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Road vehicles — Diagnostic communication over Internet Protocol (DoIP) —

Part 1: General information and use case definition

Véhicules routiers — Communication de diagnostic au travers du protocole internet (DoIP) —

Partie 1: Informations générales et définition de cas d'usage

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13400-1 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 13400 consists of the following parts, under the general title *Road vehicles — Diagnostic communication over Internet Protocol (DoIP)*:

— *Part 1: General information and use case definition*

— *Part 2: Transport protocol and network layer services*

— Part 3: *Wired vehicle interface based on IEEE 802.3*

The following parts are under preparation:

— *Part 4: Ethernet Diagnostic Connector*

— *Part 5: Conformance test specification*

Introduction

Vehicle diagnostic communication has been developed starting with the introduction of the first legislated emissions-related diagnostics and has evolved over the years, now covering various use cases ranging from emissions-related diagnostics to vehicle manufacturer specific applications like calibration or electronic component software updates.

With the introduction of new in-vehicle network communication technologies the interface between the vehicle's electronic control units and the external test equipment has been adapted several times to address the specific characteristics of each new network communication technology requiring optimized data link layer definitions and transport protocol developments in order to make the new in-vehicle networks usable for diagnostic communication.

With increasing memory size of electronic control units and the demand to update this increasing amount of software and an increasing number of functions provided by these control units, technology of the connecting network and buses has been driven to a level of complexity and speed similar to computer networks. New applications (x-by-wire, infotainment) require high band-width and real time networks (like FlexRay, MOST) which cannot be adapted to provide the direct interface to a vehicle. This requires gateways to route and convert messages between the in-vehicle networks and the vehicle interface to external test equipment.

The intent of ISO 13400 (all parts) is to describe a standardized vehicle interface which

— separates in-vehicle network technology from the external test equipment vehicle interface requirements to allow for a long-term stable external vehicle communication interface,

— utilizes existing industry standards to define a long-term stable state-of-the-art communication standard usable for legislated diagnostic communication as well as for manufacturer-specific use cases, and

— can be easily adapted to new physical and data link layers, including wired and wireless connections using existing adaptation layers.

To achieve this, all parts of ISO 13400 are based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 and ISO/IEC 10731, which structures communication systems into seven layers. Where mapped on this model, the services specified by ISO 14229-1, ISO 14229-2 and ISO 14229-5 are divided into

a) unified diagnostic services (layer 7), specified in ISO 14229-1, ISO 14229-5 and ISO 27145-3,

b) presentation (layer 6):

    1) for enhanced diagnostics, specified by the vehicle manufacturer;

    2) for WWH-OBD (World-Wide Harmonized On-Board Diagnostics), specified in ISO 27145-2, SAE J1930-DA, SAE J1939:2011, Appendix C (SPNs), and SAE J1939-73:2010, Appendix A (FMI), SAE J1979-DA, SAE J2012-DA,

c) session layer services (layer 5), specified in ISO 14229-2,

d) transport protocol (layer 4), specified in ISO 13400-2,

e) network layer (layer 3) services, specified in ISO 13400-2, and

f) physical and data link services (layers 1 and 2), specified in ISO 13400-3,

in accordance with Table 1.

Table 1 — Enhanced and legislated WWH-OBD diagnostic specifications applicable to the OSI layers

Applicability	OSI seven layers	Vehicle manufacturer enhanced diagnostics	WWH-OBD reference
Seven layers according to ISO/IEC 7498-1 and ISO/IEC 10731	Application (layer 7)	ISO 14229-1/ISO 14229-5	ISO 14229-1/ISO 27145-3
	Presentation (layer 6)	Vehicle manufacturer specific	ISO 27145-2, SAE J1930-DA, SAE J1939:2011, Appendix C (SPNs), SAE J1939-73:2010, Appendix A (FMIs), SAE J1979-DA, SAE J2012-DA
	Session (layer 5)	ISO 14229-2	ISO 14229-2
	Transport (layer 4)	ISO 13400-2	ISO 13400-2
	Network (layer 3)		
	Data link (layer 2)	ISO 13400-3	ISO 13400-3
	Physical (layer 1)		

The application layer services covered by ISO 14229-5 have been defined in compliance with diagnostic services established in ISO 14229-1, but are not limited to use only with them.

The transport and network layer services covered by ISO 13400-2 have been defined to be independent of the physical layer implemented.

For other application areas, ISO 13400-3 can be used with any Ethernet physical layer.

Road vehicles — Diagnostic communication over Internet Protocol (DoIP) —

Part 1:
General information and use case definition

IMPORTANT — The electronic file of this part of ISO 13400 contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this part of ISO 13400 using a colour printer.

