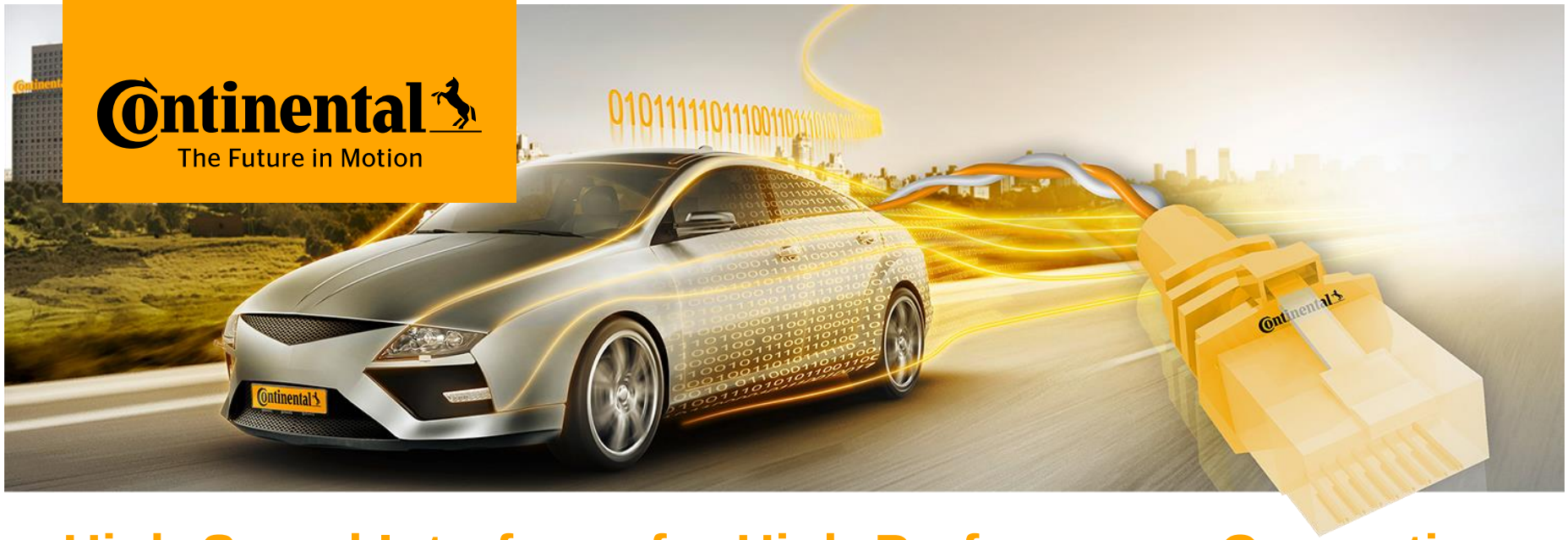
Continental
The Future in Motion



High-Speed Interfaces for High-Performance Computing

Ethernet & IP @ Automotive Technology Week, September 15, 2020

Daniel Hopf, Continental AG

Definitions for this presentation

High-Speed	≥100 Mbit/s Ethernet, no 10BASE-T1S
xMII	Placeholder for an MII interface variant
HPC	High-Performance Computer/Computing (ECU with one or more powerful microprocessors)
SerDes	Serializer / Deserializer (mechanism for serial data transmission)

High-Speed Interfaces for High-Performance Computing
Agenda

1. Motivation
2. It’s been easy so far
3. It suits me, it suits me not
4. Standardization & Summary

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Motivation
High-Performance Computing is here

Source: *https://www.continental.com/en/press/press-releases/2019-11-12-icas-vw-199636*

