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ISO 13400-2

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

Part 2: Transport protocol and network layer services

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

Partie 2: Protocole de transport et services de la couche réseau

Reference number
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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 13400-2 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 emission-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, 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 easily be adapted to new physical and data link layers, including wired and wireless connections, by 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. When 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, 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), 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 this part of ISO 13400,

e) network layer (layer 3) services, specified in this part of ISO 13400, 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 7 layers	Vehicle manufacturer enhanced diagnostics	WWH-OBD document 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 this part of ISO 13400 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 2:
Transport protocol and network layer services

1 Scope

1.1 This part of ISO 13400 specifies the requirements for diagnostic communication between external test equipment and vehicle electronic components using Internet Protocol (IP) as well as the transmission control protocol (TCP) and user datagram protocol (UDP). This includes the definition of vehicle gateway requirements (e.g. for integration into an existing computer network) and test equipment requirements (e.g. to detect and establish communication with a vehicle).

1.2 This part of ISO 13400 specifies features that can be used to detect a vehicle in a network and enable communication with the vehicle gateway as well as with its sub-components during the various vehicle states. These features are separated into two types: mandatory and optional.

1.3 This part of ISO 13400 specifies the following mandatory features:

— vehicle network integration (IP address assignment);

— vehicle announcement and vehicle discovery;

— vehicle basic status information retrieval (e.g. diagnostic power mode);

— connection establishment (e.g. concurrent communication attempts), connection maintenance and vehicle gateway control;

— data routing to and from the vehicle's sub-components;

— error handling (e.g. physical network disconnect).

1.4 This part of ISO 13400 specifies the following optional features:

— DoIP entity status monitoring;

— DoIP entity firewall capabilities.

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 3779, *Road vehicles — Vehicle identification number (VIN) — Content and structure*

ISO 13400-1, *Road vehicles — Diagnostic communication over Internet Protocol (DoIP) — Part 1: General information and use case definition*

ISO 13400-3, *Road vehicles — Diagnostic communication over Internet Protocol (DoIP) — Part 3: Wired vehicle interface based on IEEE 802.3*

IEEE 802.3, *IEEE Standard for Information Technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

IETF RFC 147, *The Definition of a Socket*

IETF RFC 768, *User Datagram Protocol*

IETF RFC 791 (September 1981), *Internet Protocol — DARPA Internet Program — Protocol Specification*

IETF RFC 792, *Internet Control Message Protocol — DARPA Internet Program — Protocol Specification*

IETF RFC 793, *Transmission Control Protocol — DARPA Internet Program — Protocol Specification*

IETF RFC 826, *An Ethernet Address Resolution Protocol*

IETF RFC 1122, *Requirements for Internet Hosts — Communication Layers*

IETF RFC 2131, *Dynamic Host Configuration Protocol*

IETF RFC 2132, *DHCP Options and BOOTP Vendor Extensions*

IETF RFC 2460, *Internet Protocol, Version 6 (IPv6) — Specification*

IETF RFC 2375, *IPv6 Multicast Address Assignments*

IETF RFC 3315, *Dynamic Host Configuration Protocol for IPv6 (DHCPv6)*

IETF RFC 3484, *Default Address Selection for Internet Protocol version 6 (IPv6)*

IETF RFC 3927, *Dynamic Configuration of IPv4 Link-Local Addresses*

IETF RFC 4291, *IP Version 6 Addressing Architecture*

IETF RFC 4443, *Internet Control Message Protocol (ICMP v6) for the Internet Protocol Version 6 (IPv6) Specification*

IETF RFC 4702, *The Dynamic Host Configuration Protocol (DHCP) Client Fully Qualified Domain Name (FQDN) Option*

IETF RFC 4861, *Neighbor Discovery for IP version 6 (IPv6)*

IETF RFC 4862, *IPv6 Stateless Address Autoconfiguration*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13400-1 and the following apply.

3.1.1
diagnostic power mode
abstract vehicle internal power supply state which affects the diagnostic capabilities of all ECUs on the in-vehicle networks and which identifies the state of all ECUs of all gateway sub-networks that allow diagnostic communication

NOTE The intent is to provide information to the external test equipment about whether diagnostics can be performed on the connected vehicle or whether the vehicle needs to be put into a different diagnostic power mode (i.e. technician interaction required). In this part of ISO 13400, the following states are relevant: Not Ready (not all ECUs accessible via DoIP can communicate), Ready (all ECUs accessible via DoIP can communicate) and Not Supported (the Diagnostic Information Power Mode Information Request message is not supported).

