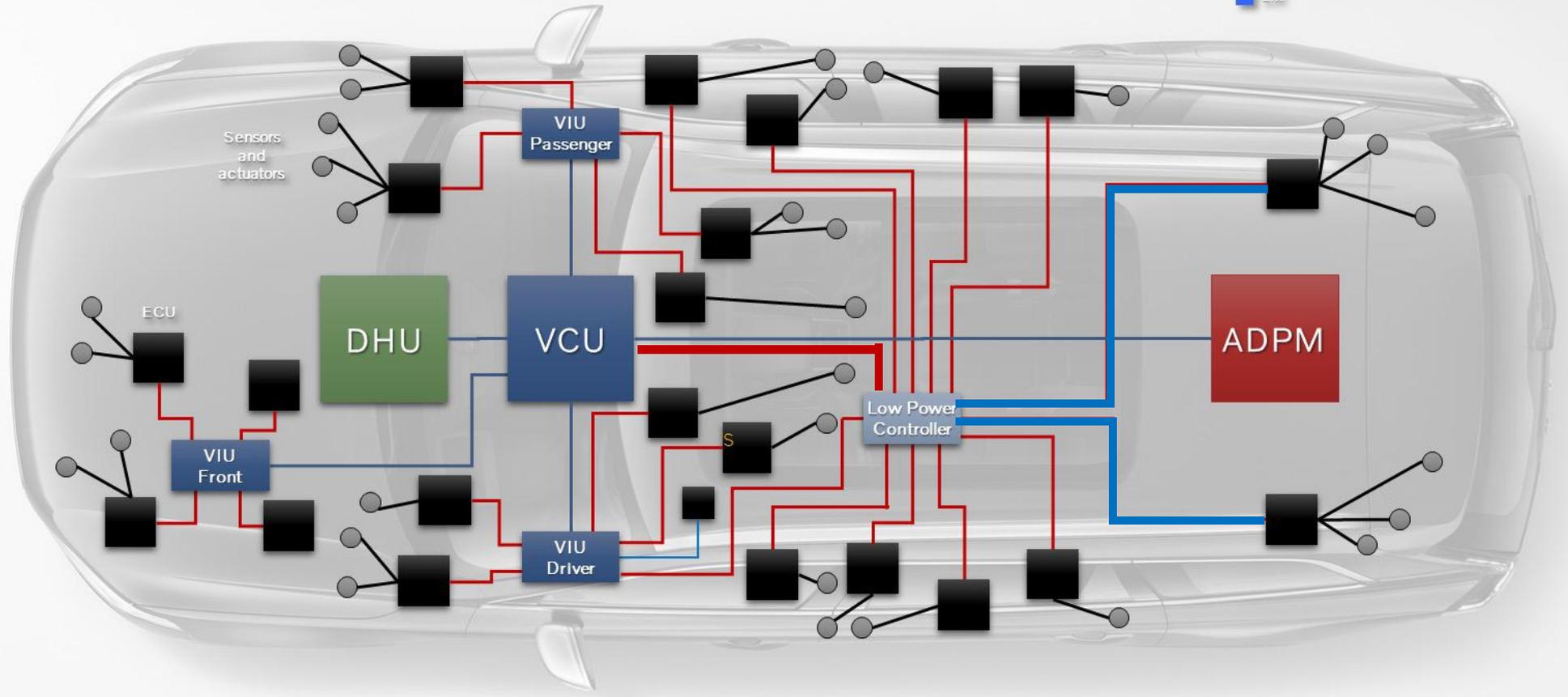
Source : DVN Tokyo June 2022, Volvo cars presentation