Press Release 2019-11-12

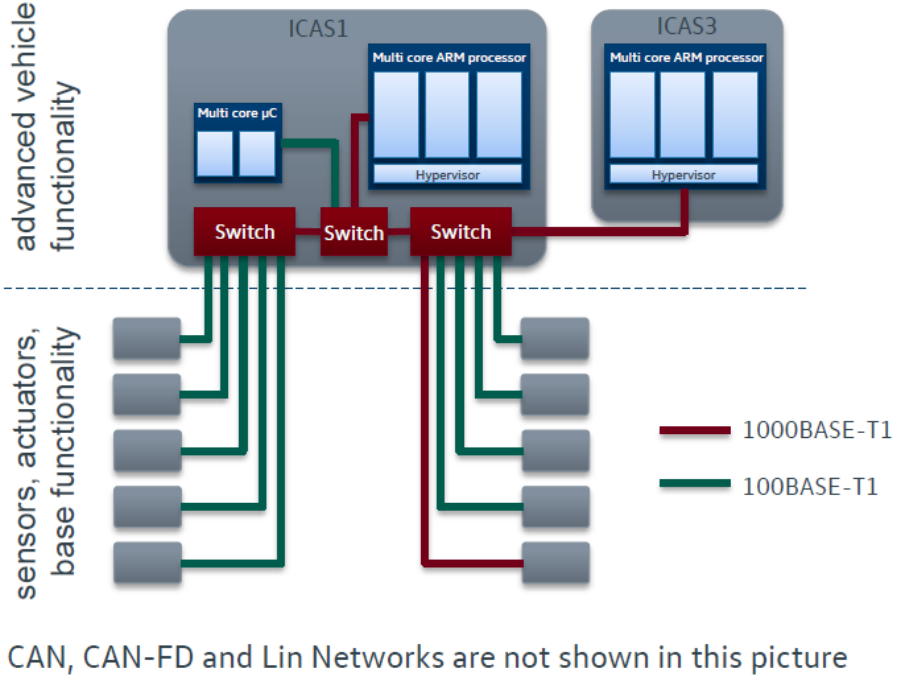
Continental Vehicle Server Connects VW ID. Electric Vehicles

- **Continental's new server concept is a central element for the conversion to a service-oriented electronics architecture in highly connected ID. electric cars**
- **Volkswagen uses the server as an in-car application server (ICAS1) for ID. vehicle models based on the modular electric drive matrix (MEB)**
- **High computing power and a consistent separation of hardware and software are paving the way for new functions and convenient over-the-air updates**

Regensburg/Wolfsburg, November 12, 2019. The electronics architecture of the modern generation of vehicles is undergoing a profound transformation, moving away from the many individual control units of current cars and towards a small number of high-performance computers. In the future, they will provide the computing power for the functional domains in the vehicle. The server developed by the technology company Continental is now going into production at Volkswagen as an in-car application server (ICAS1). The largest European carmaker is using ICAS1 technology for its upcoming ID. electric vehicles based on the modular electric drive matrix MEB developed by Volkswagen.

Motivation

Architecture of the VW MEB ICAS platform



ICAS1 ECU

- Extensive 100BASE-T1 and 1000BASE-T1 Ethernet connectivity
- Multiple on-board Ethernet Switches
- Two Controllers
- 3x 1000 Mbit/s Ethernet link on PCB
- 1x 100 Mbit/s Ethernet link on PCB

Image source: *"1000BASE-T1 from Standard to Series Production";* O. Krieger, C. Mash, IEEE-SA Ethernet Technology Day 2018

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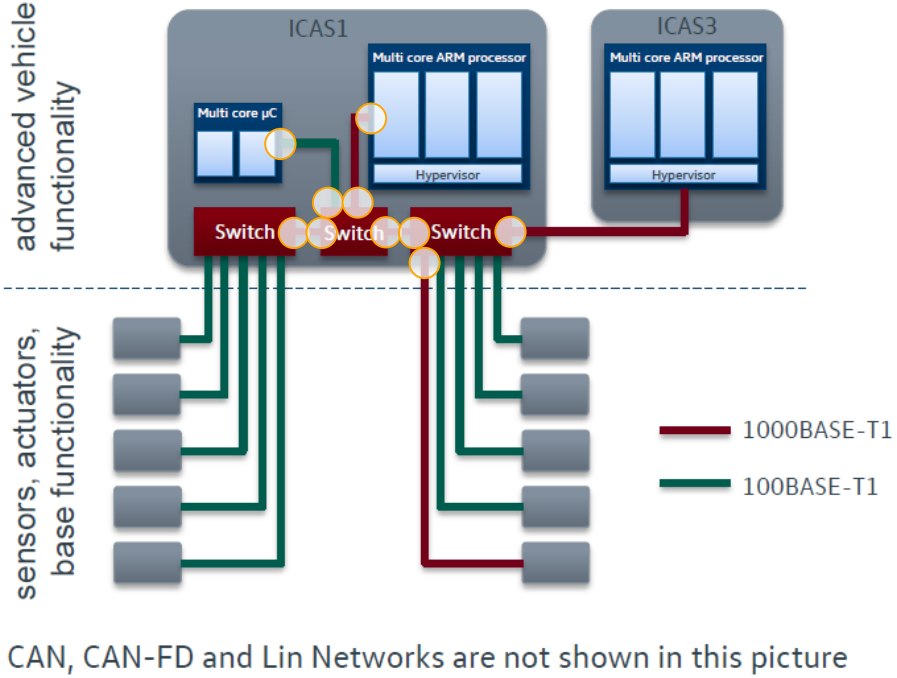

