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Road vehicles — In-vehicle Ethernet —

Part 10:
Transport layer and network layer conformance test plans

Véhicules routiers — Ethernet embarqué —

Partie 10: Plans de test de conformité des couches transport et réseau

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

A list of all parts in the ISO 21111 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 21111 series includes in-vehicle Ethernet requirements and test plans that are disseminated in other International Standards and complements them with additional test methods and requirements. The resulting requirement and test plans are structured in different documents following the Open Systems Interconnection (OSI) reference model and grouping the documents that depend on the physical media and bit rate used.

In general, the Ethernet requirements are specified in ISO/IEC/IEEE 8802-3. The ISO 21111 series provides supplemental specifications (e.g. wake-up, I/O functionality), which are required for in-vehicle Ethernet applications. In road vehicles, Ethernet networks are used for different purposes requiring different bit-rates. Currently, the ISO 21111 series specifies the 1-Gbit/s optical and 100-Mbit/s electrical physical layer.

The ISO 21111 series contains requirement specifications and test methods related to the in-vehicle Ethernet. This includes requirement specifications for physical layer entity (e.g. connectors, physical layer implementations) providers, device (e.g. electronic control units, gateway units) suppliers, and system (e.g. network systems) designers. Additionally, there are test methods specified for conformance testing and for interoperability testing.

Safety (electrical safety, protection, fire, etc.) and electromagnetic compatibility (EMC) requirements are out of the scope of the ISO 21111 series.

The structure of the specifications given in the ISO 21111 series complies with the Open Systems Interconnection (OSI) reference model specified in ISO/IEC 7498-1[1] and ISO/IEC 10731[2].

ISO 21111-1 defines the terms which are used in this series of standards and provides an overview of the standards for in-vehicle Ethernet including the complementary relations to ISO/IEC/IEEE 8802-3, the document structure, type of physical entities, in-vehicle Ethernet specific functionalities and so on.

ISO 21111-2 specifies the interface between reconciliation sublayer and physical entity including reduced gigabit media independent interface (RGMII), and the common physical entity wake-up and synchronized link sleep functionalities, independent from physical media and bit rate.

ISO 21111-2 specifies supplemental requirements to a physical layer capable of transmitting 1-Gbit/s over plastic optical fibre compliant with ISO/IEC/IEEE 8802-3, with specific application to communications inside road vehicles, and a test plan for physical entity conformance testing.

ISO 21111-4 specifies the optical components requirements and test methods for 1-Gbit/s optical invehicle Ethernet.

ISO 21111-5 specifies, for 1-Gbit/s optical in-vehicle Ethernet, requirements on the physical layer at system level, requirements on the interoperability test set-ups, the interoperability test plan that checks the requirements for the physical layer at system level, requirements on the device-level physical layer conformance test set-ups, and device-level physical layer conformance test plan that checks a set of requirements for the OSI physical layer that are relevant for device vendors.

ISO 21111-6 specifies advanced features of an ISO/IEC/IEEE 8802-3 in-vehicle Ethernet physical layer (often also called transceiver), e.g. for diagnostic purposes for in-vehicle Ethernet physical layers. It specifies advanced physical layer features, wake-up and sleep features, physical layer test suite,

physical layer control requirements and conformance test plan, physical sublayers test suite and physical sublayers requirements and conformance test plan.

ISO 21111-7 specifies the implementation for ISO/IEC/IEEE 8802-3:2021, which defines the interface implementation for automotive applications together with requirements on components used to realize this Bus Interface Network (BIN). ISO 21111-7 also defines further testing and system requirements for systems implemented according to the system specification. In addition, ISO 21111-7 defines the channels for tests of transceivers with a test wiring harness that simulates various electrical communication channels.

ISO 21111-8 specifies the transmission media, the channel performance and the tests for ISO/IEC/IEEE 8802-3 in-vehicle Ethernet.