# Main parts to the future E/E Architecture



# Step 1: Centralisation

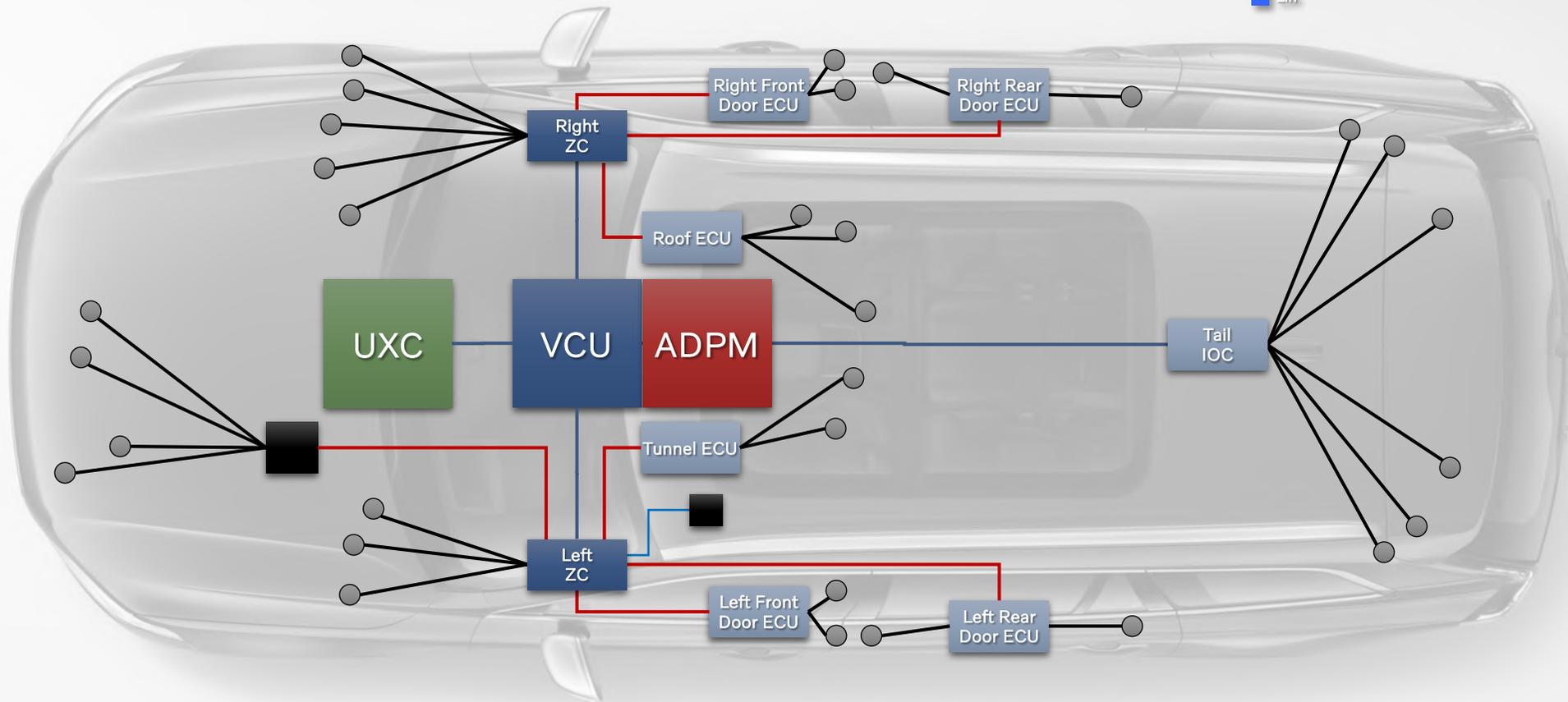
- Ethernet
- CAN/CAN FD
- Lin



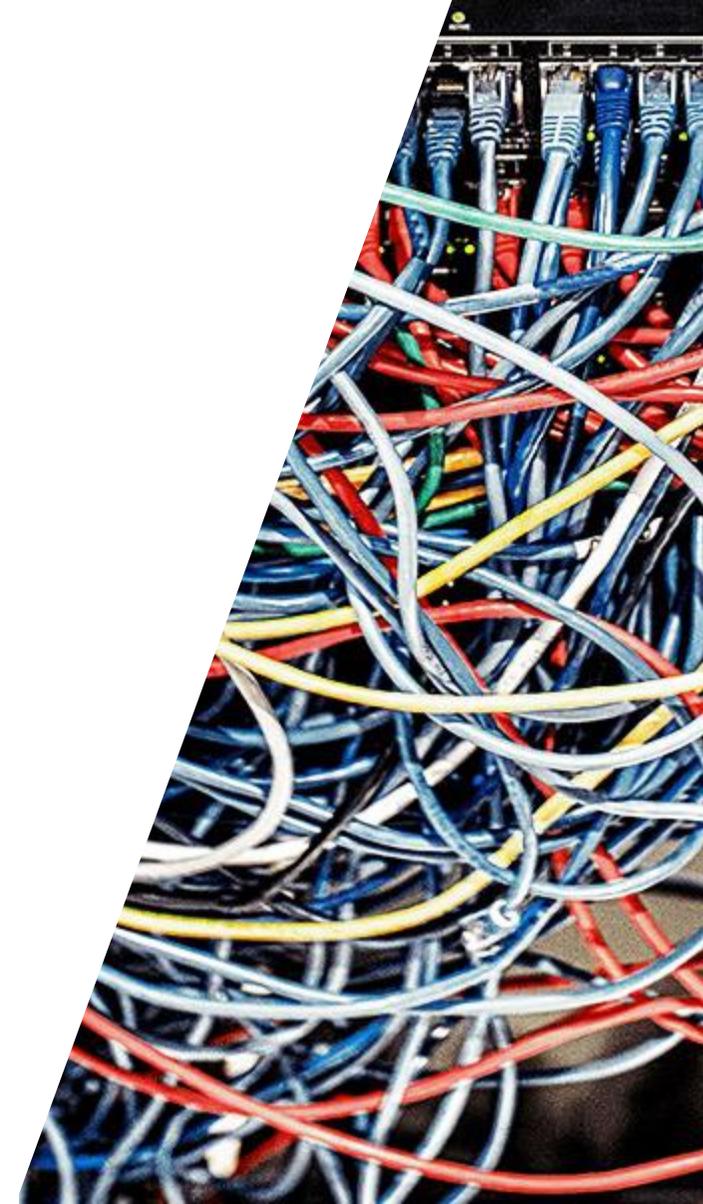
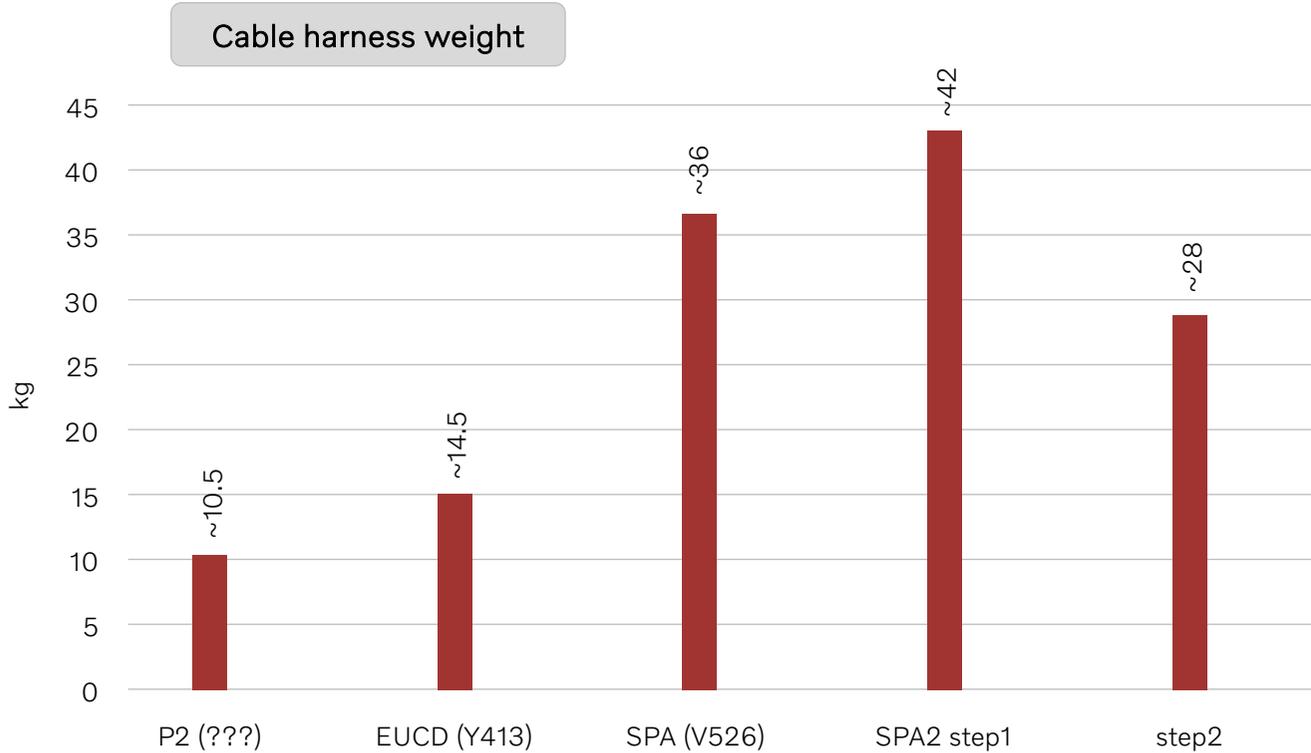
# Step 2: Integration