1 Scope

This part of ISO 13400 describes the general use cases and communication scenarios which are covered by an Internet Protocol-based vehicle communication standard. Each use case drives specific communication capabilities of the vehicle communication interface, for instance in order to be interoperable in an existing computer network.

The diagnostic communication over Internet Protocol (DoIP) protocol supports the standardized service primitive interface as specified in ISO 14229-2.

The descriptions in this part of ISO 13400 cover different application layer implementations, such as:

— enhanced vehicle diagnostics (system diagnostics beyond legislated functionality, non-emissions-related system diagnostics);

— WWH-OBD as specified in ISO 27145-2 and ISO 27145-3.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14229-1, *Road vehicles — Unified diagnostic services (UDS) — Part 1: Specification and requirements*

ISO/IEC 7498-1, *Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*

ISO/IEC 10731, *Information technology — Open Systems Interconnection — Basic Reference Model — Conventions for the definition of OSI services*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14229-1 and the following apply.

3.1.1
controller area network
CAN
network with ECUs exchanging data frames

3.1.2
DoIP entity
host that implements the DoIP-protocol

NOTE A DoIP entity is either a DoIP node or a DoIP gateway.

3.1.3
DoIP gateway
host inside the vehicle which implements the DoIP-protocol and thereby provides access to itself and the ECUs of its connected vehicle subnetworks

3.1.4
DoIP node
host inside the vehicle which implements the DoIP-protocol to provide access to itself but does not route DoIP protocol data to the vehicle subnetworks

3.1.5
external programming equipment
off-vehicle device which is used to programme vehicle subsystem ECUs with changed software; a subset of external test equipment

3.1.6
external test equipment
off-vehicle device which is used to obtain information from vehicle subsystems during the act of performing manufacturing, maintenance, diagnostics and repair

3.1.7
Internet Protocol
IP
protocol for packet-switched end-to-end data communication over various transport media

3.1.8
network address translation
NAT
process of modifying network addresses in IP datagram headers while routing

3.1.9
transport control protocol
TCP
transport protocol for connection-oriented data communication via an IP network

3.1.10
user datagram protocol
UDP
transport protocol for connectionless data communication via an IP network

3.2 Abbreviated terms

CAN   controller area network

ECU   electronic control unit

FMI   failure mode indicator

IP   Internet Protocol

NAT   network address translation

OSI   Open Systems Interconnection

PC   personal computer

SAP   service access point

SPN   suspect parameter number

TCP   transmission control protocol

UDP   user datagram protocol

WLAN wireless local area network

4 Conventions

ISO 13400 is based on the conventions discussed in the OSI Service Conventions (as specified in ISO/IEC 10731) as they apply to diagnostic services.

5 Document overview

5.1 General

All parts of ISO 13400 are applicable to vehicle diagnostic systems implemented on an IP communication network.

ISO 13400 has been established in order to define common requirements for vehicle diagnostic systems implemented on an IP communication link.

Although primarily intended for diagnostic systems, ISO 13400 has been developed to also meet requirements from other IP-based systems needing a transport protocol and network layer services.

