

BMW
GROUP



DOIP OPTIMIZATION FOR ZONAL ARCHITECTURES

IEEE ETHERNET & IP @ AUTOMOTIVE TECHNOLOGY DAY, SEPTEMBER 19-20, 2023, SAO PAULO

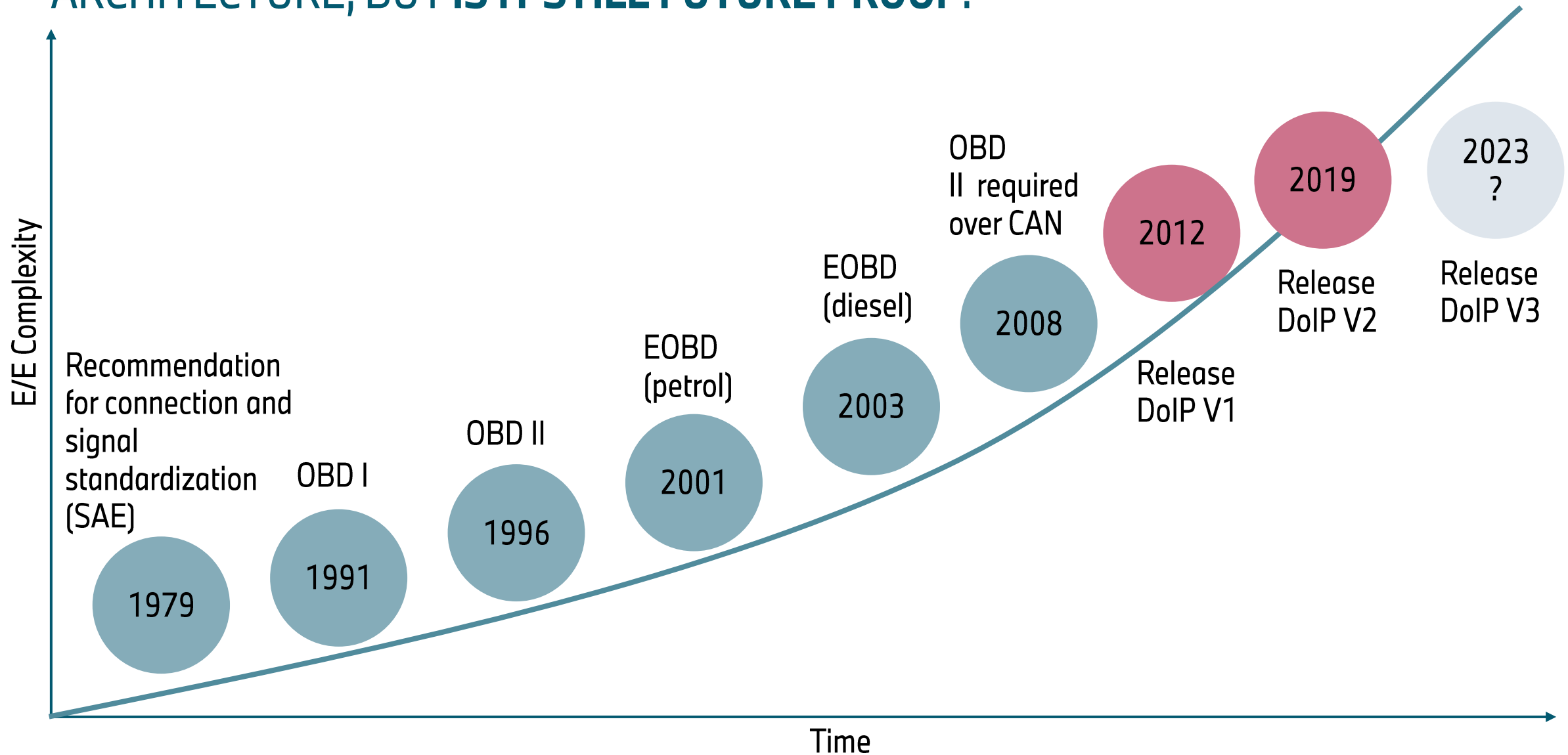
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Agenda

- History of vehicle diagnostics
- ISO 13400-2:2019
- DoIP basics
- DoIP limitations now and in the future
- Solution proposal