Integrating VIUs, power distribution and mechatronic ECUs into zone controllers

- Ethernet
- CAN/CAN FD
- Lin



## E/E architecture evolution at Volvo Cars (4/4)



## Volvo cars solution, Rearlamp

LIN  
microcontroller

SW in lamp, developed by Tier1



## Example 2 : Rivian

Rivian

Lamp : Varroc

LIN, Elmos LED IC 522.49



MCU

SW in lamp, developed by Tier1



## Example 2 : Rivian

Rivian

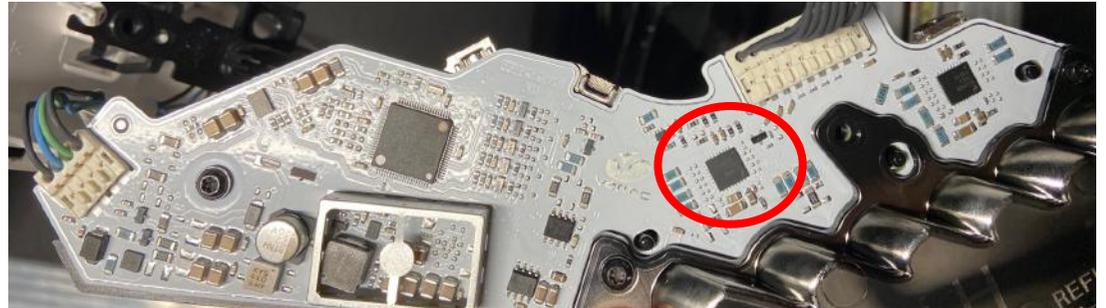
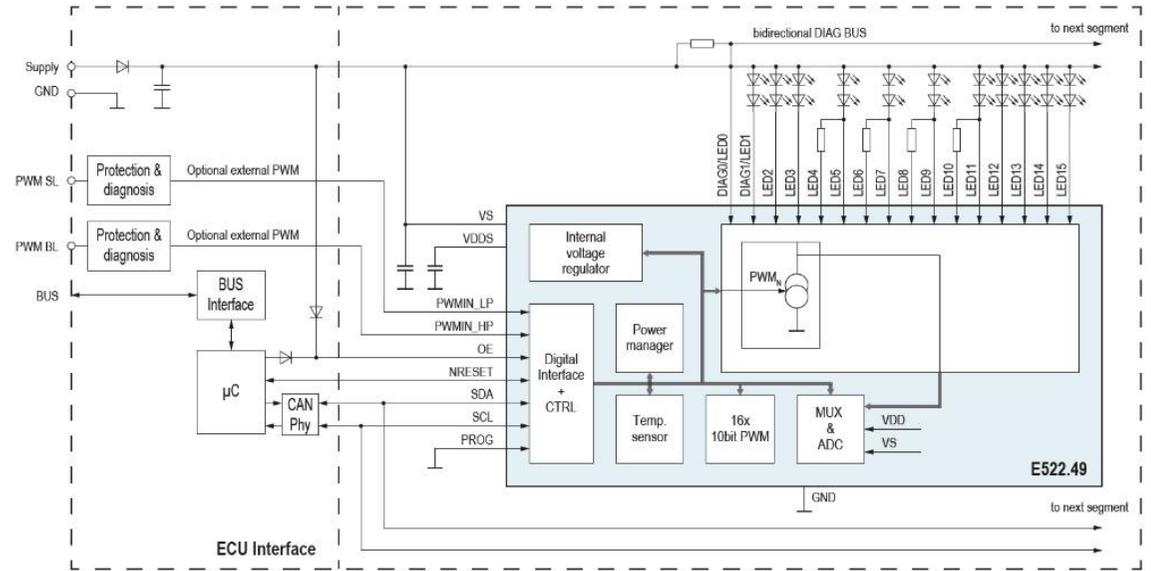
Varroc