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- **10+ xMII connection points**

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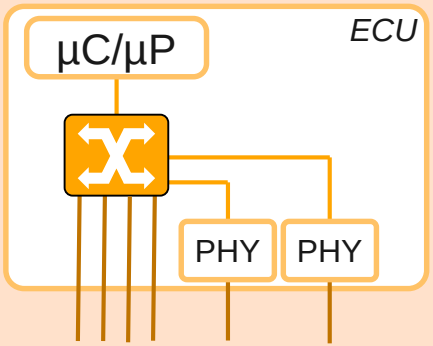
Motivation

Exemplary distribution of High-Speed Interfaces on ECUs

Legacy	Server	HPC-Brain



- Majority of High-Speed links is for external connectivity, minority for internal connectivity
- Typically 100 or 1000 Mbit/s links, mostly Ethernet

- More intra-ECU connectivity
  - Controllers ←→ Switches
  - Switches ←→ Switches
- Introduction of PCIe and Multi-Gig xMIIs

- Many Multi-Gig intra-ECU connects
- Higher port count Ethernet Switches, higher integration

Motivation

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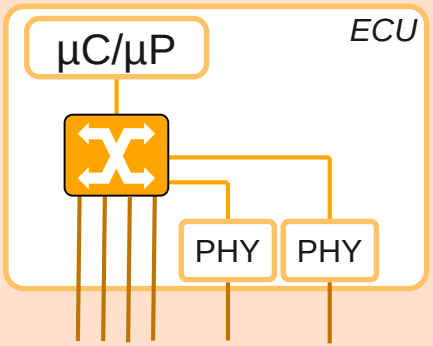

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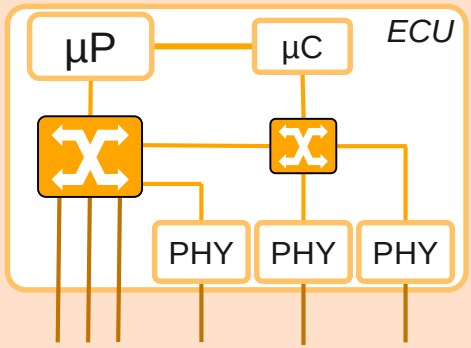

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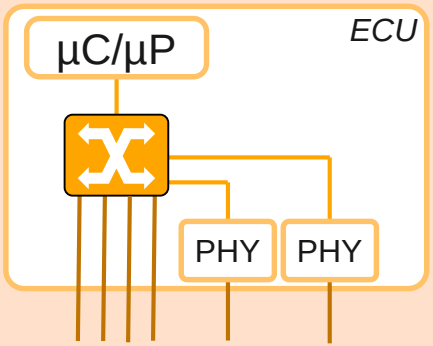

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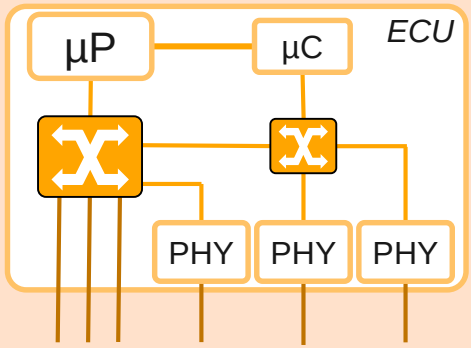