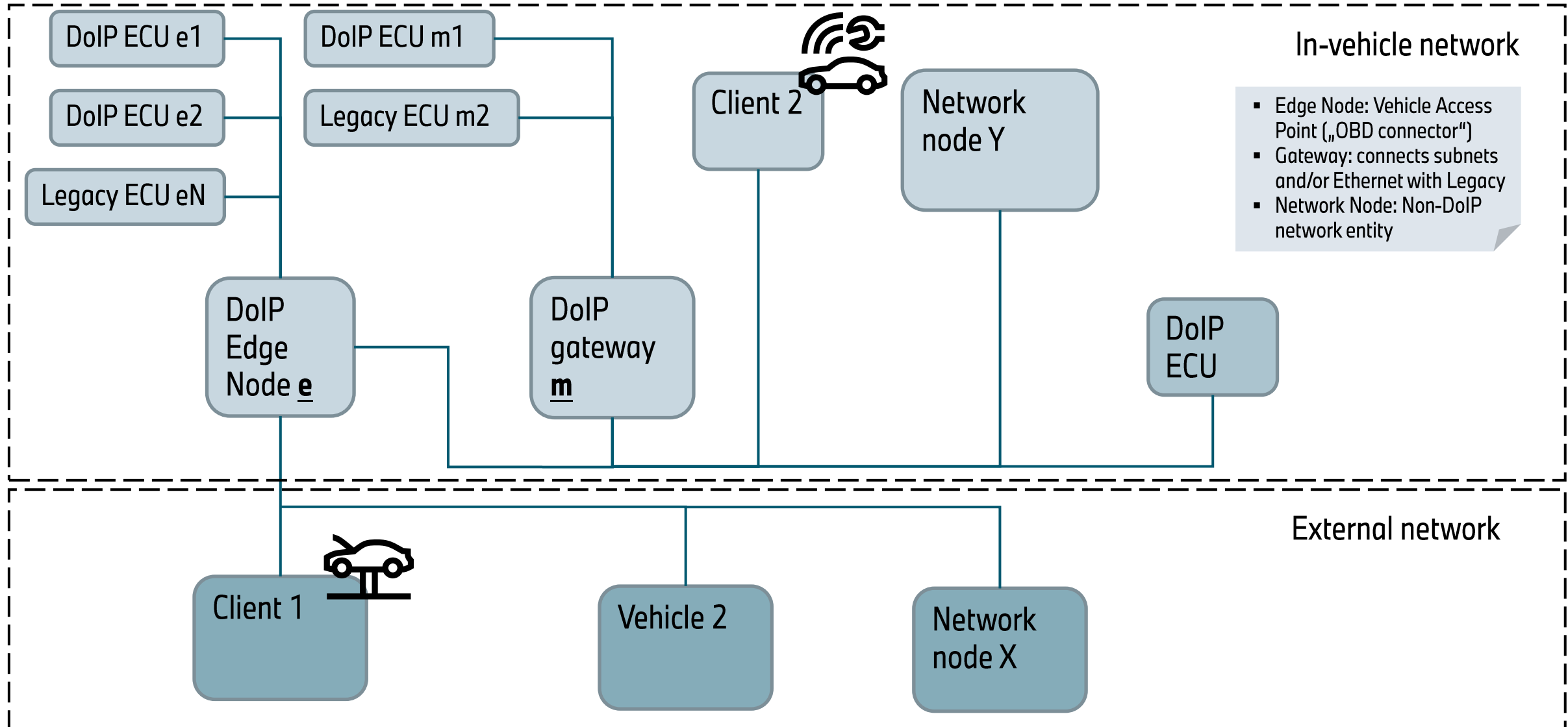
IN THE PAST, VEHICLE DIAGNOSTICS HAS EVOLVED AHEAD OF THE E/E ARCHITECTURE, BUT IS IT STILL FUTURE PROOF?



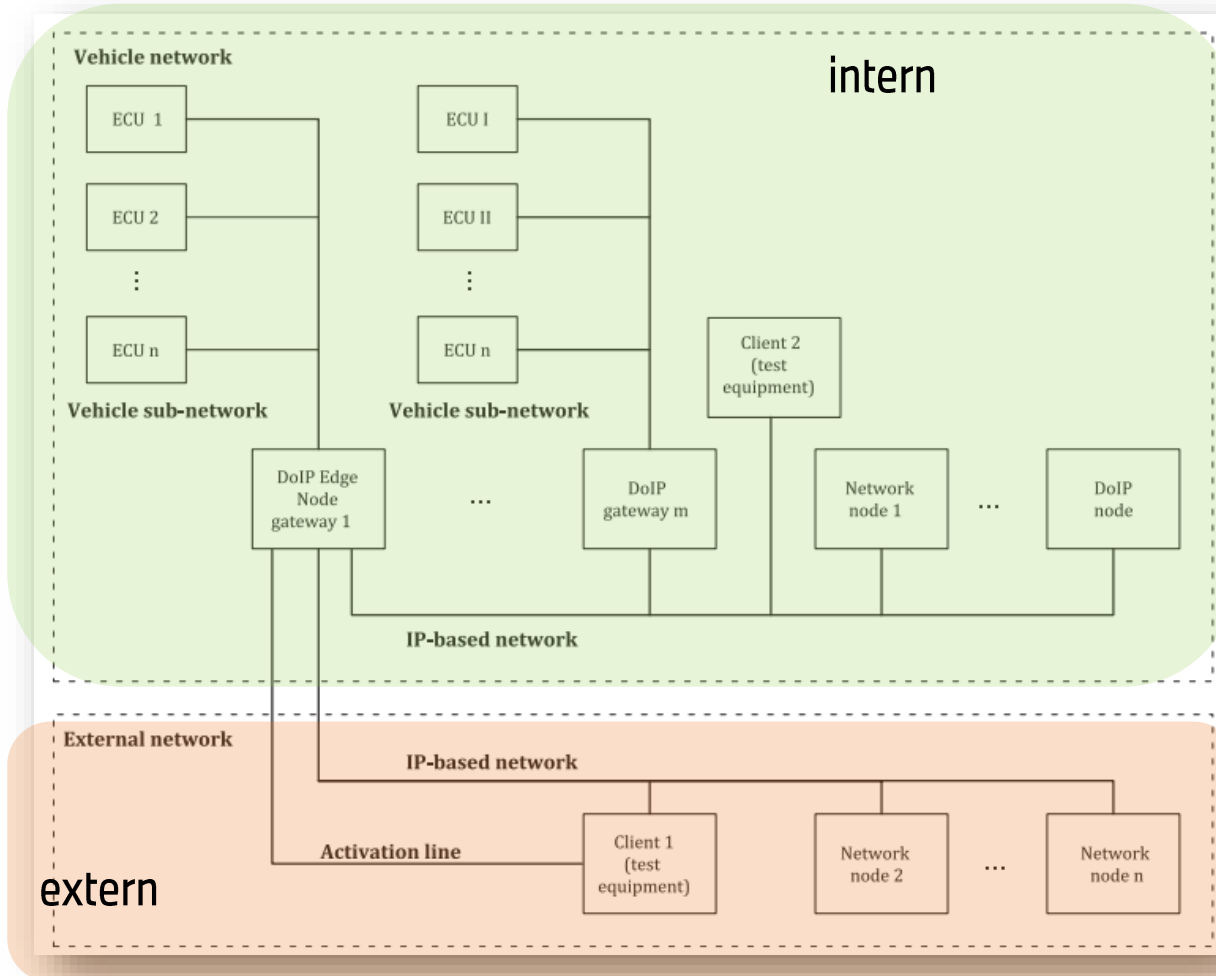
VEHICLE DIAGNOSTICS TODAY: DIAGNOSTICS OVER IP (DOIP)