Figure 1 illustrates the most applicable application implementations utilizing DoIP.
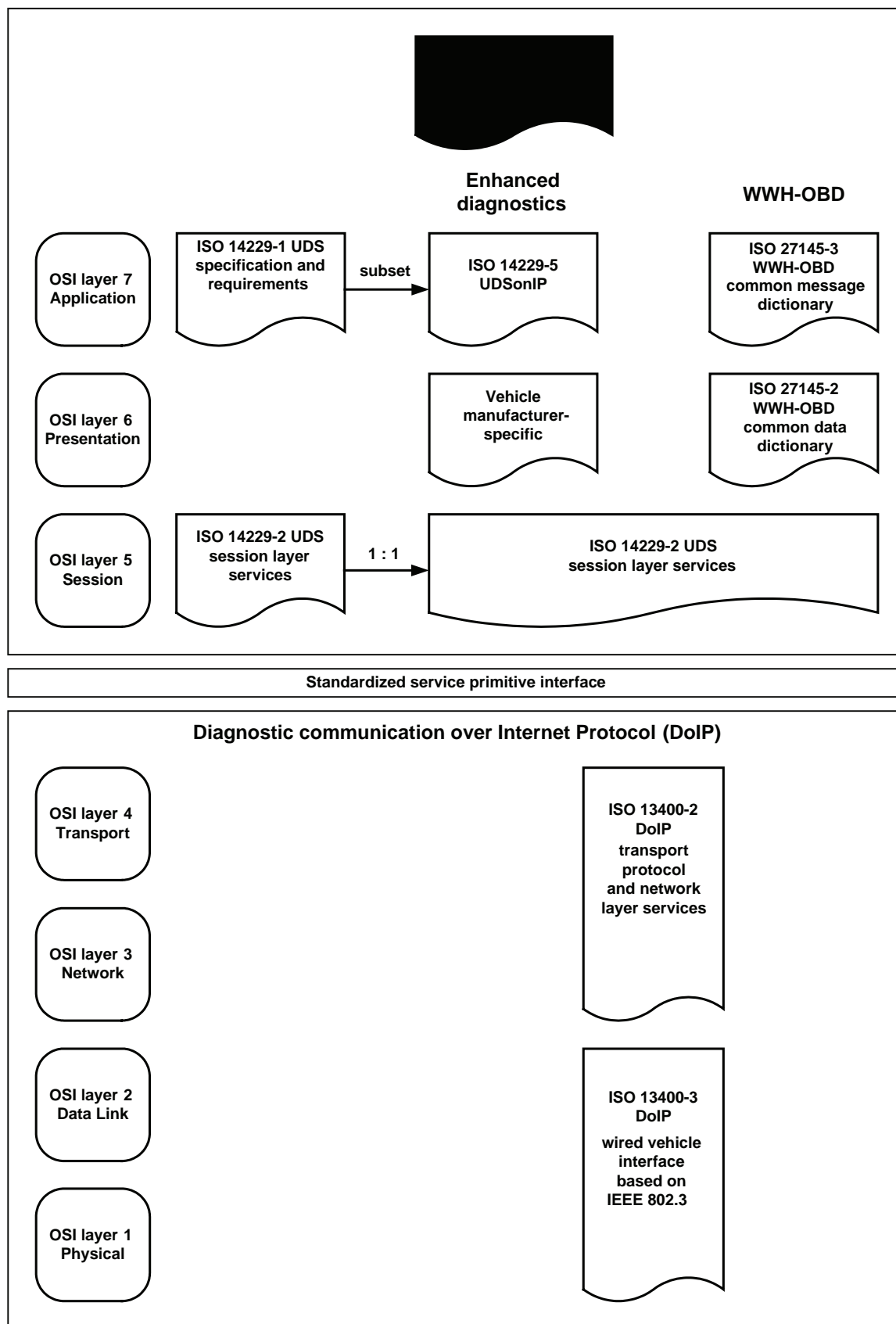
Figure 1 — DoIP document reference according to OSI model

5.2 OSI model

All parts of ISO 13400 are based on the OSI Basic Reference Model, as specified in ISO/IEC 7498-1, which structures communication systems into seven layers.

ISO 13400 is guided by the OSI service conventions, as specified in ISO/IEC 10731, to the extent that they are applicable to diagnostic services. These conventions define the interaction between the service user and the service provider through service primitives.

The aim of this subclause is to give an overview of the OSI model and show how it has been used as a guideline for this part of ISO 13400. It also shows how the OSI service conventions have been applied to ISO 13400.

The OSI model structures data communication into seven layers called (from top down) Application layer (layer 7), Presentation layer, Session layer, Transport layer, Network layer, Data Link layer and Physical layer (layer 1). A subset of these layers is used in ISO 13400.

ISO 13400 specifies the Transport layer, Network layer, Data Link layer and Physical layer for DoIP.

The purpose of each layer is to provide services to the layer above it. The application layer provides services to the diagnostic application. The active parts of each layer, implemented in software, hardware or any combination of software and hardware, are called entities. In the OSI model, communication takes place between entities of the same layer in different nodes. Such communicating entities of the same layer are called peer entities.

The services provided by one layer are available at the SAP of that layer. The layer above can use them by exchanging data parameters.

ISO 13400 distinguishes between the services provided by a layer to the layer above it and the protocol used by the layer to send a message between the peer entities of that layer. The reason for this distinction is to make the services, especially the application layer services and the transport layer services, reusable also for other types of networks than the IP, e.g. CAN. In this way, the protocol is hidden from the service user and it is possible to change the protocol if special system requirements demand it.

6 Diagnostic network architecture

6.1 Diagnostic network

The diagnostic network contains all DoIP entities as well as any external test equipment.

A diagnostic network can range from a simple point-to-point connection between external test equipment and a single DoIP entity to a complex distributed network architecture with several test equipment hosts, multiple vehicles, each with multiple DoIP entities and vehicle subnetworks connected via DoIP gateways.