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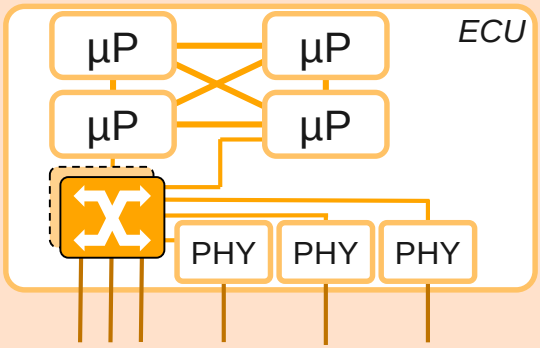

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It’s been easy so far

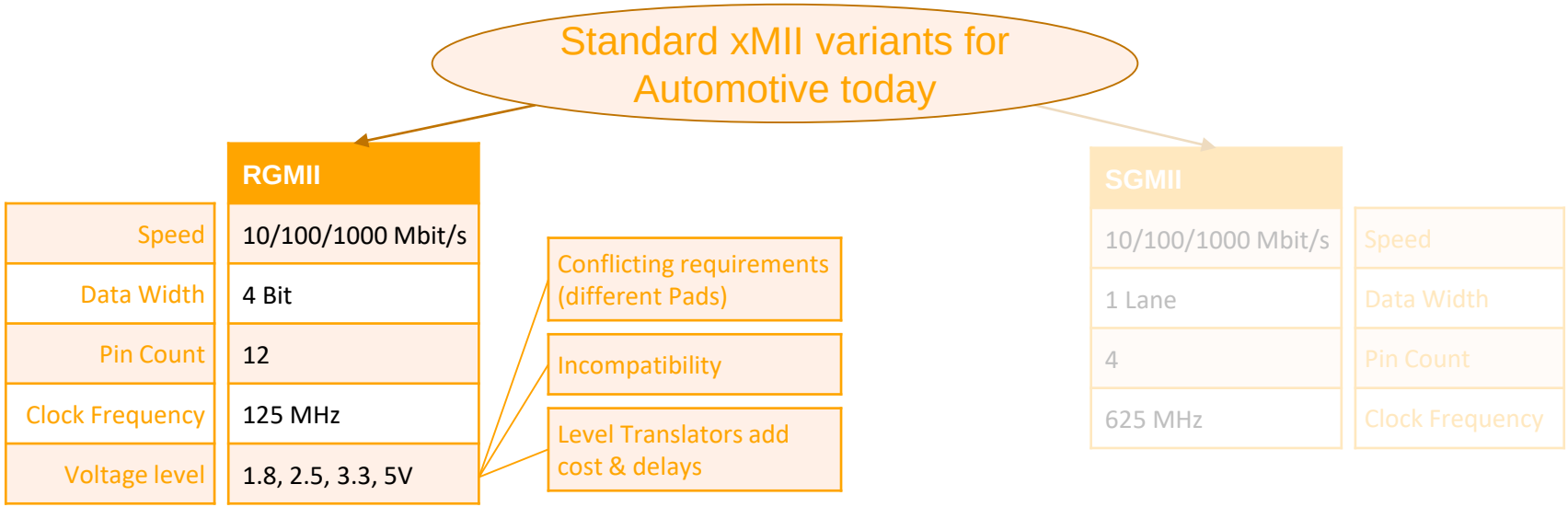
The choice for 100 & 1000 Mbit/s

	RGMII
Speed	10/100/1000 Mbit/s
Data Width	4 Bit
Pin Count	12
Clock Frequency	125 MHz

SGMII	
10/100/1000 Mbit/s	Speed
1 Lane	Data Width
4	Pin Count
625 MHz	Clock Frequency

It’s been easy so far … really?