ISO 21111-9 specifies the data link layer requirements. It specifies the requirements for devices and systems with bridge functionality.

This document specifies the transport layer and network layer requirements and conformance test plans. It specifies the conformance test plans for devices and systems that include functionality related with OSI layers from 4 and 3.

ISO 21111-11 specifies the application layer to session layer requirements and conformance test plans. It specifies the conformance test plans for devices and systems that include functionality related with OSI layers from 7 to 5.

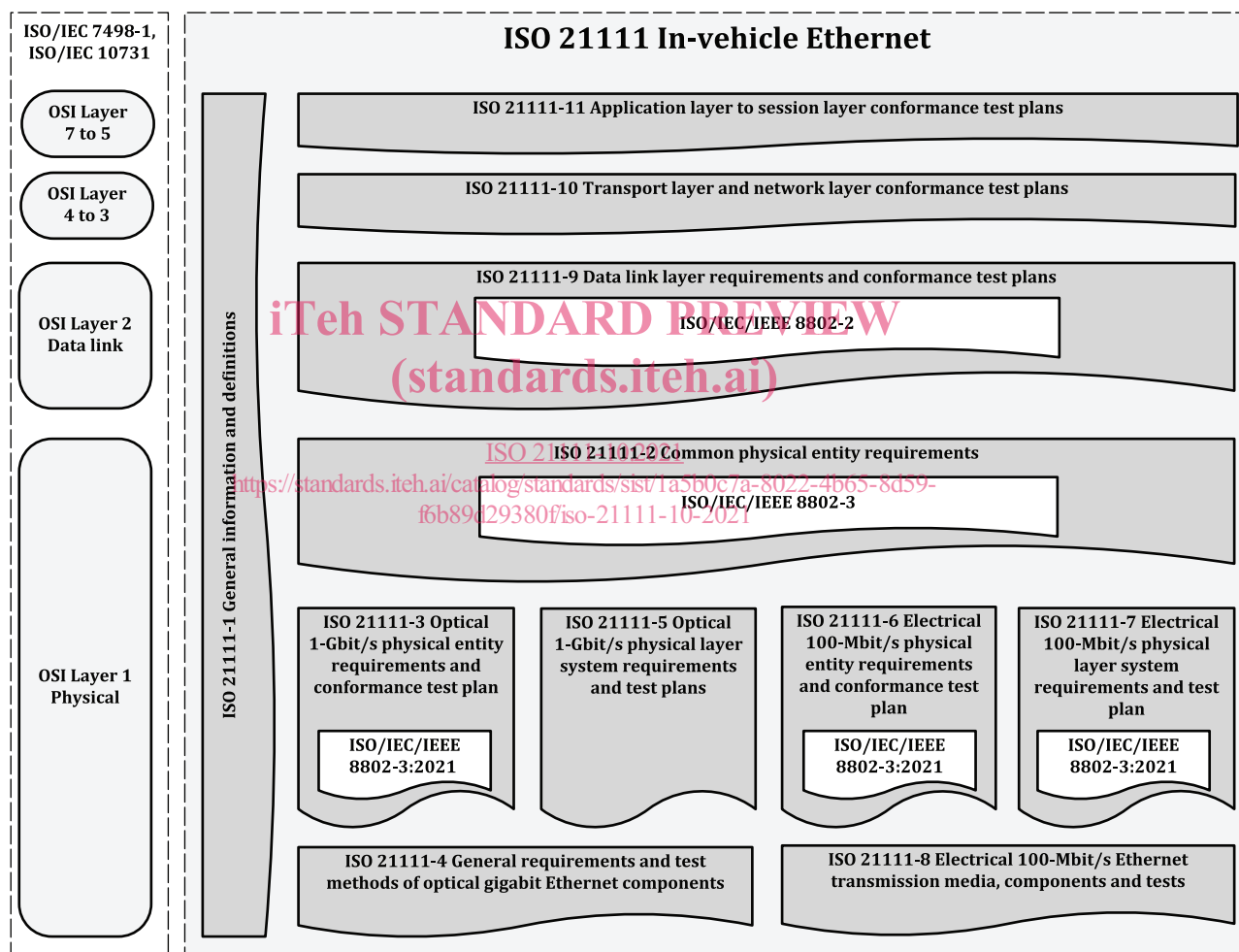Figure 1 shows the parts of the ISO 21111 series and the document structure.