- DoIP is a transport protocol, meant to support UDS and ODX
- It is standardized in the ISO 13400-2
- Software specification for embedded systems is available in AUTOSAR
- Scope not limited to a single vehicle, but ready to operate in a network of vehicles
- Considers gateways within the vehicle, which connect Ethernet with other communication technologies such as CAN or FlexRay
- Since 2019:
 - Optional use of a secure communication channel using TLS
 - Internal testers, potentially in another network are considered
 - The rules of an external tester apply also to internal tester (clients)

ISO HW ARCHITECTURE APPROACH: DOIP CONSIDERS ALL RELEVANT ELEMENTS OF THE NETWORK



ISO 13400-2:2019 IS IMPLEMENTED DIFFERENTLY THROUGH OEMS

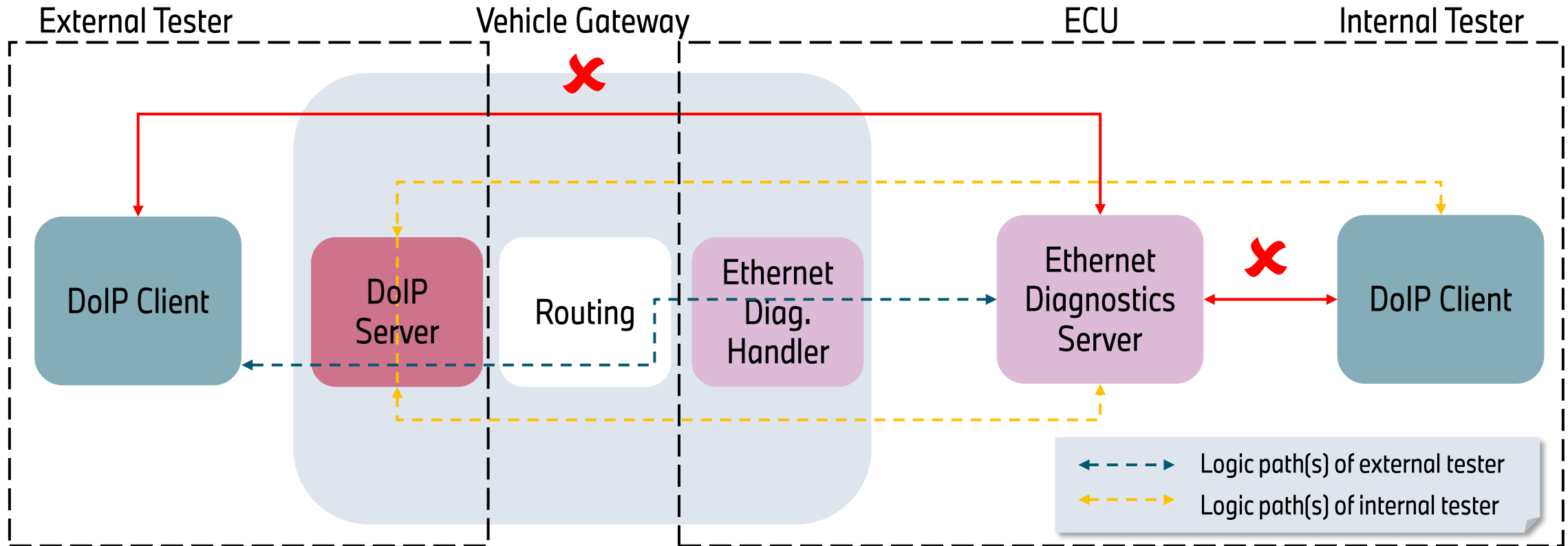


There are different implementations of the standard:

- The DoIP communication ends on the OBD connector.
- All communication must go through the Edge Node, including internal testers, like OTA devices.
- Not all DoIP rules are necessary in the vehicle network.