3.1.2
DoIP edge node
host inside the vehicle, where an Ethernet activation line in accordance with ISO 13400-3 is terminated and where the link from the first node/host in the external network is terminated

NOTE Adapted from ISO 13400-3:2011, 3.1.2.

3.1.3
network node
component which is connected to the IP-based network (e.g. Ethernet) and which communicates using Internet Protocol but does not implement the DoIP protocol

NOTE 1 Ethernet is an example of an IP-based network.

NOTE 2 Some network nodes might also be connected to a vehicle sub-network, but they are not DoIP gateways as they don’t implement the DoIP protocol. Consequently, these network nodes do not interact with (e.g. respond to) DoIP-compliant external test equipment.

3.1.4
host
node connected to the IP-based network

3.1.5
invalid source address
source address that is outside the range reserved for testers

3.1.6
logical address
means of identifying a diagnostics application layer entity

3.1.7
socket
unique identification, as defined in IETF RFC 147, to or from which information is transmitted in the network

3.1.8
unknown source address
source address that is not listed in the connection table entry

3.1.9
vehicle sub-network
vehicle network which is not directly connected to the IP-based network

NOTE Data can only be sent to and from a vehicle sub-network through the connecting DoIP gateway.

3.2 Symbols

<d> payload length, given in bytes

<m> number of concurrent DoIP TCP sessions that the external test equipment is required to support in order to connect to one or more DoIP entities

<n> number of concurrent DoIP TCP sessions that the DoIP entity needs to support in order to accept one up to n concurrent connections to one or more items of external test equipment

<u>, <v> number of individual ECUs in a vehicle sub-network

<w> number of individual DoIP gateways in a vehicle network

<x> number of individual in-vehicle network nodes

<y> number of individual vehicle DoIP nodes in a vehicle network

<z> number of individual vehicle external network nodes

3.3 Abbreviated terms

Alt	alternative
ARP	address resolution protocol
ASCII	American standard code for information interchange
Auto-MDI(X)	automatic medium-dependent interface crossover
CAN	controller area network
DHCP	dynamic host control protocol
DNS	domain name system
DoIP	diagnostic communication over Internet Protocol
ECU	electronic control unit
EID	entity identification (see Table 19)
FMI	failure mode indicator
GID	group identification (see Table 19)
GUI	graphical user interface
IANA	internet assigned numbers authority (see References [13] and [14])
ICMP	internet control message protocol
IETF RFC	Internet Engineering Task Force Request for Comments
IP	Internet Protocol
IPv4	Internet Protocol version 4 (see IETF RFC 791)
IPv6	Internet Protocol version 6 (see IETF RFC 2460)
MAC	media access control
MSC	message sequence chart
NDP	neighbour discovery protocol
OEM	original equipment manufacturer
OSI	Open Systems Interconnection
SA	source address
SDU	service data unit
SPN	suspect parameter number
TA	target address
TCP	transmission control protocol
UDP	user datagram protocol
VIN	vehicle identification number (see ISO 3779)
XOR	exclusive or

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

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.