Figure 1 — In-vehicle Ethernet documents reference according to OSI model

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Road vehicles — In-vehicle Ethernet —

Part 10:
Transport layer and network layer conformance test plans

1 Scope

This document specifies in-vehicle Ethernet transport layer and network layer conformance test plans (CTP) for electronic control units (ECUs). This document is a collection of all conformance test cases which are recommended to be considered for automotive use and should be referred by car manufacturers within their quality control processes.

The document includes conformance test plans for the address resolution protocol, Internet control message protocol version 4, Internet protocol version 4, Internet protocol version 4 auto configuration, user datagram protocol, transport control protocol, and dynamic host configuration protocol version 4.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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/IEC 9646-1, *Information technology — Open Systems Interconnection — Conformance testing methodology and framework — Part 1: General concepts*

ISO 21111-1, *Road vehicles — In-vehicle Ethernet — Part 1: General information and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21111-1, ISO/IEC 9646-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
REPEAT
pseudo code command for an iteration

3.2
full-sized segment
segment with size equal to the effective send MSS

3.3
result code
value attributed to a result

3.4
generic result code
specific and universal value attributed to a result

3.5
full-window operation
IUT's TCP has reached a state where it is allowed to send data segments of size of test system Host-1's entire receive without getting any acknowledgement from the test system Host-1

4 Symbols and abbreviated terms

4.1 Symbols

—	empty table cell or feature undefined
V_{BAT}	voltage of the battery
$t_{ARP\text{-}Dynamic\text{-}Cache\text{-}Timeout}$	time for which a dynamic entry is present in the ARP cache
$t_{ARP\text{-}Dynamic\text{-}Cache\text{-}Tolerance}$	tolerance time for the ARP dynamic cache of the IUT to get refreshed
$t_{ARP\text{-}Tolerance}$	IUT: tolerance time for the ARP cache of the IUT to get refreshed
	LT: time variance associated to any wait-event
$t_{Valid\text{-}Time\text{-}To\text{-}Live}$	time interval of IP datagram send
$t_{Listen\text{-}Time}$	maximum time interval for which the LT waits for an ICMP reply segment
$t_{Fragment\text{-}Reassemly\text{-}Timeout}$	fragment reassembly timeout
$t_{Valid\text{-}Time\text{-}To\text{-}Live}$	value used in IP datagram send
t_{Probe_Min}	value of PROBE_MIN constant
t_{Probe_Max}	value of PROBE_MAX constant
$t_{Announce\_Wait}$	value of ANNOUNCE_WAIT constant
$t_{Announce\_Interval}$	value of ANNOUNCE_INTERVAL constant
$t_{Rate\_Limit\_Interval}$	value of RATE_LIMIT_INTERVAL constant
$t_{Defend\_Interval}$	value of DEFEND_INTERVAL constant

4.2 Abbreviated terms

ACK	acknowlege
Addr	address
AL	application layer
ANVL	automated network validation library
ARL	address resolution lookup
ARP	address resolution protocol
ASP	abstract service primitive
CTC	conformance test case

CTP	conformance test plan
EMC	electromagnetic compatibility
EOP	end of option
ETS	enhanced testability service
FIF	filtering of incoming frames
FIN	finish control flag
FINWAIT	finish wait
GEN	general requirements
GND	ground
ICMP	internet control message protocol
IHL	Internet header length
IUT	implementation under test
IUT-Iface	IUT physical layer interface
ISN	initial sequence number
LT	lower tester
LT-Iface	LT physical layer interface
MSL	maximum segment lifetime
MSS	maximum segment size
MTU	maximum transmission unit
Mv	manipulated value
NL	network layer
NOP	no operation
PCO	points of control and observation
PHY	physical layer
PSH	push
QOS	qualitiy of service and audio/video bridging
RCVD	received
RCV.NXT	receive next
RPC	remote procedure call
RST	reset
RTO	retransmission timeout