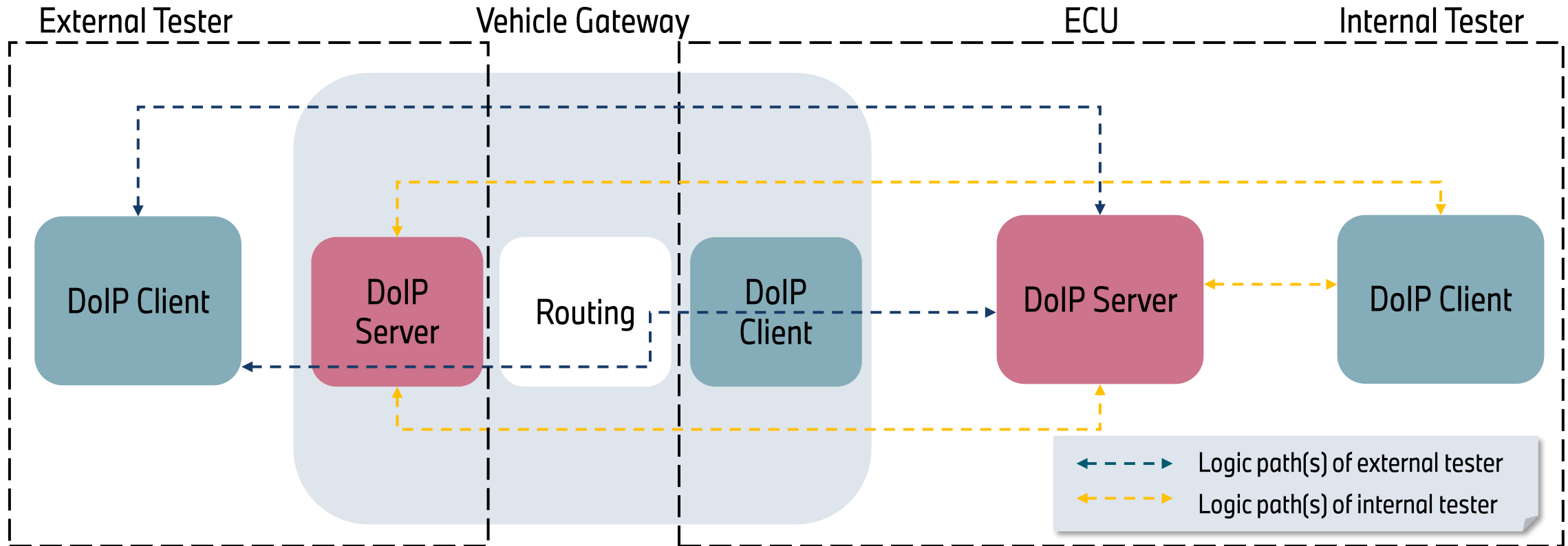
The ISO standard already approaches internal and external connections!