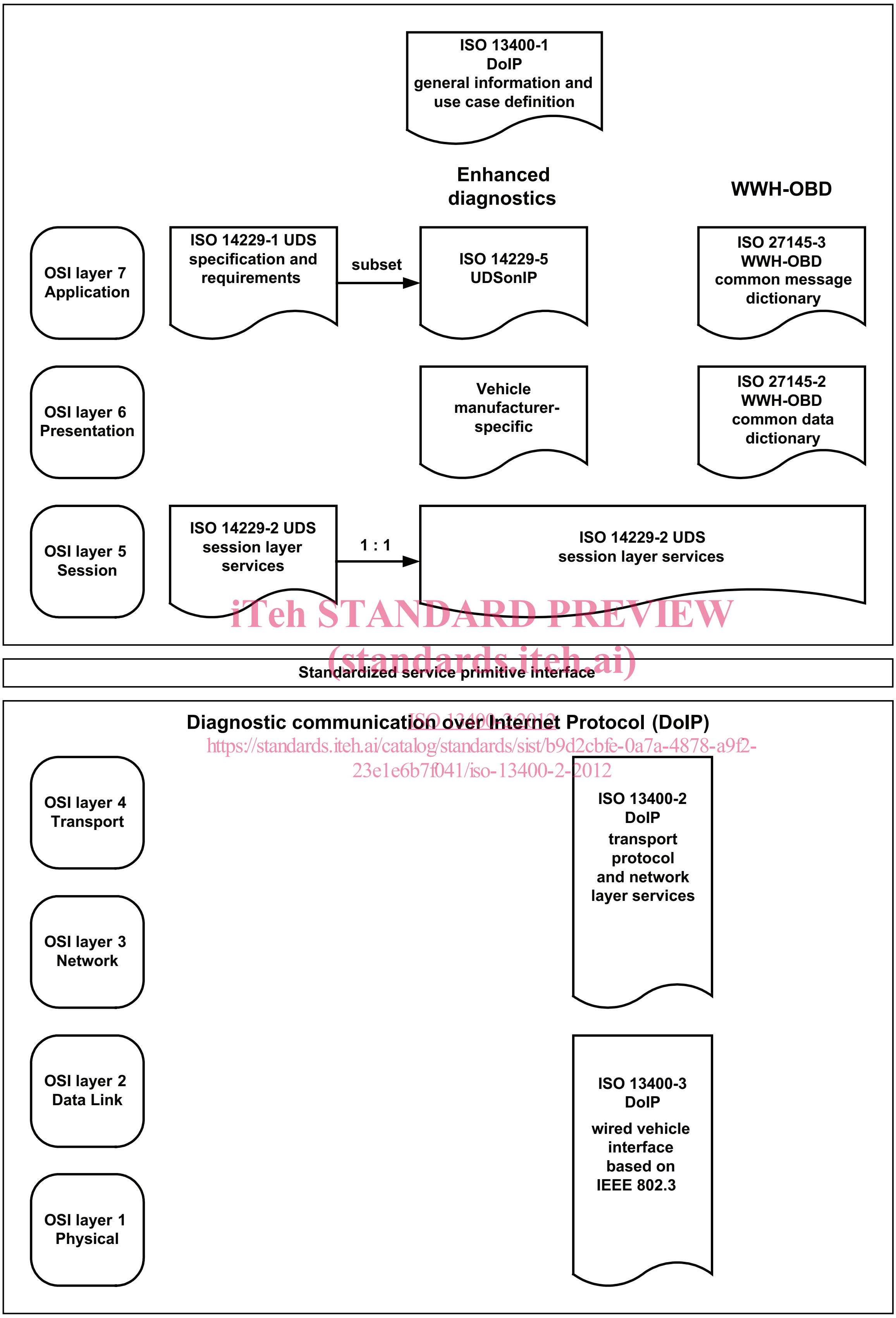

Figure 1 — DoIP document reference according to OSI model

6 Basic requirements for implementation of internet protocols

6.1 General considerations

Subclauses 6.2 to 6.5 specify the requirements that shall be implemented by a vehicle in order to allow for communication between the vehicle and external test equipment. Usually, this protocol standard is implemented by one or more DoIP entities, depending on the vehicle's network architecture. Figure 2 shows an example of the vehicle network architecture.

In this part of ISO 13400, the requirements are assigned a unique number of the form "DoIP-yyy", allowing for easier requirement tracking and test case specification in ISO 13400-5.

NOTE Requirements in this part of ISO 13400 are not numbered sequentially because the order of individual requirements changed during document development.

Requirements formulated as "The vehicle shall implement…" imply that all DoIP entities shall implement the required functionality if not explicitly stated otherwise. If multiple DoIP entities are present on a vehicle network, implementation details may differ slightly for each DoIP entity (e.g. for identification purposes), so that the external test equipment is able to identify the individual DoIP gateways that support this protocol standard.

Where reference is made to RFC documents, note that the forms "must/must not" are used to express requirements in these documents.