LIN, Elmos LED IC 522.49



MCU

SW in lamp, developed by Tier1



## Example 3 : Lucid

Lucid

Lamp : Hella, Rebo

Uart over CAN, Melexis LED IC 81116

MCU

Bandwidth : 2 Mb per second

SW in vehicle, developed by OEM

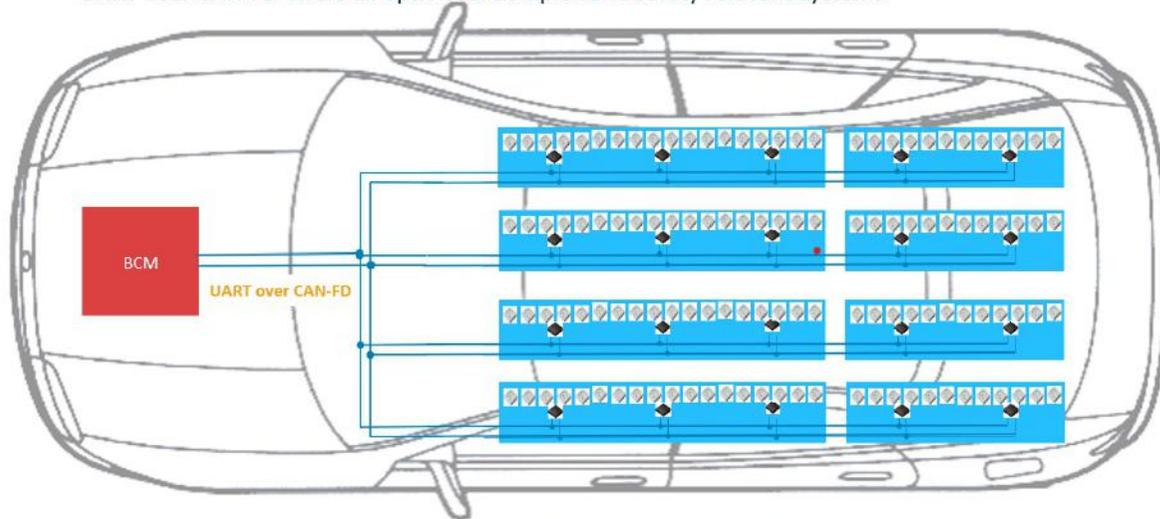
**MeLiBu**<sup>®</sup>  
by Melexis



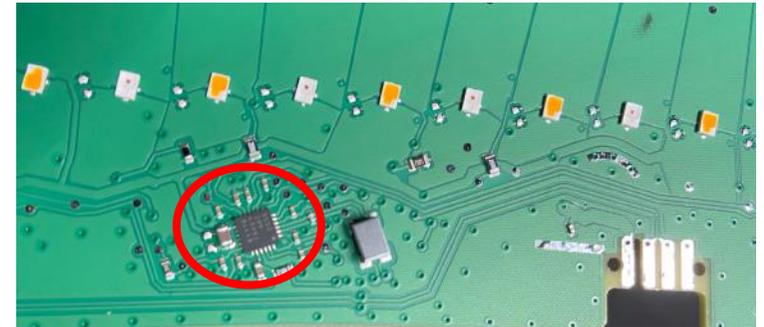
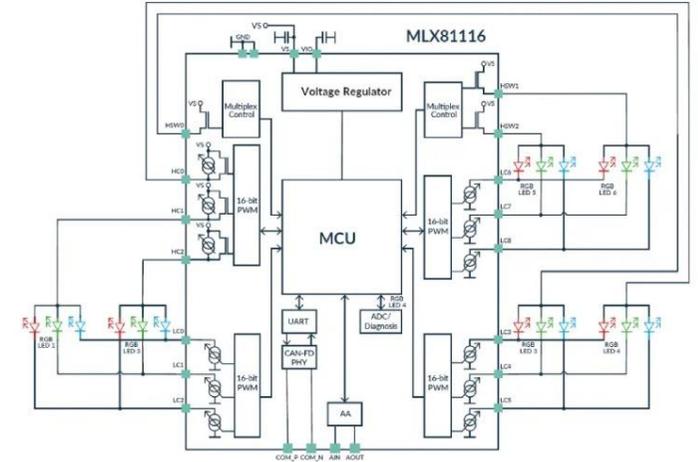
# Example 3 : Lucid

## UART over CAN-FD Advanced Architecture

UART over CAN-FD offers all option for complex and safety relevant systems



Animated Light based on MeLiBu Multichannel RGB LED Driver (e.g. MLX81116/17/43)