The choice for 100 & 1000 Mbit/s



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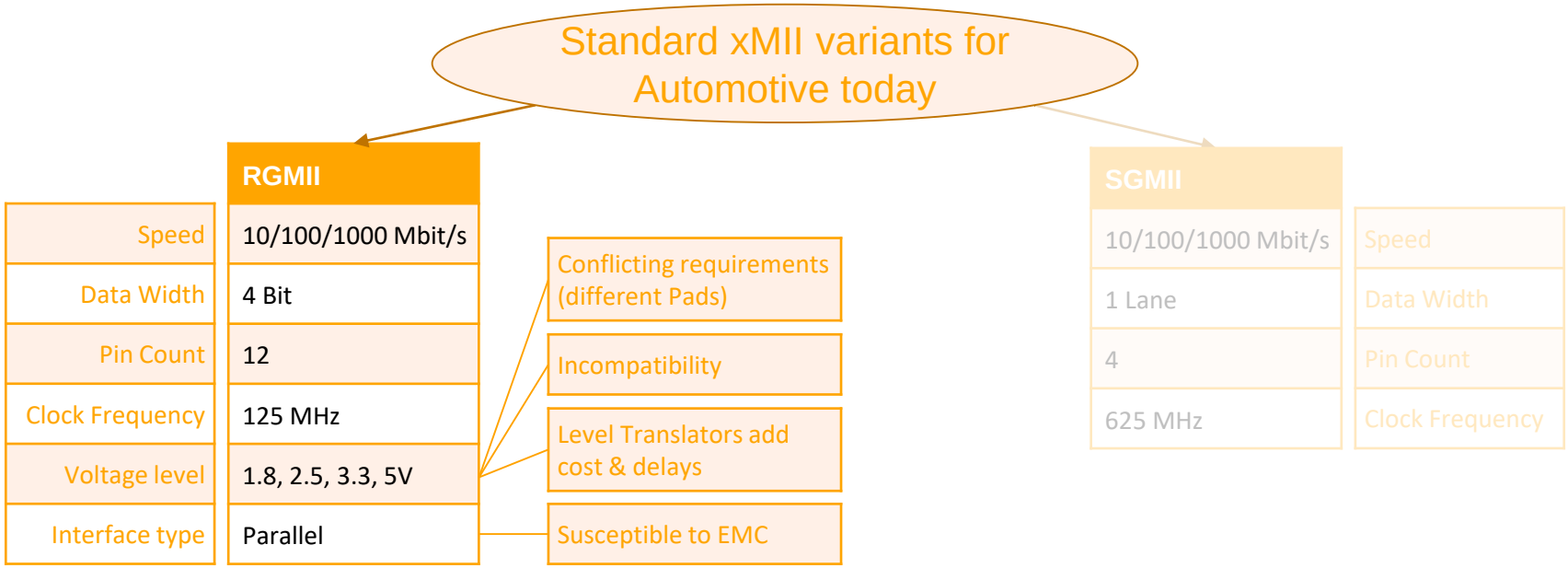

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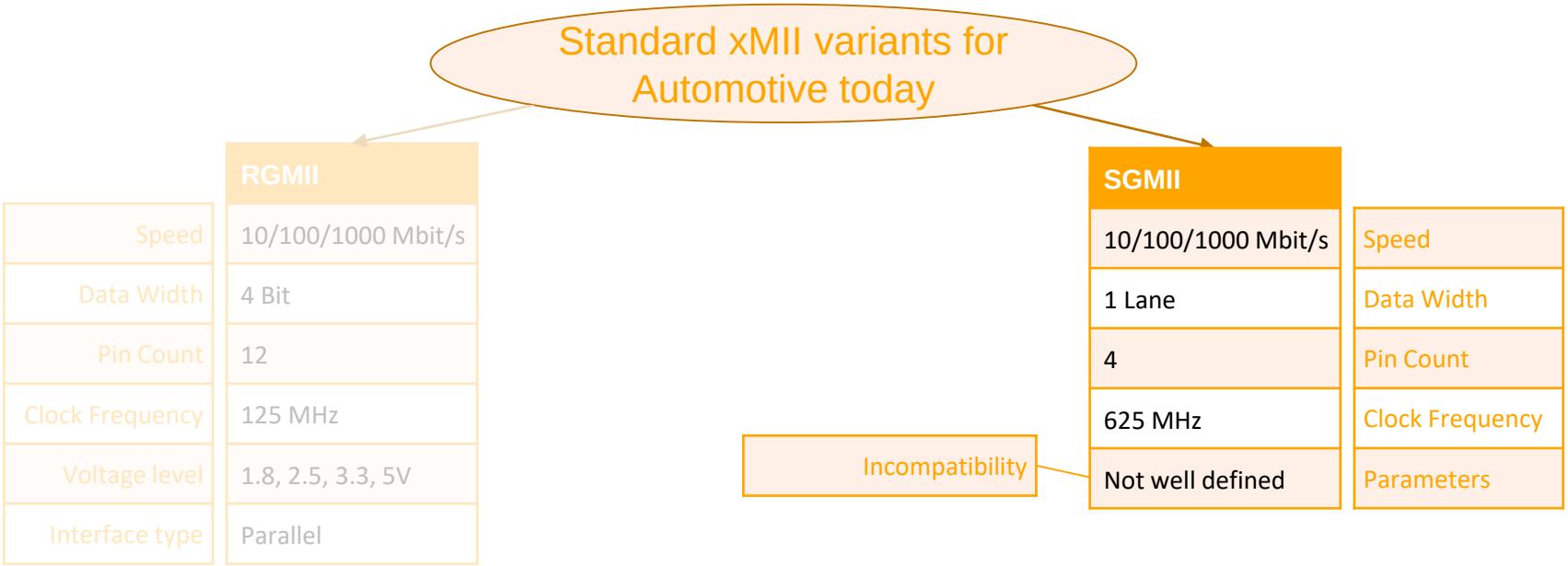