EXAMPLE FOR A REDUCED IMPLEMENTATION: TESTER MUST GO THROUGH THE VEHICLE GATEWAY TO FLASH ECUS



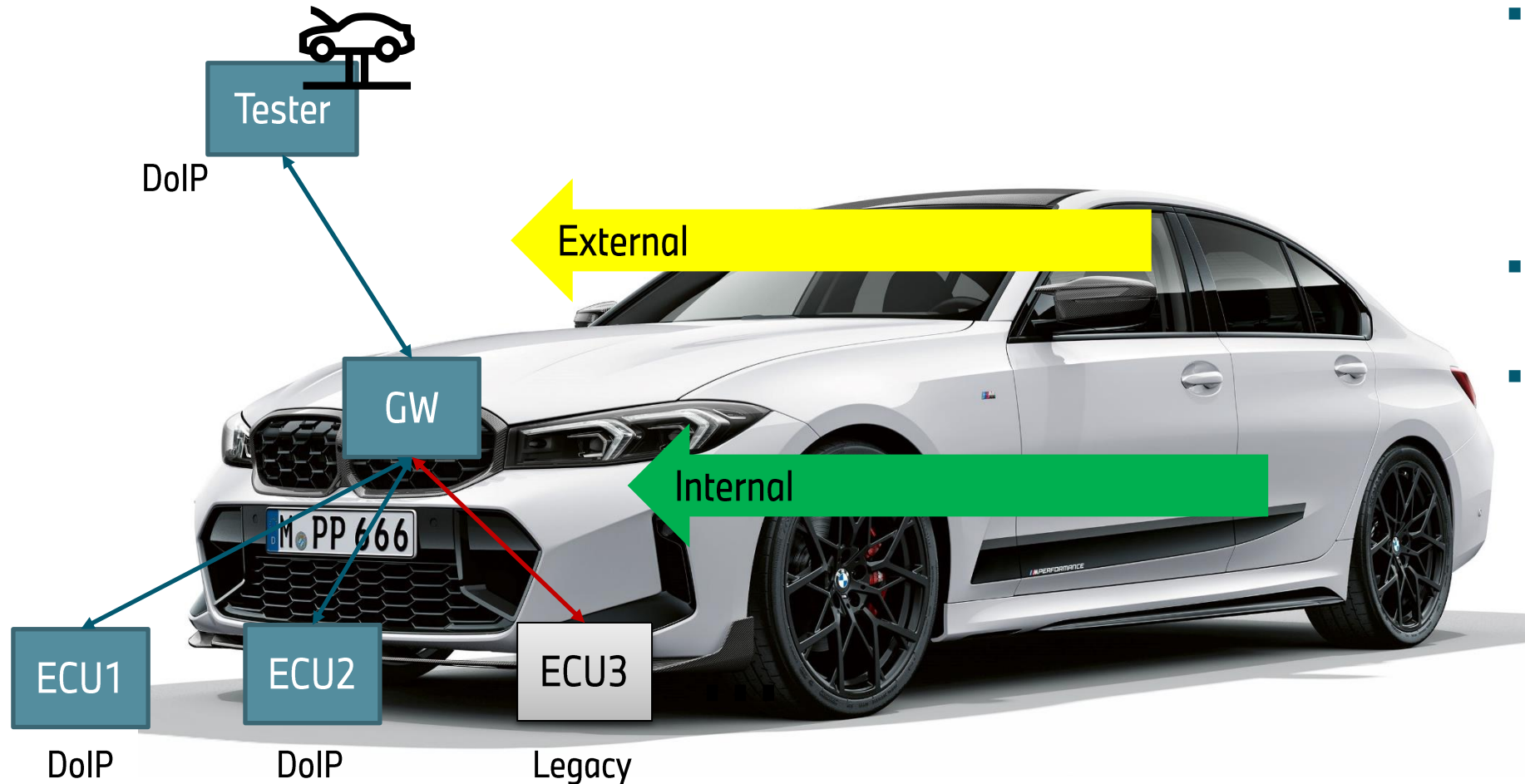
This reduced implementation of DoIP **limits** communication workflows and **restrains** flashing performance!

FULL IMPLEMENTATION: DOIP ALLOWS FOR VARIOUS CONNECTION SCENARIOS



Standard SW architecture brings **flexibility** and **uniformity** to the diagnostic communication!

SIMPLE DOIP WORKFLOW: SINGLE EXTERNAL TESTER DIAGNOSES ECUS



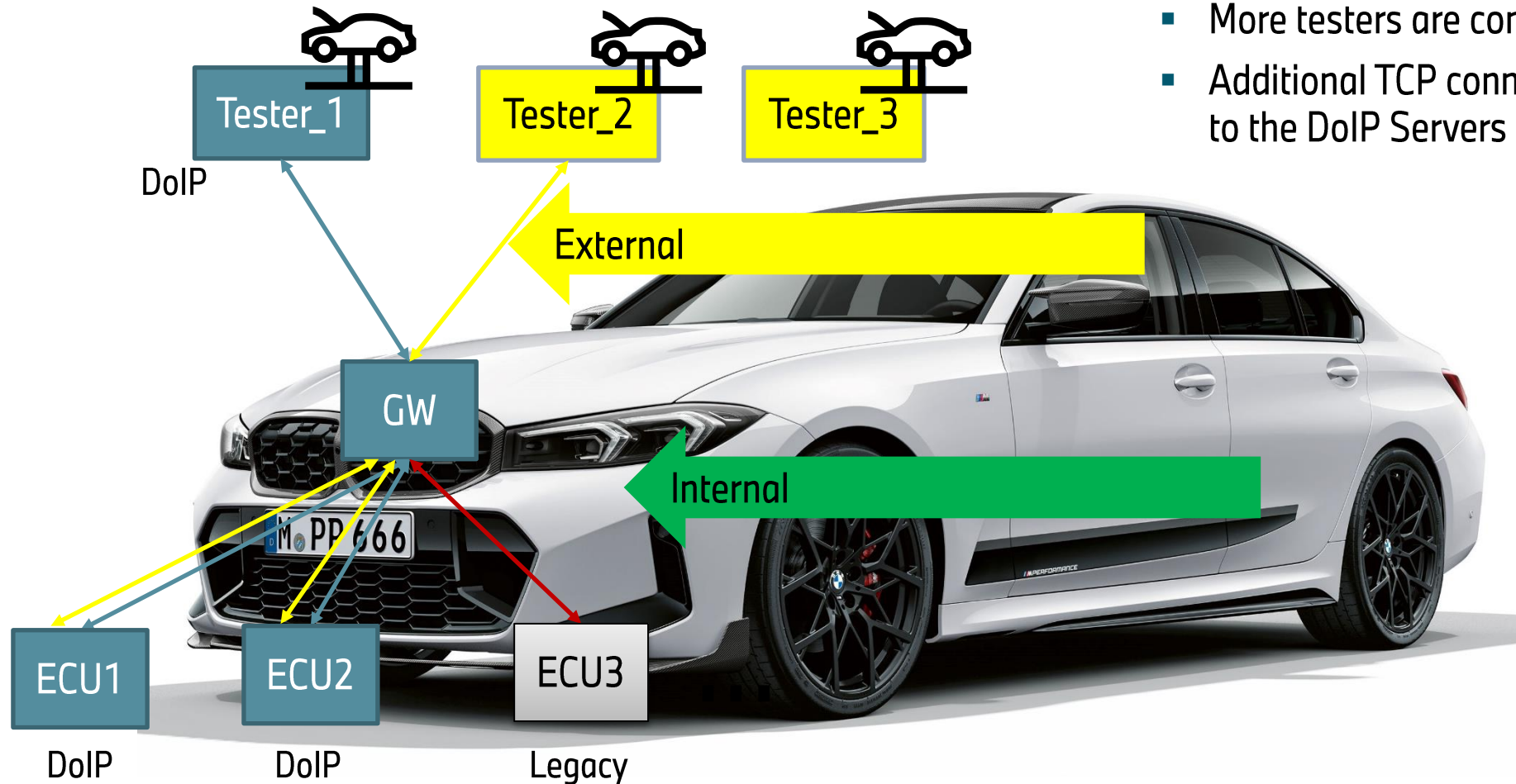
- External and internal vehicle network are split → Different subnets
- Tester wants to diagnose ECU1
- Gateway simply routes the communication via dedicated TCP connection.