## Example 4 : VW

VW ID3

Plastic Omnium

LIN



SW in lamp, developed by Tier1



## Example 5 : Lotus

Lotus Eletre

Odelo

CAN

SW in lamp, developed by Tier1



## Example 6 : audi

Audi a8

Lamp : Valeo

LIN 

ST LED IC / Elmos IC

MCU in lamp

SW in lamp, developed by Tier1



## Example 7 : Hippi and IMM

Hippi & IM Motors

Hasco

Ethernet/CAN



Gateway / bridge developed by Hasco

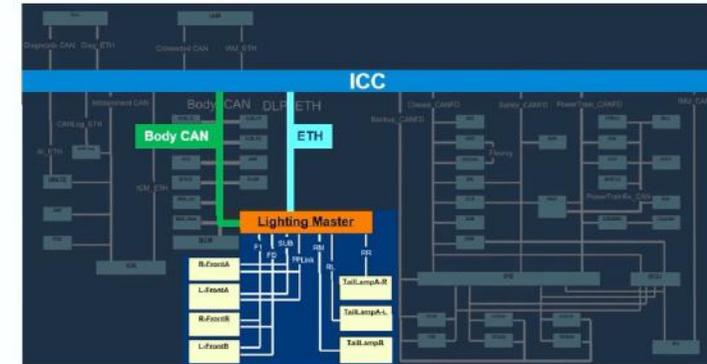
SW developed by Hasco

Source :  
Hasco, DVN Paris January 2023  
IM Motors, EAC June 2022, Suzhou, China

### Vehicle Electrical/Electronic Architecture

#### ➤ Deeply integrated into the vehicle SOA architecture

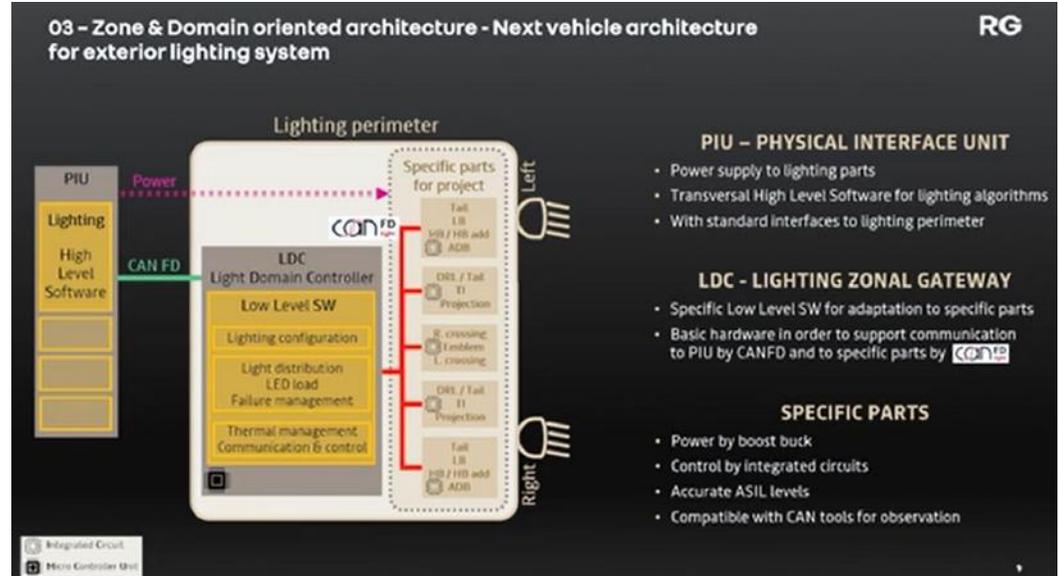
- Lighting Master is a local domain, active/passive mode which could be integrated to the global domain of EE Architecture
- Higher bandwidth with Ethernet
- Compatible with „old“ EE Architecture



## Example 8 : Renault

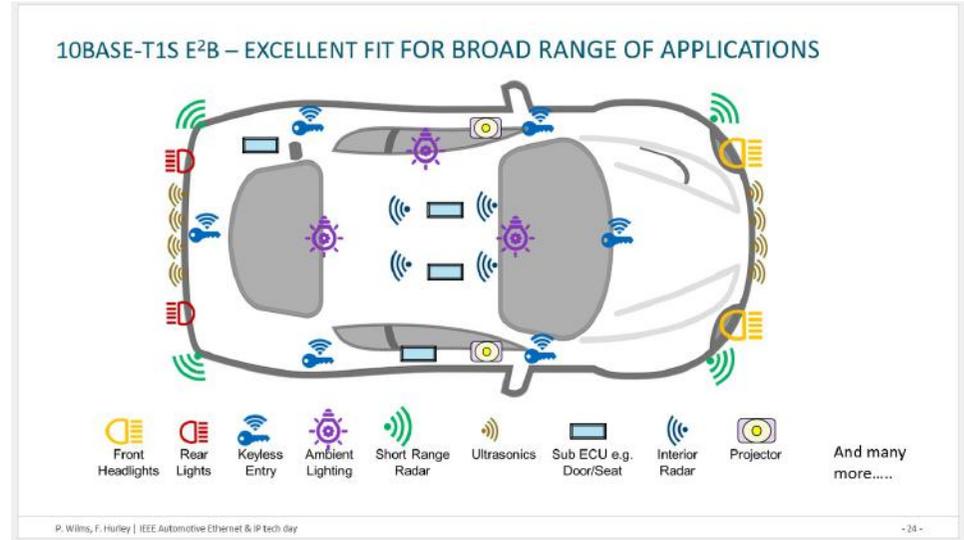
Lighting zonal gateway

CAN FD and CAN FD light



## Example 9 : BMW

Promotion of Ethernet 10B-T1S for lighting



Source : IEEE automotive Ethernet & IP tech day

# Benchmark tier1

Not a lot of communication in congress

**ECU-Free Exterior Lighting:**  
Disruptive trend for vehicle E/E architecture with focus on exterior lighting

R. Leute<sup>1</sup>, M. Schnerr<sup>1</sup>, H. Seibold<sup>1</sup>, D. Petris<sup>2</sup>, F. Iannacone<sup>2</sup>

<sup>1</sup>Marelli Automotive Lighting Reutlingen GmbH, Germany;

<sup>2</sup>Marelli Automotive Lighting Italy S.p.A.