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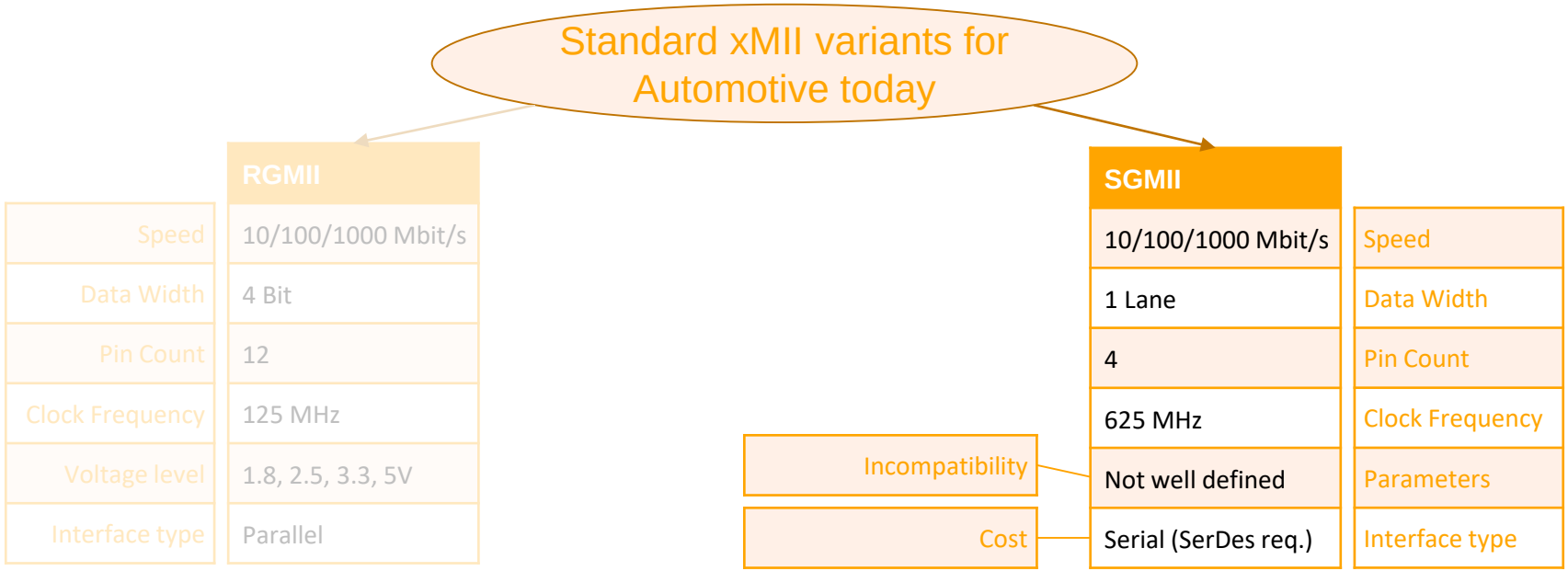