Open TCP socket

Perform Routing Activation

Send Diagnostic requests

TYPICAL DOIP WORKFLOW (PRODUCTION PLANT): MULTIPLE TESTERS



- More testers are connected
- Additional TCP connections from GW to the DoIP Servers

Open TCP socket

Perform Routing Activation

Send Diagnostic requests

MULTIPLE TESTERS ARE USEFUL, BUT REQUIRE EITHER HIGH VEHICLE GATEWAY PERFORMANCE OR CUSTOM IMPLEMENTATION!

- The access component of the vehicle (referred as GW) has to handle all TCP connections
- Number of External testers (n) → $n + n * \text{DoIP Server ECUs}$
- Server ECUs must handle ,n' TCP connections

For a vehicle architecture with 15 Ethernet ECUs and 3 Testers → **48 TCP connections**

→ **Minimum** consumption of 6KB per socket (even more for a more performant TCP receive window)

→ Causes more receive **interrupts** and vain additional "header-traffic"

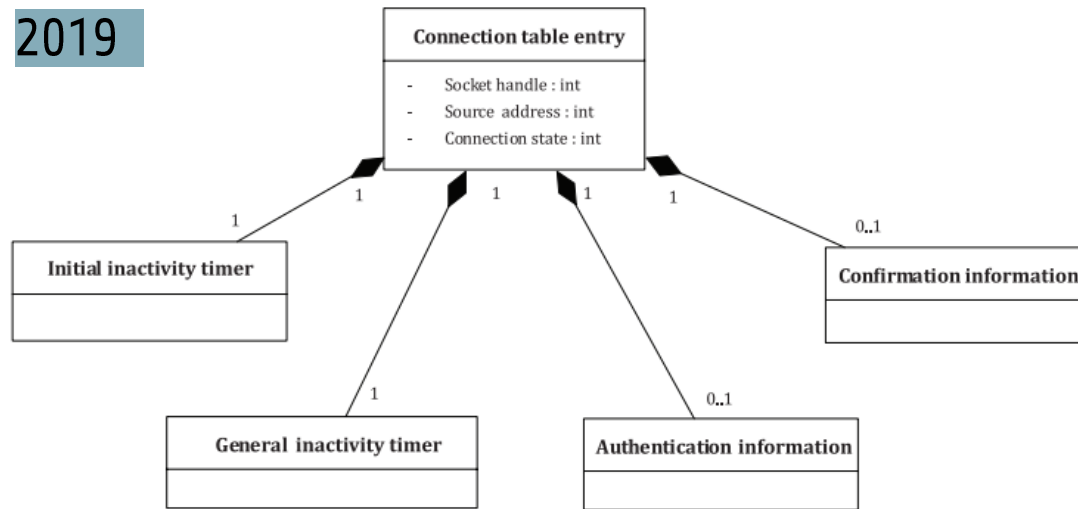
...unnecessary **costly, inefficient and complex!**



DoIP needs to be enhanced → Multiplex TCP connections!