6.2 Vehicle subnetwork

A vehicle subnetwork is an in-vehicle network which is not directly connected to the IP-based network.

NOTE   Data to and from this vehicle subnetwork can only be sent through the connecting DoIP gateway.

6.3 Diagnostic gateway

A diagnostic gateway is a node in the network that is physically connected to two (or more) subnetworks and has the ability to transfer diagnostic messages between the subnetworks.

Connecting individual subnetworks via diagnostic gateways creates larger diagnostic network architectures.

7 DoIP use case overview and principles

7.1 Overview

This subclause lists the individual use case which is covered by DoIP. These use cases derive from the use of diagnostic communication in the following areas:

— vehicle/ECU engineering (development);

— vehicle/ECU manufacturing (production plant, assembly line);

— service (franchised dealership, aftermarket repair shop);

— legislated inspections (emissions check, safety inspections).

The following use cases are identified and are supported by the communication protocol.

NOTE   This specification only focuses on communication protocol provisions which are necessary to support these use cases. It does not specify data contents, signal update rate, signal availability, etc..

7.2 DoIP use case clusters

The following is a summary of the use cases applicable to systems which support the DoIP protocol.

Table 2 provides an overview of the main DoIP use cases. A main DoIP use case cluster may have one or more use case definitions.

Table 2 — DoIP main use case clusters

Use case no.	Main title of use case cluster	Brief description
1	Vehicle inspection and repair	The purpose of this use case is to require all data necessary to perform an inspection/maintenance (I/M) test as well as repair to be made available through the IP network from the vehicle. The vehicle data can be quickly retrieved without requiring connection establishment and/or security negotiations.
2	Vehicle/ECU software reprogramming	The purpose of this use case is to require the in-vehicle IP network to have the capability to provide vehicle/ECU software programming in order to update software/calibrations of the ECU(s). The vehicle requires connection establishment with security negotiations.
3	Vehicle/ECU assembly line inspection and repair	The purpose of this use case is to require all data necessary to perform a vehicle/ECU assembly line I/M test as well as a repair to be made available through the IP network from the vehicle. The vehicle data can be quickly retrieved without requiring connection establishment and/or security negotiations.

NOTE   For security reasons, certain use cases and communication scenarios can be rejected by the vehicle depending on vehicle state conditions (e.g. while driving) or can require additional security provisions, especially when wireless communication is performed.

8 DoIP use case definition

8.1 Use case 1 — Vehicle inspection and repair

Table 3 specifies the use case to enable external test equipment to qualify readiness of the vehicle and to perform vehicle diagnostic fault tracing as part of a repair.

Table 3 — UC 1 Vehicle inspection and repair

Actor	Inspection and maintenance agency and repair facilities
Goal	Data shall be transferred reliably and in the order as requested by the external test equipment to qualify vehicle readiness by an external I/M test system or repair. Vehicles, which had recently replaced one of their DoIP entities, shall be correctly detected on the IP network even if not all DoIP entities are correctly configured at the time of request.
Use case input	One or multiple requests from the external test system to the vehicle IP network.
Use case output	One or multiple response messages from the vehicle including data to qualify vehicle readiness or to perform vehicle diagnostic fault tracing.
Brief description	In this case, usually an external test equipment is connected to the vehicle which implies that the communication is not time critical (within standard timing requirements of communication) and request vehicle data which can be qualified to determine readiness of the vehicle or to perform vehicle diagnostic fault tracing as part of a repair.

8.2 Use case 2 — Vehicle/ECU software reprogramming

Table 4 specifies the use case to enable external programming equipment to perform vehicle ECU programming in the vehicle manufacturer assembly plant or at repair facilities.

Table 4 — UC 2 Vehicle/ECU software reprogramming

Actor	Vehicle engineering/manufacturing or service
Goal	Provide efficient and reliable data transfer mechanism between external programming equipment and ECU(s) in the vehicle. It also implies that the communication protocol contains provisions to allow for an efficient gateway implementation (i.e. data splitting and reassembly).
Use case input	A predefined sequence of usually larger messages and data exchange between the external programming equipment and the vehicle's ECU(s). The security-related data need to be available to the external programming equipment in order to unlock the secured vehicle ECU(s).
Use case output	A final status which provides information on whether the programming of the vehicle's ECU(s) was performed with success or not.
Brief description	This use case implies that large amounts of data are transferred from the external test equipment to the vehicle. The vehicle requires connection establishment with optional security negotiations.

8.3 Use case 3 — Vehicle/ECU assembly line inspection and repair

Table 5 specifies the use case to enable an external test system to perform vehicle readiness in the vehicle manufacturer assembly plant and a repair if necessary.

