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Intelligent transport systems — Communications access for land mobiles (CALM) — Non-IP networking

Systèmes intelligents de transport — Accès aux communications des services mobiles terrestres (CALM) — Réseautique non-IP

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 29281 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

This International Standard is part of a family of International Standards based on the communications access for land mobiles (CALM) concept. These International Standards specify a common architecture (see ISO 21217), network protocols and communication interface definitions for wired and wireless communications using various access technologies including cellular 2nd generation, cellular 3rd generation, satellite, infra-red, 5 GHz microwave, 60 GHz millimetre-wave and mobile wireless broadband. These and other access technologies that can be incorporated are designed to provide broadcast, unicast and multicast communications between mobile stations, between mobile and fixed stations and between fixed stations in the intelligent transport systems (ITS) sector.

A fundamental advantage of the CALM concept over traditional systems is that applications are abstracted from the access technologies that provide the wireless connectivity and the networks that transport the information from the source to the destination(s). This means that ITS stations are not limited to a single access technology and networking protocol and can implement any of those supported, and the ITS station management can make optimal use of all these resources. To exploit this flexibility, CALM-complaint systems may support handover of different types including

— those involving a change of communication interface without a change of access technology,

— those involving a change of communication interface with a change of access technology,

— those involving reconfiguration or change of the network employed to provide connectivity, and

— those involving both a change in communication interface and network reconfiguration.

A detailed introduction to the CALM family of International Standards is provided in ISO 21217.

There are applications and services in the ITS sector that are not well suited to IPv6 networking. Due to the rapidly changing topologies that can be encountered in ITS communications and the importance of physical location in some circumstances, networking & transport layer protocols specifically designed for efficiency (low-overhead, rapid initialization, etc.) and others based on geo-addressing and multi-hopping mechanisms are necessary to enable a much larger class of applications and services than would be possible with only IP networking. Examples of such applications include

— time-critical vehicle and road safety,

— road traffic efficiency,

— road tolling,

— access control, and

— commercial services.

This International Standard focuses on non-IP operations and contains specifications for the ITS station facilities layer and the non-IP networking & transport layer, which complements the IPv6 specifications given in ISO 21210.

Intelligent transport systems — Communications access for land mobiles (CALM) — Non-IP networking

1 Scope

This International Standards specifies FAST services, i.e.

— FAST networking & transport layer protocols for

  — single-hop communications,

  — N-hop broadcast communications,

  — ITS-MUX, and

  — ITS station-internal forwarding,

— FAST service for 15628 CI (DSRC CI) support,

— FAST service for 15628 application support,

and the related support of the MN-SAP and MF-SAP.

This International Standard references ISO 24102 for related specifications of

— FAST ITS service announcement, and

— groupcast management.

NOTE Formerly “FAST ITS service announcement” was referred to as “FAST service advertisement”. The name is being changed in order to align with terminology specified in ISO 21217.

Wherever practicable, this International Standard has been developed by reference to suitable extant standards, adopted by selection.

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/IEC 8825-2, *Information technology — ASN.1 encoding rules: Specification of Packed Encoding Rules (PER)*

ISO 15628:2007, *Road transport and traffic telematics — Dedicated short range communication (DSRC) — DSRC application layer*

ISO 21210, *Intelligent transport systems — Communications access for land mobiles (CALM) — IPv6 Networking*

ISO 21215, *Intelligent transport systems — Communications access for land mobiles (CALM) — M5*

ISO 21217, *Intelligent transport systems — Communications access for land mobiles (CALM) — Architecture*

ISO 21218, *Intelligent transport systems — Communications access for land mobiles (CALM) — Medium service access points*

ISO 24102, *Intelligent transport systems — Communications access for land mobiles (CALM) — Management*

ISO 24103, *Intelligent transport systems — Communications access for land mobiles (CALM) — Media adapted interface layer (MAIL)*

ARIB STD-T88, DSRC application sub-layer

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21217, ISO 21218, ISO 21210, ISO 24102, ISO 24103 and the following apply.