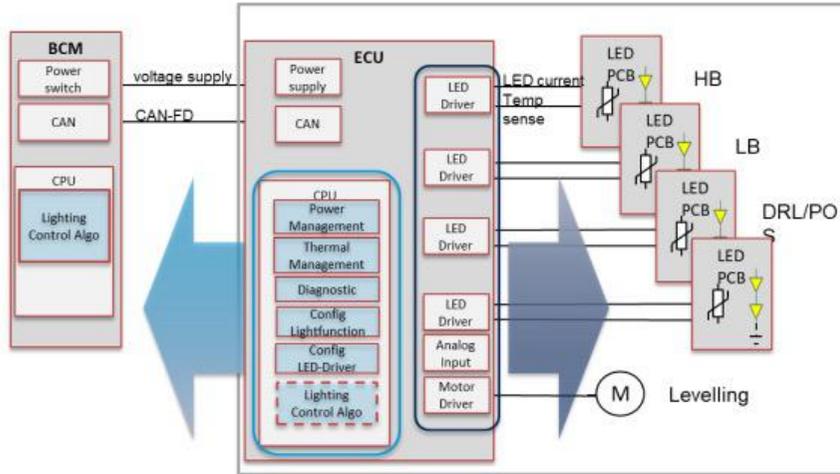


Figure 1: Traditional approach. Both algorithms (software) and electronic drivers are combined in a lamp ECU. We propose to separate these functions, with centralized algorithms outside the lamps and drivers situated on PCB.

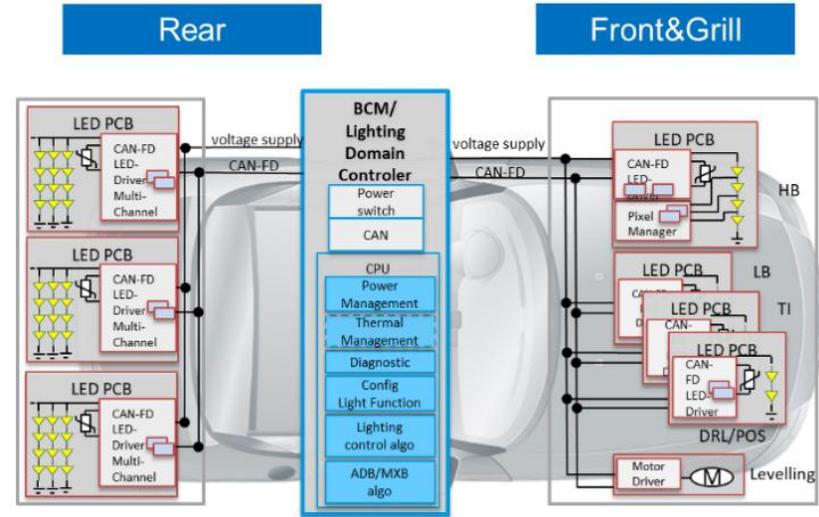


Figure 2: ECU-free system view. High level functions are centralized. Components are supplied by vehicle voltage supply. Control signals are exchanged via CAN FD.

# Benchmark tier 2



Solution with Gateway / bridge

Solution without Gateway / bridge

- UART over CAN, or
- CAN FD

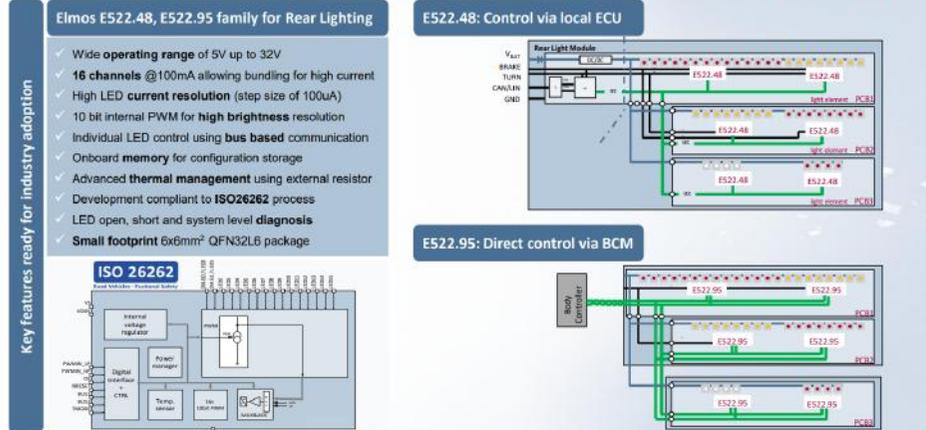
No MCU

2 MB bandwidth

Source : DVN December 2020

[News - Elmos Semiconductor SE](#)

## DISTRIBUTED VS. CENTRALIZED SYSTEMS: E522.48 AND E522.95



### DIRECT BCM CONTROL OF REAR LAMPS

Introducing E522.95 through collaborative innovation



Home // Über Elmos // Newsroom // Pressemitteilungen  
**Elmos and Audi strengthen partnership for LED rear light control**

New IC enables direct LED lamp control using advanced networking interface capability

Elmos Semiconductor AG and Audi AG extend their long lasting partnership for LED rear light control with the new Elmos IC E522.95. This multichannel LED controller for exterior lighting allows direct control of LED lamps. Equipped with a 32-bit CAN FD interface.