Table 5 — UC 3 Vehicle/ECU assembly line inspection and repair

Actor	Vehicle manufacturing
Goal	Data shall be transferred reliably and in the order as requested by the external test equipment to qualify whether the vehicle has passed the end-of-assembly line readiness test. Vehicles which are currently in the assembly process shall be correctly detected on the IP network even if not all DoIP entities are installed on the vehicle or correctly configured at the time of request. In addition, data shall be provided by the vehicle to allow for vehicle diagnostic and repair.
Use case input	One or multiple requests from the external test system to the vehicle IP network
Use case output	One or multiple response messages from the vehicle including data to qualify vehicle readiness or to perform vehicle diagnostic fault tracing
Brief description	This use case is similar to the use case described in 8.1, but is limited to the production area. Diagnostic communication between external test equipment and the vehicle usually uses several parallel diagnostic communication sessions to be supported by the vehicle. This includes several logical connections between one or multiple entities of external test equipment and ECUs in the vehicle.

NOTE   The same physical data link which is used for all parts of ISO 13400 diagnostic communication can also be used for non-diagnostic communication. However, this is not specified in detail in ISO 13400.

9   Communication scenarios

9.1   Overview about network configurations

This subclause describes the communication scenarios for communication with a vehicle over IP. The following network configurations are considered:

— direct physical connection between one vehicle and one instance of external test equipment,

— networked connection between one vehicle and one instance of external test equipment,

— networked connection between multiple vehicles and one instance of external test equipment, and

— networked connection between one vehicle and multiple instances of external test equipment or test applications on a single physical instance of an external test equipment.

NOTE 1   Each vehicle can contain multiple DoIP entities.

NOTE 2   The connectors in Figures 2, 3, 4 and 5 do not represent actual connector design and are used for depicting the wired Ethernet connection.

9.2   Direct physical connection between one vehicle and one instance of external test equipment

This communication scenario occurs when a vehicle directly interfaces with a single external test equipment. This implies that no other external test equipment or vehicle may interfere when the vehicle and the external test equipment perform communication. It is also always clear by the physical connection with which vehicle the external test equipment is communicating. Vehicle and external test equipment are using suited mechanisms to establish a connection (e.g. predefined sets of network layer parameters such as IP-addresses or auto-configuration).

Figure 2 depicts the direct peer-to-peer connection.
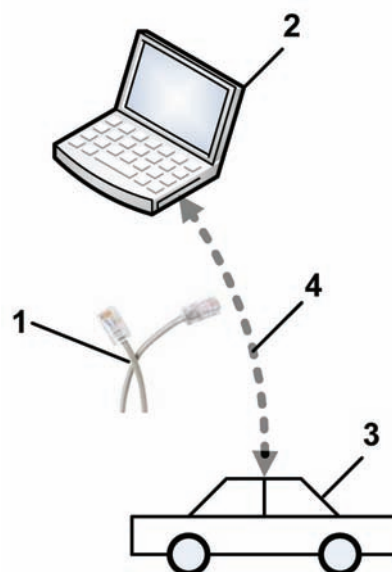
Key

1   ethernet cable
2   external test equipment
3   vehicle
4   logical connection
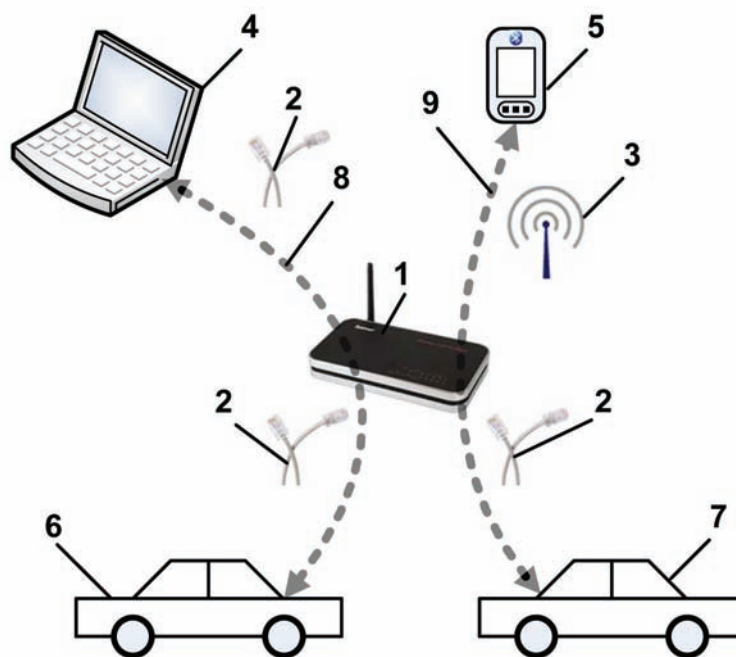
Figure 2 — Direct peer-to-peer connection