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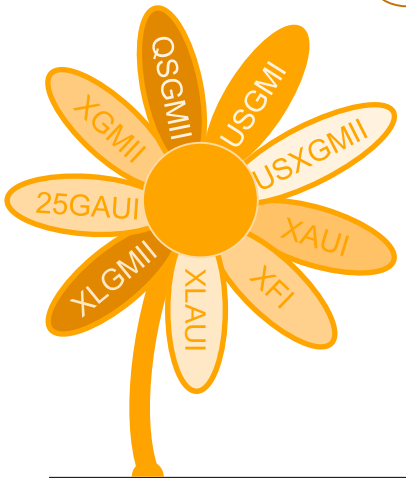
It suits me, it suits me not

New PHY speeds grow xMII flowers



- Enterprise IT offers a wide variety of xMIIs for multi-Gigabit connectivity
- The advent of (higher) Multi-Gig speeds for Automotive makes it necessary to evaluate those against automotive requirements
- SOP for IEEE802.3ch speeds **~2024**

It suits me, it suits me not

Detailing the petals of that flower

Host Interface	Speed	Data width	# Pins	Clock Frequency	Transmission	Specification
QSGMII	4x ≤1 Gbit/s	1 Lane	4	5.0 GHz	Serial	Cisco
XGMII	10 Gbit/s	32 Bit	74	156.25 MHz	Parallel	IEEE standard
XFI (“Ziffie”)	10 Gbit/s	1 Lane	4	10.3125 GHz	Serial	SFP+ MSA
XAUI (“Zowie”)	10 Gbit/s	4 Lanes	16	3.125 GHz	Serial	IEEE standard
USGMII	8x ≤1 Gbit/s	1 Lane	4	10.3125 GHz	Serial	Cisco
USXGMII	10 Gbit/s	1 Lane	4	10.3125 GHz	Serial	Cisco
25GAUI	25 Gbit/s	1 Lane	4	26.5625 GHz	Serial	IEEE standard
XLAUI	40 Gbit/s	4 Lanes	16	10.3125 GHz	Serial	IEEE standard
XLGMII	40 Gbit/s	8 x 8 Bit-Lanes	146	625 MHz	Parallel	IEEE standard

Note: This listing is not exhaustive - there are even more variants which are not mentioned

It suits me, it suits me not

Strike out parallel interfaces

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Not used in new designs

It suits me, it suits me not
QSGMII & USGMII

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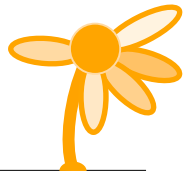
For aggregation of multiple ports only



It suits me, it suits me not

25GAUI

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Critical freq. for FR4 PCB material (starting ~20 GHz)

It suits me, it suits me not
XLAUI

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Multiple lanes with XFI-like interface characteristics

It suits me, it suits me not

The candidates for further evaluation

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- XAUI has a relatively low frequency (but seems to be superseded by XFI)
- USXGMII as only remaining interface in this list supports multiple rates (10/100/1000/2.5G/5G/10G) – preferable for MultiSpeed PHYs ≤10 Gbit/s
- XFI is well-known by semiconductors and already showing up on next-gen devices
- 10 GHz frequencies should still be ok for FR4 material PCBs
  - But for 25 Gbit/s, 25GAUI will become relevant with its higher frequency