SEQ	sequence
SL	session layer
SUT	system under test
SYN	synchronize control flag
SYN-RCVD	SYN received
SYN-SENT	SYN sent
TCP	transmission control protocol
TIME	time synchronisation
TL	transport layer
UDP	user datagram protocol
UT	upper tester

5 Conventions

This document is based on OSI service conventions as specified in ISO/IEC 10731[2].

6 CTP test system set-up and CTC structure

6.1 General

This document specifies a CTP according to the requirements as specified in the ISO/IEC 9646 series. A CTP does not provide qualification of test results but expected responses of the IUT. A CTP is used by a test house to develop a conformance test specification specific for the test system used in their lab environment.

The CTCs specified in this document are organized in such a manner as to simplify the identification of information related to a test and to facilitate in the actual testing process. CTCs are organized into groups, primarily in order to reduce set-up time in the lab environment. The different groups typically also tend to focus on specific aspects of device functionality.

A CTC reference name, e.g. "ARP_03 – ARP entry learned on ARP request (no ARP request)" is used to organize the CTC name, where:

— CTC indicates that this is a conformance test case;

— name/subject of CTC;

— supplemental name, e.g. ARP, which is address resolution protocol;

— CTC number;

— after the hyphen a descriptive name of the CTC follows.

The CTC definitions themselves are intended to provide a high-level description of the purpose, references, prerequisite, steps/procedures, expected responses, remarks, and methodologies pertinent to each test (see 6.3).

6.2 Test system set-up

The test system topology follows ISO/IEC 9646-1 and consists of a test set-up which consists of a test system and a system under test (SUT) connected via the physical medium. The test system implements a UT and an LT. The UT uses the test control protocol (Figure 2, key 2) to control the LT. The LT supports the functionality required to test the OSI layer (Figure 2, key 5, key 6, and key 7) of the IUT. The test system uses IUT-specific set-up parameters (Figure 2, key 1) for testing the communication with the IUT.

The control and measurement functionality is provided by direct logical access to the service interface (dashed line) (Figure 2, key 3) and the associated parameters of the OSI layer. The UT in the IUT (Figure 2, key 4) supports an equivalent part of the abstract service interface (ASPs, PCO) (dashed line) (Figure 2, key 3) and the associated parameters to control and measure the state(s) of the IUT.