9.3   Networked connection between one vehicle and one instance of external test equipment

This communication scenario implies that more than one vehicle and also more than one external test equipment are connected to the same network. This implies that the external test equipment shall have the possibility to identify the vehicles in the network and select a specific vehicle with which to establish communication. From the vehicle point of view, this implies that the vehicle shall implement identification mechanisms and shall also be able to handle or reject multiple connection attempts since other external test equipment can interfere with the currently established communication. Both the external test equipment and the vehicle shall support the integration of themselves into an existing IP network, which includes negotiation of network layer parameters.

This communication scenario usually occurs when a vehicle is connected to an existing network or wireless infrastructure which is also used by other vehicles and external test equipment (e.g. repair workshop network).

Figure 3 depicts the peer-to-peer connection through network.

Key

1   ethernet switch and WLAN access point
2   ethernet cable
3   WLAN
4   external test equipment no. 1 (laptop)
5   external test equipment no. 2 (PDA)
6   vehicle no. 1
7   vehicle no. 2
8   logical connection no. 1 between external test equipment no. 1 (key item 4) and vehicle no. 1 (key item 6)
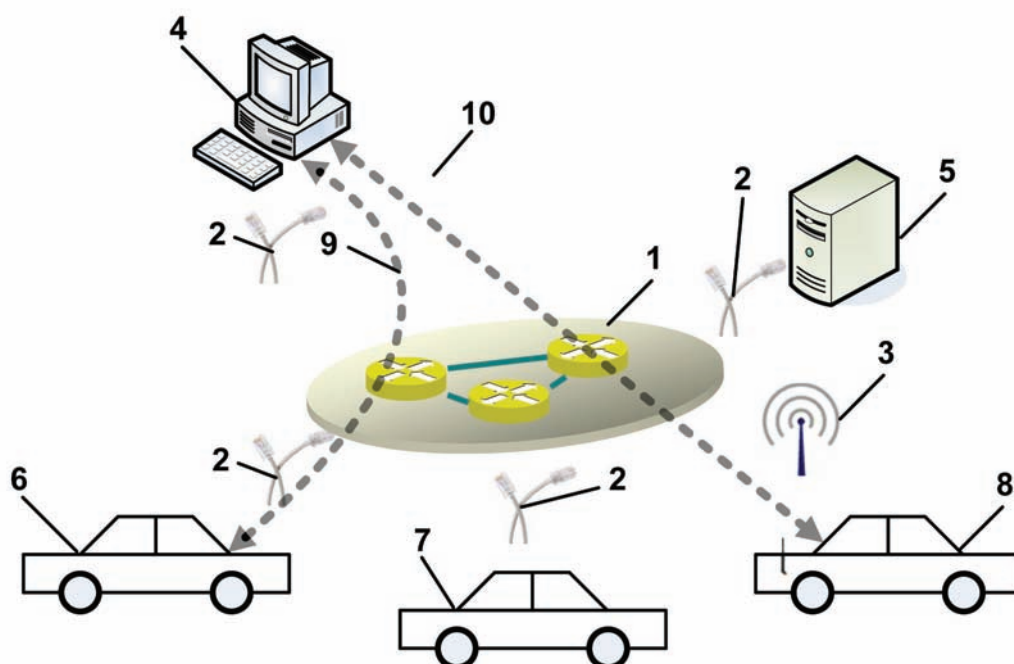9   logical connection no. 2 between external test equipment no. 2 (key item 5) and vehicle no. 2 (key item 7)

Figure 3 — Peer-to-peer connection through network

9.4   Networked connection between multiple vehicles and one instance of external test equipment

This communication scenario is identical to the scenario described in 9.3 from a vehicle point of view. Only the external test equipment shall be capable of supporting multiple connections (i.e. sockets).

This communication scenario can occur where there is, for instance, a dedicated flash reprogramming server which updates multiple vehicles at the same time (e.g. in dealership or manufacturing area).

Figure 4 depicts the network connection between single external test equipment and multiple vehicles.