3.1
ITS station information
information on the identity, location and movement of an ITS station together with a time stamp

3.2
forwarding data
information received in a network node, optionally evaluated, modified and amended, and finally retransmitted, without involvement of an ITS-S application

3.3
ITS FAST service provider
entity using an ITS-S application (e.g. referred to as server application) in order to provide an ITS service to an ITS FAST service user, initiating and controlling communications for the transmission/exchange of packets with the FAST networking & transport layer protocol

3.4
ITS FAST service user
entity using an ITS-S applications (e.g. referred to as client application) in order to consume an ITS service offered by an ITS FAST service provider entity, where the ITS-S applications of the ITS FAST service provider and ITS FAST service user are complementary parts of the same ITS application

3.5
FAST ITS service
service offered by an ITS FAST service provider, by means of an ITS-S application (e.g. referred to as server application) residing in one ITS station, to the ITS FAST service user applying the complementary ITS-S application (e.g. referred to as client application) residing in another ITS station, which implies at least transmission of a single message or an exchange of messages between these ITS-S applications applying the FAST networking & transport layer protocol

3.6
GeoNetworking
networking functionality based on the geographic coordinates of the transmitter location and a geographic description of the destination

3.7
NWref handler
functionality to handle assignment and usage of NWref numbers

3.8
Host ITS-SCU
ITS-SCU containing the functionality of an ITS-S host

3.9
Router ITS-SCU
ITS-SCU containing the functionality of an ITS-S router

3.10
FAST basic header
header of the FAST networking & transport layer protocol supporting its basic functionality

3.11
FAST extension header
additional header of the FAST networking & transport layer protocol appended to the FAST basic header, supporting its extended functionality

3.12
FAST forwarding header
header of the FAST networking & transport layer protocol replacing the FAST basic header for ITS station-internal forwarding of packets

3.13
FAST ITS service announcement
ITS service announcement using the FAST networking & transport layer protocol as specified in ISO 24102

4 Symbols and abbreviated terms

Symbols and abbreviated terms used in this International Standard are listed below. Reference should also be made to ISO 21217, ISO 21210, ISO 21215, ISO 21218, ISO 24102 and ISO 24103.

CIP	CI Parameters
CIP0	LSB of CIP reference
CIP1	Middle bit of CIP reference
CIP2	MSB of CIP reference
ELCP	Extended Link Control Protocol
ETC	Electronic Toll Collection
ITSSI	ITS Station Information
LCP	LAN Control Protocol
LPCP	Local Port Control Protocol
LPP	Local Port Protocol
NWref	Network reference
OBE	On-board equipment
SAF	Service Advertisement Frame

SCF	Service Context Frame
SID	Service Identifier
STA	Service Table for Advertisement
HMI	Human–Machine Interface

5 Requirements

The principal requirements of this International Standard are specified in Clauses 6, 7, 8 and 9 as follows:

— Clause 6 gives an overview of the functionalities specified in this International Standard;

— Clause 7 specifies protocols of the networking & transport layer;

— Clause 8 specifies protocols of the facilities layer;

— Clause 9 specifies common elements and procedures.

Clauses 10 and 11 are related to conformance declaration and testing.

Annexes provide further normative and informative details related to the principal requirements.

6 Overview

6.1 ITS-S architecture

The specifications given in this International Standard shall comply with the ITS station architecture and with the concept of an ITS station communication unit (ITS-SCU) as specified in ISO 21217 and ISO 24102.

NOTE The terminology from the series of International Standards on CALM was modified during the process of harmonization of the standards. ITS-SCU (ITS-S communication unit) was formerly referred to as “CALM communication kernel” (CCK).

6.2 Services

6.2.1 Types of services

This International Standard specifies ITS-S FAST services:

a) protocols in the networking & transport layer for

   1) single-hop communications,

   2) N-hop broadcast communications,

   3) ITS-MUX, and

   4) ITS station-internal forwarding;

b) 15628 CI (DSRC CI) support;

c) 15628 application support;

d) ITS service announcement (specification is done by reference to ISO 24102).

ITS-S FAST services located in the facilities layer are offered to ITS-S applications designed to use the FAST protocols in the ITS-S networking & transport layer.