The UT conformance test controller in the test system manipulates the service primitive interface parameters in the IUT via the ASPs (ETSs) and PCO of the OSI layers to fulfil the purpose of each CTC.
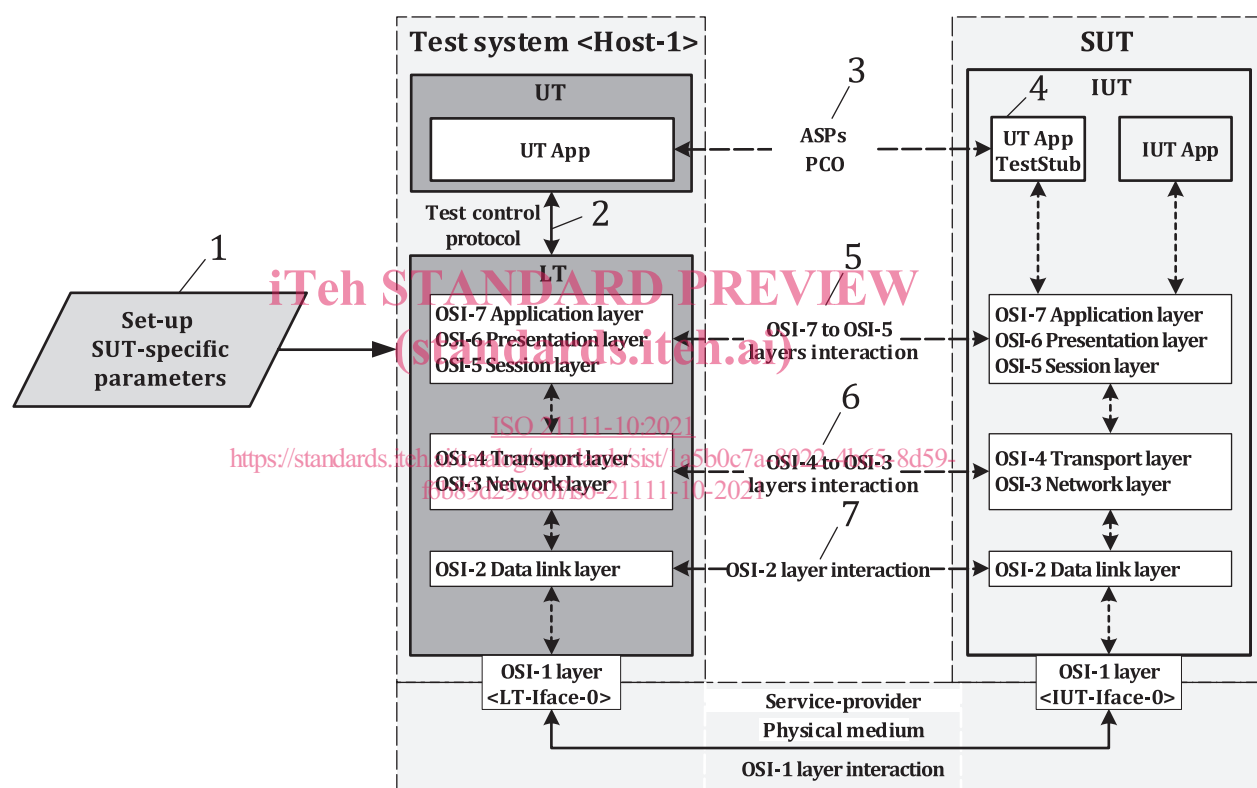
Key

1 set-up parameters (node's electronic data sheet)
2 test control protocol
3 points of control and observation (PCO) and abstract service primitives (ASPs) based on enhanced testability services (ETS)
4 UT application with ETS interface
5 OSI layer 7 to 5 protocol
6 OSI layer 4 to 3 protocol
7 OSI layer 2 protocol

Figure 2 — Test system set-up

6.3   CTC definition

CTCs are independent of one another. Each CTC checks the behaviour of the IUT for a particular purpose of this document. CTCs, which require variations of individual parameters, shall be repeated for each value of the parameter. Each CTC is specified according to a common CTC structure as shown in Table 1.