Key

1 franchised dealership or repair workshop network
2 ethernet cable
3 WLAN
4 external test equipment (PC)
5 network server
6 vehicle no. 1
7 vehicle no. 2
8 vehicle no. 3
9 logical connection no. 1 between external test equipment (PC) (key item 4) and vehicle no. 1 (key item 6)
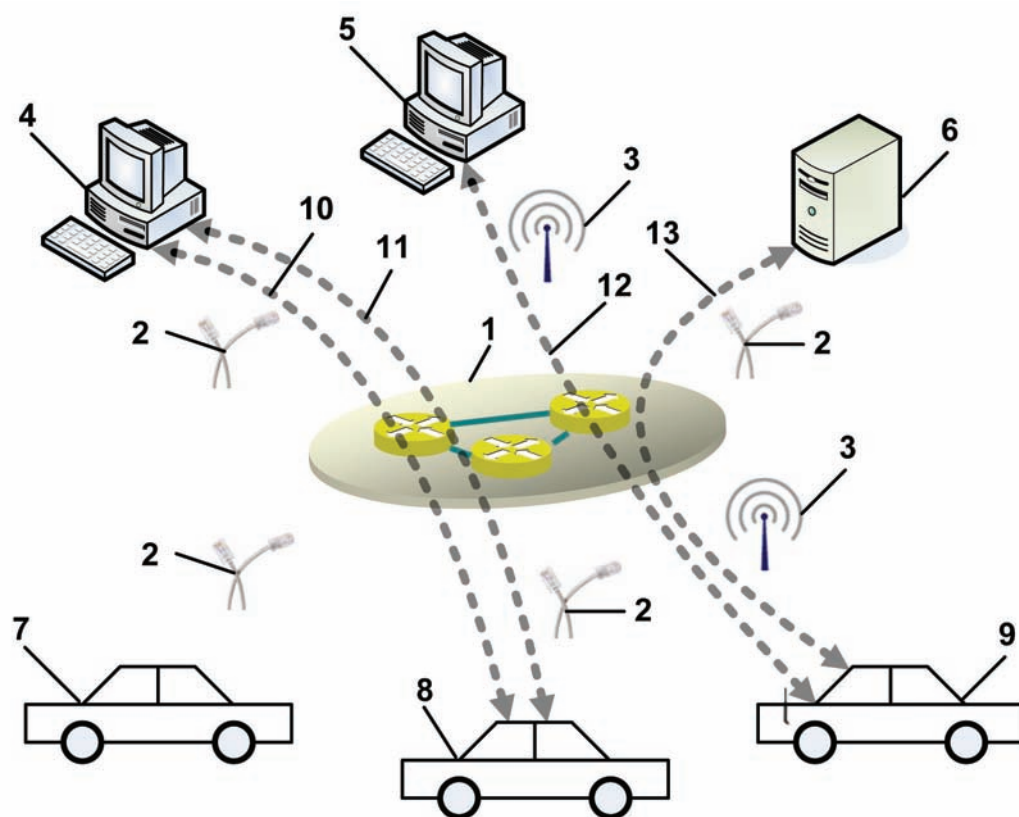10 logical connection no. 2 between external test equipment (PC) (key item 4) and vehicle no. 3 (key item 8)

Figure 4 — Network connection between single external test equipment and multiple vehicles

9.5 Networked connection between one vehicle and multiple instances of external test equipment or test applications on a single physical instance of external test equipment

This communication scenario is similar to the network configuration scenario described in 9.3 except for the fact that a vehicle may be capable of supporting more than one connection to external test equipment. In this case, the vehicle shall be capable of clearly separating diagnostic requests and responses for each external test equipment responsible for each logical link. Also, the test equipment or the applications running on a single instance of test equipment shall be capable of detecting that other test equipment instances or applications already communicate with the same vehicle and that, consequently, not all operations may be supported by the vehicle at the same time.

This communication scenario usually occurs when a vehicle is hooked up to an existing network or wireless infrastructure, which is also used by other vehicles and test equipment (e.g. manufacturing area) and separate instances of external test equipment or applications on the same computer perform different tasks on one vehicle (e.g. one external test equipment/application for flash reprogramming and another external test equipment /application for trouble shooting).

Figure 5 depicts the network connection between multiple instances of external test equipment and a single vehicle.

Key

1   franchised dealership or repair workshop network

2   ethernet cable

3   WLAN

4   external test equipment no. 1 (PC)

5   external test equipment no. 2 (PC)

6   network server

7   vehicle no. 1

8   vehicle no. 2

9   vehicle no. 3

10   logical connection no. 1 between external test equipment no. 1 (PC) (key item 4) and vehicle no. 2 (key item 8)

11   logical connection no. 2 between external test equipment no. 1 (PC) (key item 4) and vehicle no. 2 (key item 8)

12   logical connection no. 3 between external test equipment no. 2 (PC) (key item 5) and vehicle no. 3 (key item 9)

13   logical connection no. 4 between network server (key item 6) and vehicle no. 3 (key item 9)

Figure 5 — Network connection between multiple instances of external test equipment and single vehicle

9.6   Network characteristics

9.6.1   Overview

This subclause describes various network communication scenarios for transmitting IP packets over the network considering the following characteristics of the individual network topologies:

—   dropped packets and errors;

—   delay and jitter;

— out-of-order delivery;

— transmission rate.