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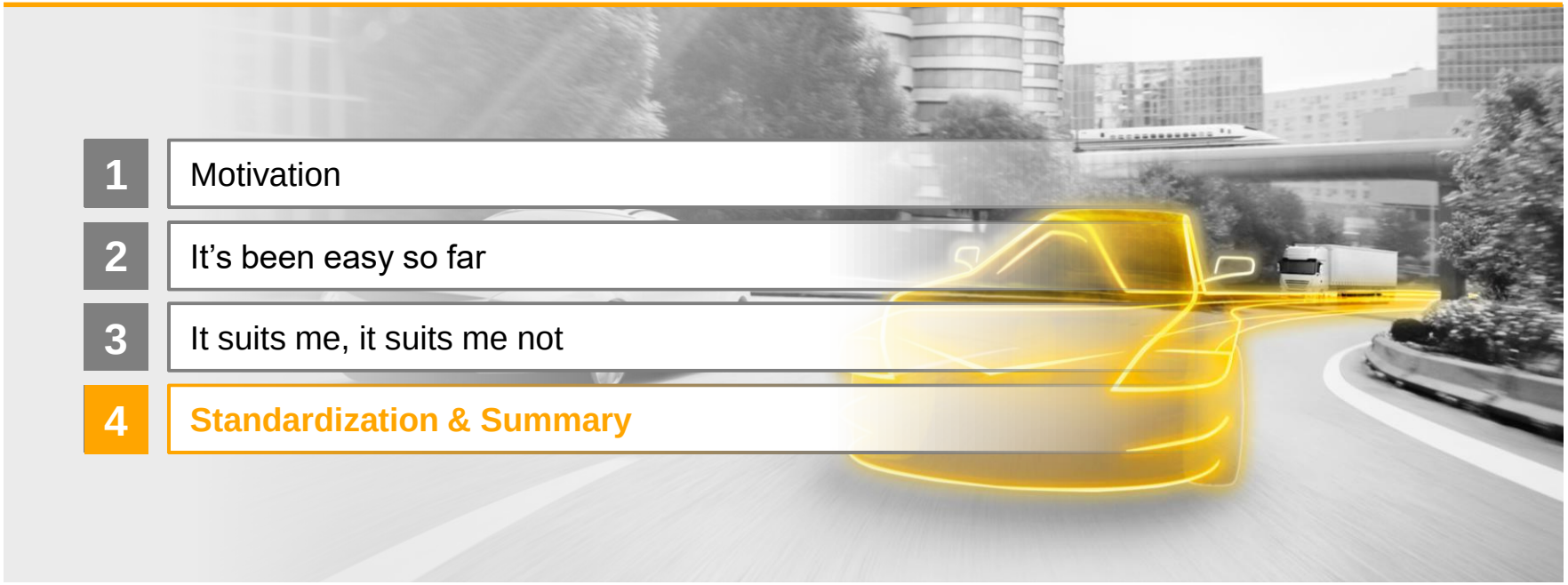

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Standardization
The need

- Automotive test specs usually don’t cover any conformance on MII-level
  - Data Link Layer tests implicitly verify basic functionality of xMIIs (e.g. OPEN TC8)
  - OPEN TC6 created automotive xMII specs, but no conformance test plans
- Even if serial Multi-Gig MII variants like XFI seem well-known from enterprise IT, our industry has many diverging requirements

Standardization
Potential consortia

IEEE SA STANDARDS ASSOCIATION

- IEEE802.3 has definitions for many xMII-variants
  - No specifics for automotive
  - Precise parameter definitions out of scope of IEEE(?)
- Potential for “Automotive MII profile(s)” similar to IEEE802.1’s DG “TSN Profile for Automotive”?

NAV Alliance™
Networking for Autonomous Vehicles

- TWG3 “Physical Layer System and Component Integration”
- Charter states *“Specify PCB design rules that cover the needed signal integrity for Automotive Multi-Gig PHYs”* and *“Define host CPU interconnection for Automotive Multi-Gig PHYs”*

OPEN ALLIANCE

- TC6 “Common xMII Interface Definition”
  - Released RGMII spec
  - Ongoing SGMII spec
- Charter states *“improve the applicability of existing xMII standards for Ethernet-based automotive networks with data rates of 100 Mbit/s and 1 Gbit/s”*
  - Potentially extend focus to >1 Gbit/s in future
- RGMII-Spec in translation to ISO 21111-2 with support from TC6

ISO

Summary

- RGMII and SGMII brought some problems in automotive implementations
  - Learning curve for ECU vendors and semiconductor suppliers
  - Need for (additional) standardization work
- Multi-Gig Automotive Ethernet is increasing the xMII landscape drastically
  - At closer look, only a handful of candidates are promising
  - Proposal to investigate these interfaces more closely by industry experts with automotive requirements in mind and close any gaps for automotive use


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