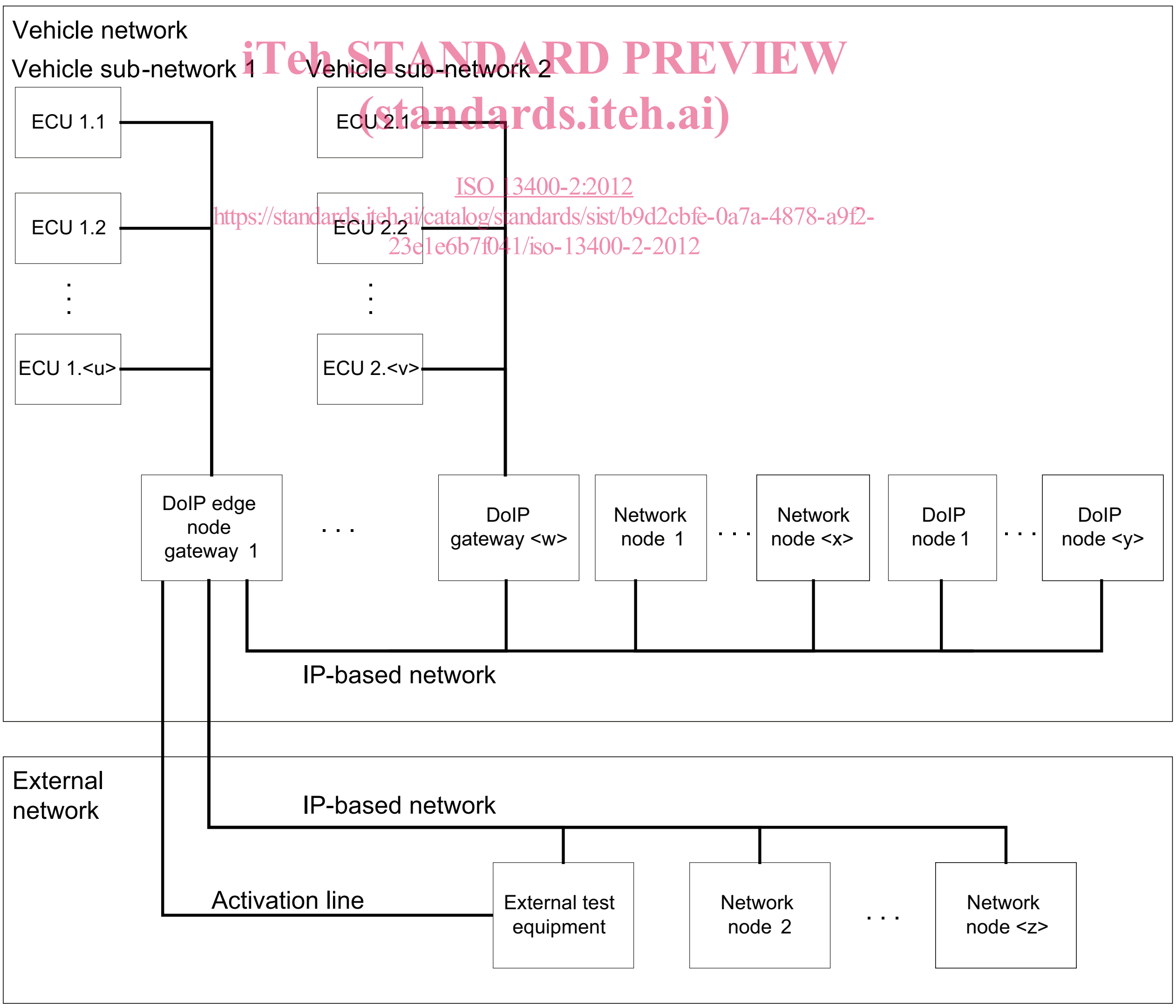

Figure 2 — Vehicle network architecture schematics (functional view)

[DoIP-108] Each DoIP entity on a vehicle network shall implement the protocol standard specified in this part of ISO 13400.

6.2 Network layer requirements

6.2.1 MAC-layer

[DoIP-146] MAC addresses shall be unique and in accordance with IEEE 802.3.

The MAC layer may limit the maximum transport unit (MTU). For IEEE 802.3 based systems, the limit is usually approximately 1 500 Bytes. In IEEE 802.3 based systems, there is no provision for fragmentation at this layer, so the upper layer (IP) will have to handle fragmentation (i.e. send a single data packet in multiple IP packets which fit into the MTU size of the Ethernet frames).