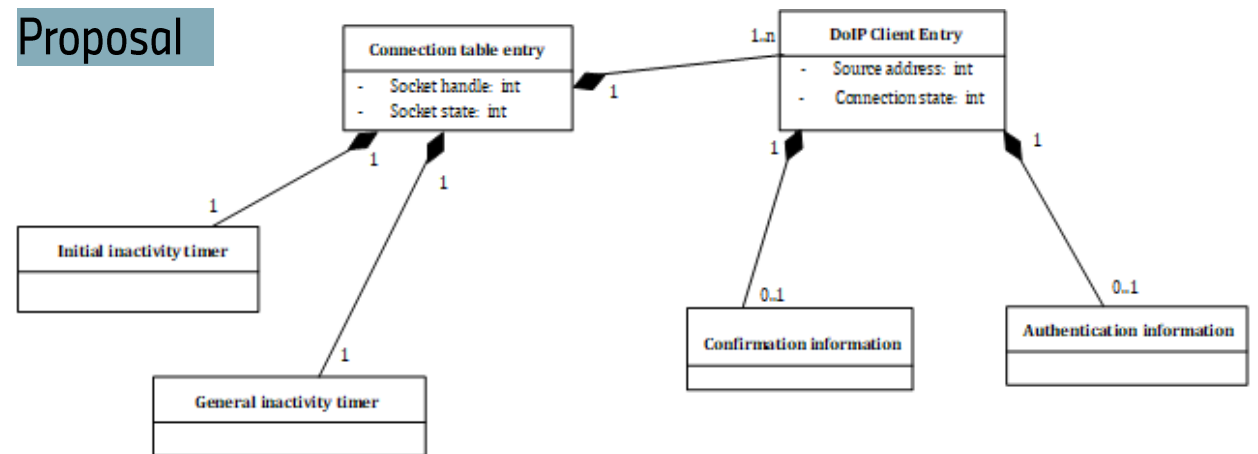
PROPOSAL: ENHANCE THE ROUTING ACTIVATION AND CONNECTION TABLE HANDLING TO ALLOW MULTIPLEXING OF TESTERS

2019



1:1 Relationship between tester and socket
Current routing activation enforces this limitation