9.6.2 Dropped packets and errors

This aspect describes the probability of packet loss (misdirection, corruption or dropping due to overload) on the involved networks. The more packets are lost on their way between the external test equipment and the vehicle, the more retransmissions of packets occur (TCP) or retries have to be performed by the application (UDP) to ensure that the desired data are successfully transferred.

9.6.3 Delay and jitter

This aspect describes the delay of packets in a network depending on the network technology and the involved routers between the individual networks, which are passed by the packets between the external test equipment and the vehicle. The more networks and routers are involved, the more time is needed by a packet to travel from the sender to the receiver. Jitter describes the varying delay of each individual packet, meaning that some packets can have a greater delay than others using the same or different networks and routers while travelling from the sender to the receiver.

9.6.4 Out-of-order delivery

If the individual packets travel over different networks from the sender to the receiver they can arrive in a different order than the order in which they were sent. Depending on the transport layer protocol used, re-ordering of packets to ensure the correct sequence is provided by these protocols (e.g. TCP) or shall separately be ensured on the application layer (e.g. UDP). Out-of-order delivery of packets with TCP as transport layer can result in delay of subsequent DoIP messages.

9.6.5 Transmission rate

This aspect describes the available bandwidth or overall data throughput of a network, respectively all involved networks between the external test equipment and the vehicle.

9.6.6 Qualitative assessment of characteristics

The network characteristics as described in 9.6.2 to 9.6.5 shall be considered when applying use cases and application layer protocols (e.g. timing parameters for diagnostic protocols) to specific network configurations. This implies that a specific use case (e.g. short timeout values over direct connection) cannot be used on every network configuration without requiring adaptations (e.g. extended timeout values over public network).

Table 6 provides a qualitative overview of the individual characteristics of typical network topologies from a vehicle and external test equipment point of view, including the following additional aspects:

— IP address assignment;

— vehicle discovery.

Table 6 — Qualitative assessment of characteristics for typical network topologies

Characteristic		Direct connection	Switched network	Different subnetworks over private network	Different subnetworks over public network
Transmission rate		Predictable	Predictable (requires greater effort)	Predictable (requires greater effort)	Unpredictable
		Dedicated bandwidth available	Average shared bandwidth guaranteed by network design	Average shared bandwidth guaranteed by network design	No guaranteed bandwidth
		e.g. 100MBit/s for 100BaseTx Ethernet	Individual bandwidth depends on overall network traffic	Individual bandwidth depends on overall network traffic	
Dropped packets and errors		Extremely low probability	Low probability	Average probability	High probability
Delay and jitter		No delay	Low delay	Average delay	Varying delay (low … high)
		No jitter	Low jitter	Average jitter	High jitter
Out-of-order delivery		No	No	Possible	Possible
IP address	Link-local AutoIP	Supported	Supported	Unusual	Unusual
				Requires special router configuration (e.g. NAT)	Requires special router configuration (e.g. NAT)
	Private IP address	Supported	Supported	Supported	Unusual
					Requires special router configuration (e.g. NAT)
	Public IP address	Supported	Supported	Supported	Supported
Vehicle discovery		Link-local broadcast	Link-local broadcast	Subnet-specific broadcast (requires knowledge about network topology)	Subnet-specific broadcast (requires knowledge about network topology)
		Unicast (requires knowledge of vehicle's IP address)	Unicast (requires knowledge of vehicle's IP address)	Unicast (requires knowledge of vehicle's IP address)	Unicast (requires knowledge of vehicle's IP address)

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[3]   ISO 27145-2, *Road vehicles — Implementation of World-Wide Harmonized On-Board Diagnostics (WWH-OBD) communication requirements — Part 2: Common data dictionary*[2)]

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[8]   SAE J2012-DA, *Diagnostic trouble code definitions*

[9]   SAE J1939:2011, *Recommended practice for a serial control and communications vehicle network*

[10]   SAE J1939-73:2010, *Application layer diagnostics*

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1)   Under preparation.

2)   To be published. (Revision of ISO/PAS 27145-2:2006)

3)   To be published. (Revision of ISO/PAS 27145-3:2006)