6.2.2 Internet Protocol (IP)

The protocol specified in this part of ISO 13400 is based on the Internet Protocol standards known as IPv4 (see IETF RFC 791) and IPv6 (see IETF RFC 2460). Although the mandatory features of this part of ISO 13400 are intended to be based on IPv6 only, use of IPv4 is specified for applications of this communication protocol in network areas where backward compatibility to IPv4 is required. The Internet Protocol is datagram based, unreliable and located on the network layer in accordance with the OSI layered architecture model (see Table 2). IP is the first transmission-medium-independent protocol.

The process of how a node acquires an IP address is described in 6.4.2.

Table 2 — IPv4/IPv6 on OSI layers

OSI layer	Protocol	
Network	IPv6 (IETF RFC 2460; preferred)	IPv4 (IETF RFC 791; for backward compatibility reasons only)
Data link / Physical	e.g. Ethernet (IEEE 802.3)	

[DoIP-109] All DoIP entities on a vehicle wireline network shall implement the same Internet Protocol version, either IPv4 in accordance with IETF RFC 791 or IPv6 in accordance with IETF RFC 2460.

It is recommended that IPv6 be used in order to benefit from the advantages (e.g. link local IP address assignment; faster forwarding through routers) of this protocol version. IPv4 may only be used for backward compatibility reasons (e.g. for integration into existing dealership IP networks). The support of Jumbograms for IPv6 is optional and consequently compliance with IETF RFCs related to Jumbograms is not required in this part of ISO 13400.

NOTE Interaction of the vehicle wireline DoIP entities with a future wireless IPv6 entity will form the subject of future International Standards.

In accordance with 6.2.1, the MAC layer is not responsible for fragmentation.

6.2.3 Address resolution protocol (IPv4) and neighbour discovery for IP version 6 (IPv6)

The address resolution protocol (ARP) and the neighbour discovery protocol (NDP) are methods for determining a host's hardware (MAC) address when only the host's IP address is known. They are also used to verify whether an IP address is in use by another host. ARP is located on the network layer, in accordance with the OSI layered architecture model (see Table 3).

Table 3 — ARP on OSI layers

OSI layer	Protocol
Network	IPv4: ARP (IETF RFC 826) IPv6: NDP (IETF RFC 4861)
Data link / Physical	e.g. Ethernet (IEEE 802.3)

[DoIP-110] If IPv4 is used, each DoIP entity shall implement ARP as defined in IETF RFC 826.

NOTE Usually, each host that implements IPv4 also implements ARP, as it is an essential part of IPv4 communication over Ethernet-based networks. Implementation of the reverse address resolution protocol (RARP) is not required as this requires a RARP server as part of the network, which is not mandatory in IPv4 networks.

[DoIP-111] If IPv6 is used, each DoIP entity shall implement NDP as defined in IETF RFC 4861.

6.2.4 Internet control message protocol (ICMP)

The internet control message protocol (ICMP) is part of the IP suite and is used to send error messages, e.g. to indicate that a requested service is not available or that a host could not be reached. Consequently, ICMP is a mandatory part of an IP stack implementation and is located on the network layer, in accordance with the OSI layered architecture model (see Table 4).

Table 4 — ICMP on OSI layers

OSI layer	Protocol
Network	IPv4: ICMP (IETF RFC 792) IPv6: ICMPv6 (IETF RFC 4443)
Data link / Physical	e.g. Ethernet (IEEE 802.3)

[DoIP-112] If IPv4 is used, each DoIP entity shall implement ICMP as specified in IETF RFC 792.

[DoIP-113] If IPv6 is used, each DoIP entity shall implement ICMPv6 as specified in IETF RFC 4443.

6.3 Transport Layer requirements

6.3.1 Transmission control protocol (TCP)

The transmission control protocol (TCP) is a connection-oriented protocol, where applications on networked hosts can establish connections to one another, over which data can be exchanged. The protocol guarantees reliable and in-order delivery of sender-to-receiver data. Additionally, TCP provides flow control and congestion control and also provides for various algorithms in order to handle congestion and influence flow control. This part of ISO 13400 does not specify the specific algorithm that should be used. TCP is located on the transport layer, in accordance with the OSI layered architecture model (see Table 5).

Table 5 — TCP on OSI layers

OSI layer	Protocol
Transport	TCP (IETF RFC 793)
Network	IP (IPv4, IPv6)
Data link / Physical	e.g. Ethernet (IEEE 802.3)