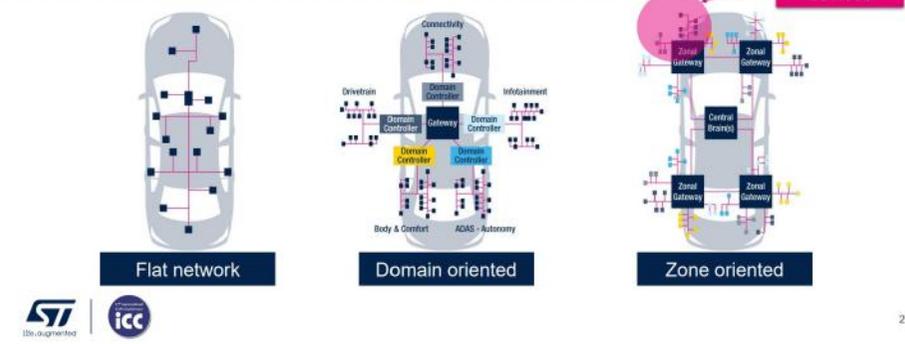
# Benchmark tier 2



- Solution without Gateway / bridge
- No crystal oscillator
- No MCU
- Standard protocol (new)
- 1 MB bandwidth

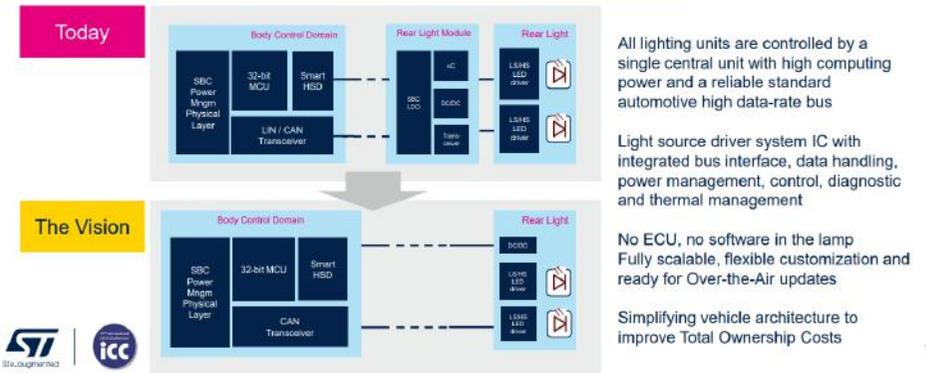
Source : 17th international CAN conference

## Domain and zone architectures



## Next-generation light design

### Domain-oriented lighting architecture

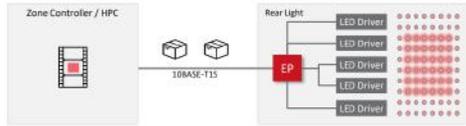


# Benchmark tier 2

Ethernet 10B- T1S



End Point concept between ethernet and LED IC



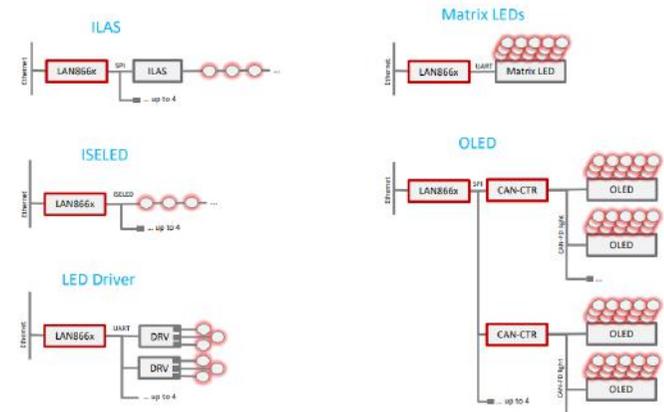
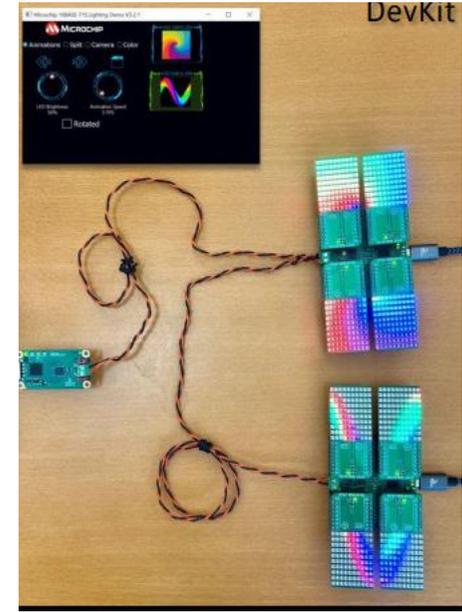
No limitation with number of segments (vs CAN limitation)

No SW diversity for OEM (handled in End Point)