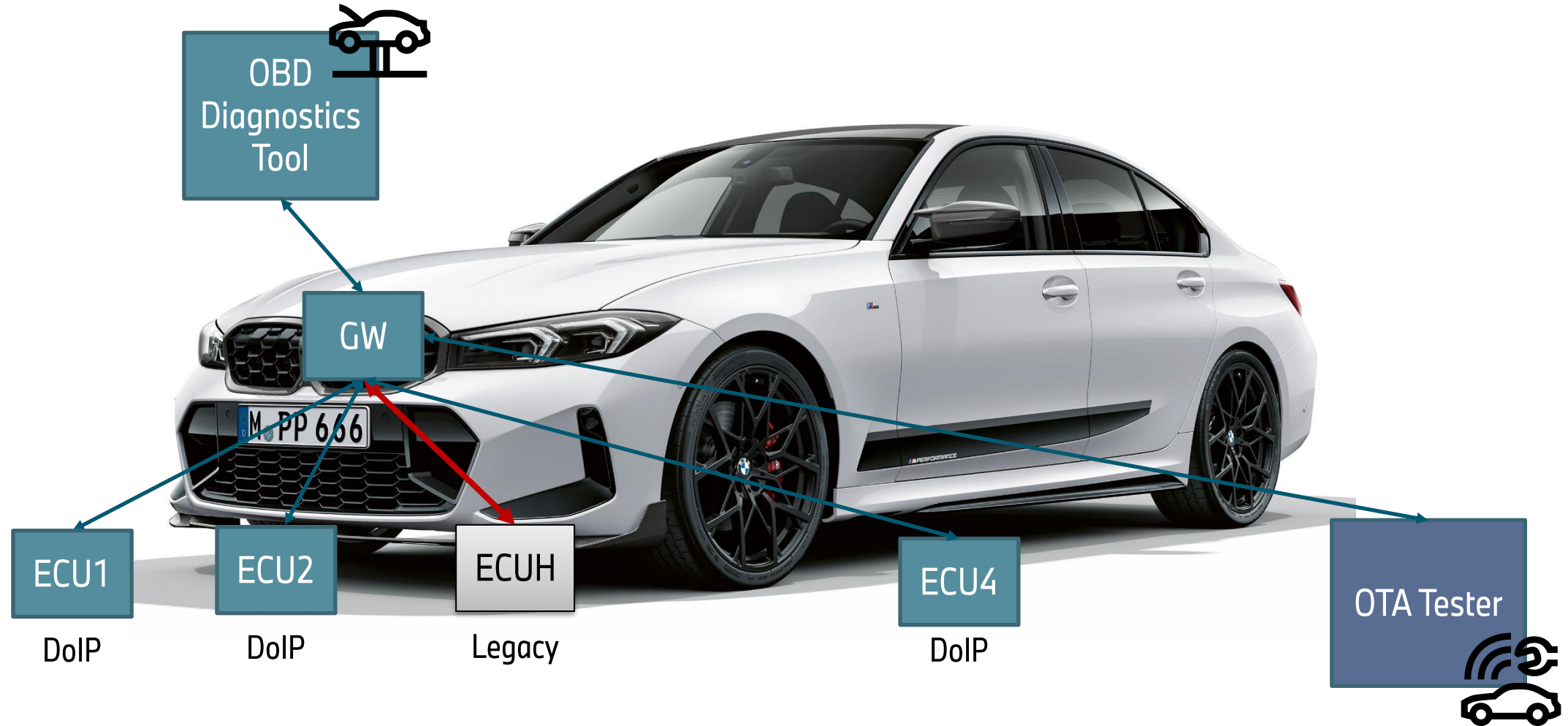
Proposal



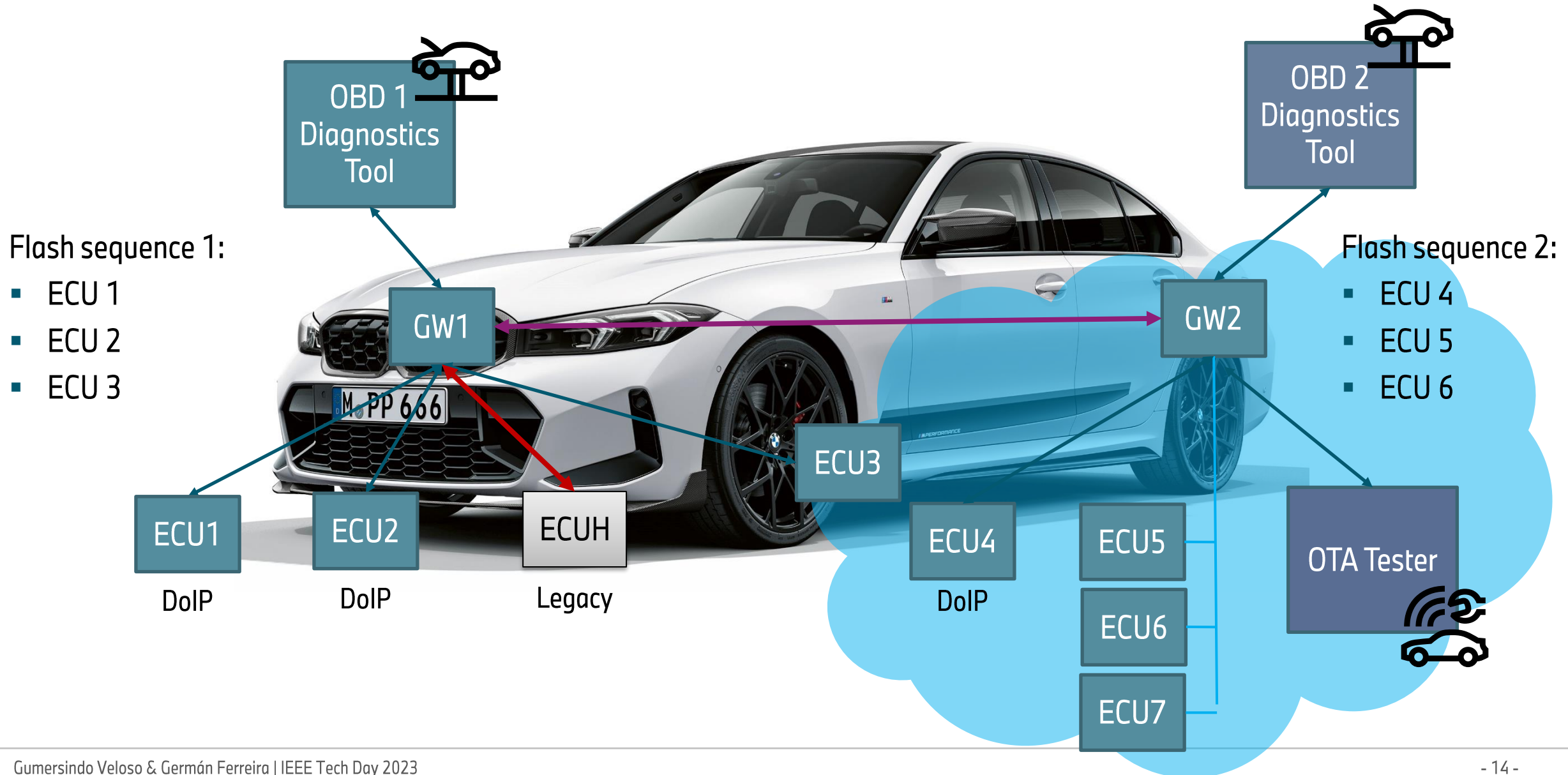
Tester and socket logically separated
Enhanced routing activation protects the ECU while providing flexibility

At the same time, be backwards compatible through configuration!

DOIP SERVES CURRENT E/E ARCHITECTURES...



...AND IF FULLY IMPLEMENTED, DOIP SUITS IDEALLY ZONAL ARCHITECTURES



DOIP: OUR RECOMMENDATIONS

**Having more than one access point
has several advantages.**

**Following DoIP manages the
complexity of modern E/E
architectures.**

**DoIP can be improved.
Adopting the multiplexing of testers!**



A white BMW concept car is shown from a front-three-quarter view, parked on a gravel driveway. The car features a sleek, aerodynamic design with large, illuminated headlights and multi-spoke wheels. The background consists of lush green foliage and a building with a window. The text "THANK YOU FOR YOUR ATTENTION" is overlaid in white, bold, sans-serif font across the upper portion of the image.

THANK YOU FOR YOUR ATTENTION

Germán Ferreira
Functional owner DoIP
BMW AG