Table 1 — CTC structure

Item	Content
CTC # – Title	CTC_x.y.z-a – CTC structure
Purpose	The purpose is a brief statement outlining what the test attempts are to achieve. The test is written at the functional level. It is recommended to begin the description of purpose with "This CTC verifies …".
Reference	The purpose of reference is to specify source material external to the test suite, including any other references that might be helpful in understanding the test methodology and/or test results. External sources are always referenced by number when mentioned in the test description. Any other references not specified by number are stated with respect to the test suite document itself. EXAMPLE AUTOSAR SOME/IP Protocol Specification, R20-11,[13] PRS_SOMEIP_00042; PRS_SOMEIP_00099; …
Prerequisite	The purpose of prerequisites is to specify the test hardware and/or software needed to perform the CTC. This is generally expressed in terms of minimum requirements. In some cases, specific equipment manufacturer/model information may be provided. EXAMPLE The IUT is running and offering the enhanced testability service.
Set-up	The purpose of set-up is to describe the initial configuration of the test environment. Small changes in the configuration should not be included here and are generally covered in the test procedure below. EXAMPLE The test system set-up shall be in accordance with Figure 3.
Step	The test procedure includes the test description, which contains the systematic instructions for carrying out the test. It provides a cookbook approach to testing and may be interspersed with observable results. Each test step shall have a numeric number in ascending order. 1. Configure the IUT as master or as slave. 2. Establish a valid link with the IUT. 3. Monitor the transmissions from the IUT and cause the management to request a PMA reset while simultaneously ceasing transmissions from the test system.
Iteration	The purpose of test iterations is to include test procedure definitions, which are repeated more than once. a) REPEAT step 2 to step 3 with the IUT configured as master, 1 time. b) REPEAT step 2 to step 3 with the IUT configured as slave, 1 time.
Expected response	The purpose of expected response is to describe the expected results to be examined by the test system Host-1 in order to verify that the IUT is operating. When multiple values for an observable are possible, this description provides a short discussion on how to interpret them. The determination of a pass or fail outcome for a particular test is generally based on the successful (or unsuccessful) detection of a specific observable. After iteration a): The IUT stops transmitting with tx_mode = SEND_N and starts transmitting with tx_mode = SEND_I for 1 iteration a). The IUT sets link_status = FAIL. After iteration b): The IUT stops transmitting for 1 iteration b). The IUT sets link_status = FAIL.
Remark	The purpose of remarks is to describe known issues with the test procedure, which can affect test results in certain situations. It can also refer the reader to test suite annexes and/or white papers that can provide more detail regarding these issues.

6.4   Terminology used in CTCs

Table 2 specifies the terminology used in CTCs.

Table 2 — Terminology used in CTCs

Name	Content
Upper tester (UT)	Entity which is responsible for controlling the LT via the test control protocol and the IUT UT ETS via the abstract service primitives (ASPs).
Lower tester (LT)	Entity which is responsible for validating the implementation under test (IUT).
IUT_CONFIGURE	This entry causes the IUT to configure/execute various commands for clearing cache, adding static address, send echo request, etc.
IUT	Implementation under test in the SUT.
CLEANUP	This is a command, which causes the IUT to remove the static entry from its ARP cache.

6.5   IUT prerequisites – TCP/IP TestStub

6.5.1   General

The TCP/IP TestStub defines interfaces required to test the TCP/IP communication stack functionality.

The protocol parts covered by the TCP/IP TestStub include:

— UDP and TCP – socket connection establishment and termination;

— UDP and TCP – message transmission and reception.

The TCP/IP TestStub is specified in Reference [14] (AUTOSAR). This document references a subset of the AUTOSAR specification.

6.5.2   TCP/IP TestStub service primitives

Table 3 references *AUTOSAR Testability Protocol and Service Primitives, TC Release 1.1.0*, '6.10 Service Primitives'[14]. A subset of service primitives are supported by the UT to observe and control the TCP/IP UT TestStub in the IUT.

Table 3 provides an overview of the service primitives, the identifier, applicability and applicability of UDP and TCP.

Table 3 — TCP/IP TestStub methods (service primitives)

Method name (service primitive)	Identifier	Applicability	UDP	TCP
GET_VERSION	1_{16}	optional	—	—
START_TEST	2_{16}	mandatory	—	—
END_TEST	3_{16}	mandatory	—	—
CLOSE_SOCKET	0_{16}	—	mandatory	mandatory
CREATE_AND_BIND	1_{16}	—	mandatory	mandatory
SEND_DATA	2_{16}	—	mandatory	mandatory
RECEIVE_AND_FORWARD	3_{16}	—	mandatory	mandatory
LISTEN_AND_ACCEPT	4_{16}	—	—	mandatory
CONNECT	5_{16}	—	—	mandatory
SHUTDOWN	7_{16}	—	—	optional
Key				
— empty cell/undefined				