Standard protocol

10 MB bandwidth

Welcome sequences handled directly by video instead of excel file



Source : Automotive Ethernet Congress, Munich 22nd of March 2023

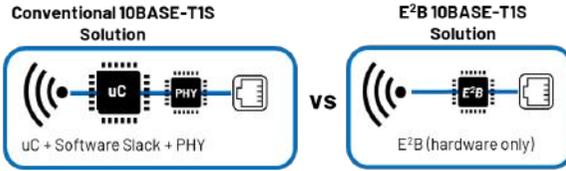
# Benchmark tier 2

Ethernet 10B- T1S



E2B concept

No MCU



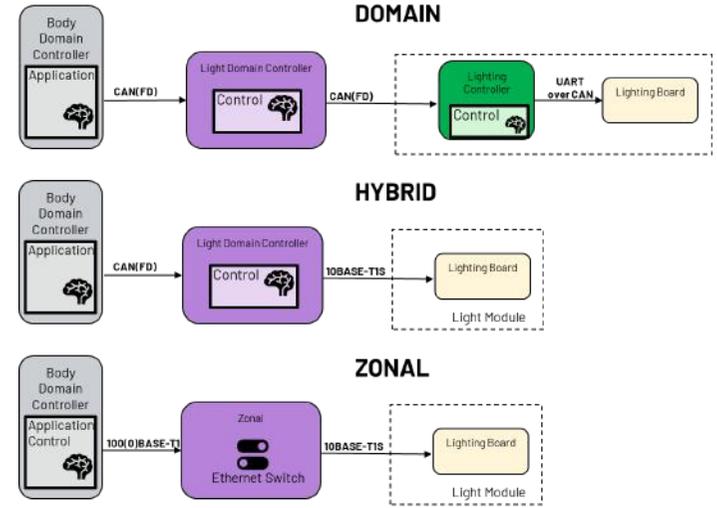
10 MB bandwidth

Remote control used to switch ON/Off leds

HPA/VCU will send LED driver specific command

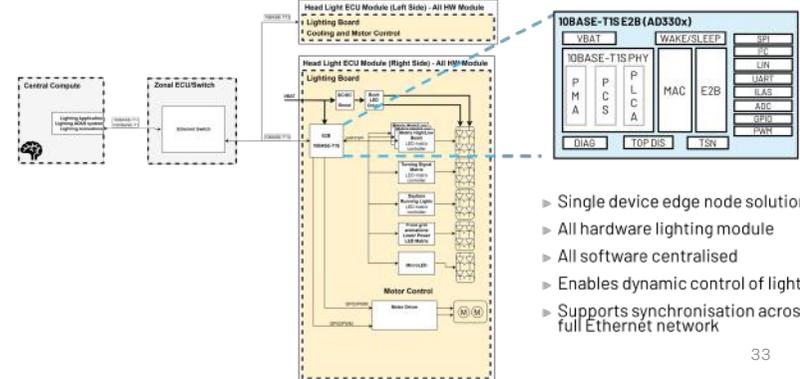
OEM will have to handle SW diversity between LED IC supplier

Source : Analog Devices



Microcontroller/Software

## All Hardware Lighting Module with 10BASE-T1S E2B

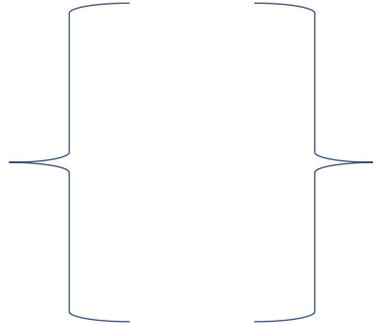


- ▶ Single device edge node solution
- ▶ All hardware lighting module
- ▶ All software centralised
- ▶ Enables dynamic control of lighting
- ▶ Supports synchronisation across the full Ethernet network

# Synthesis

Pros and Cons for each solution :

- CAN
- LIN
- CAN FD
- CAN FD light
- Uart over CAN
- Ethernet



- Cost
- Maximum number of segmentation / Bandwidth
- Software upload possibilities
- LED IC selection and limited LED IC possibilities for some solutions
- Gateway/bridge yes or No
- Gateway/bridge Supplier possible limitation
- MCU in lamp yes or no
- Standard protocol yes or No
- SW diversity for OEM yes or No
- Pre-defined animation Yes or No



## Question of Bandwidth ?

### Technology :

LIN : 19 Kbps

CAN : 500 Kbps

Can FD light : 1 Mbps

Uart over CAN : 2 Mbps

Ethernet : 10 Mbps

## Question of Bandwidth ?

### Technology :

LIN : 19 Kbps

CAN : 500 Kbps

Can FD light : 1 Mbps

Uart over CAN : 2 Mbps

Ethernet : 10 Mbps

### Requirement :

Refresh rate : 5 – 50 ms → 20-200 Hz

Resolution (PWM step) : 6 bits – 10 bits

Number of leds (or segments) : 50 – 20,000

## Question of Bandwidth ?

### Technology :

LIN : 19 Kbps

CAN : 500 Kbps

Can FD light : 1 Mbps    **Requirement :**

Uart over CAN : 2 Mbps    Refresh rate : 5 – 50 ms → 20-200 Hz

Ethernet : 10 Mbps    Resolution (PWM step) : 6 bits – 10 bits

Number of leds (o

### Needs :

\* Best case :  $20 \times 6 \times 50 = 6 \text{ Kps}$

\* Worst case :  $200 \times 10 \times 20000 = 40 \text{ Mbps}$

\* Signaling with 200 segments, refresh rate 200 Hz,  
resolution 10 bits (1024 steps) :  $200 \times 10 \times 200 = 400000$



## CONCLUSION

Same story again when CAN was in competition with other protocols in 1990's

Good opportunity to talk in DVN workshop in Europe, Asia and USA

Do we need to talk ?

Do we need a standard protocol for lighting?

Do we need specific protocol for front (ADB, HD) versus Rear ?

Do we need a unique one of different ones ?

Can we push Semiconductor industry to develop gateway and LED IC with these protocol ?



# CONCLUSION

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Round table tomorrow on the 30th of august :

- Melexis,
- Microchip,
- Flex-N-Gate,
- Rivian



Thank you