An example of an ITS-S FAST service is the “FAST ITS service announcement” specified in ISO 24102. It is a protocol optimized for low latency and single-hop communications. It is based on groupcasting and the FAST networking & transport protocol as specified in this International Standard. FAST ITS service announcement also includes announcement of locally available IPv6-based services.

6.2.2 Legacy CIs

An existing access layer technology may be implemented in a ITS station as a “Legacy CI”, as presented in Figure 1, such that it can communicate with peer stations that are not necessarily aware of any ITS-S context, and where none of the networking protocols specified for ITS-S are used in the wireless link.

Types of CIs are specified in ISO 21218 in MI-parameter 22 “Medium”. The only legacy CI medium identified so far in ISO 21218 is 128 “ISO 15628”. Further types may be added.

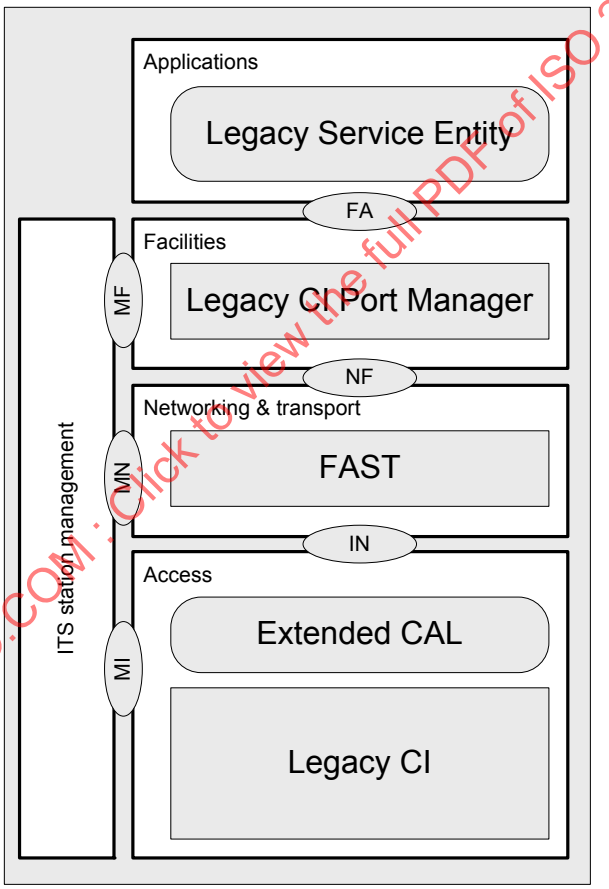

Figure 1 — Legacy CI

Inside the ITS station, the FAST networking & transport layer protocol shall be used for the forwarding of packets between the access layer and the facilities layer.

This requires

— implementing a CALM adaptation layer (CAL) as specified in ISO 21218, extended with the additional functionality for FAST networking & transport layer support as specified in this International Standard, which, optionally, may also include parts of the service processing functionality,

— making use of the “Legacy CI Port Manager” as specified in this International Standard and in ISO 24102.

Legacy CIs shall specify the medium specific parameters presented in Table 1 (see ISO 21218 for the MI parameter 254 “MediumParameter”):

Table 1 — Legacy CI parameters

MediumParam.mediumPar.no	MediumParam.detail	Description
0	LegacyOption	Optional classification of different options of the same legacy CI
1	NWrefPM	NWref of the “Legacy CI Port Manager” connecting to the applicable “Legacy Service Entity”

The “Legacy Service Entity” shall register at the “Legacy CI Port Manager” indicating the CI class and legacy option of the required legacy CI.

Further details depend on the existing communication interface technology. Normative examples for legacy systems compliant with ISO 15628:2007 are provided in Annex B.

6.2.3 15628 applications

Applications built on top of an OSI layer 7, as specified in ISO 15628:2007 may be operated over an ITS CI of CI class CIC-wl1, specified in ISO 21218. The services shall interface with the FAST networking & transport layer protocol via the “15628 Kernel Emulator” (see Figure 2).

NOTE In the given context, 15628 applications are also referred to as 15628 legacy applications.

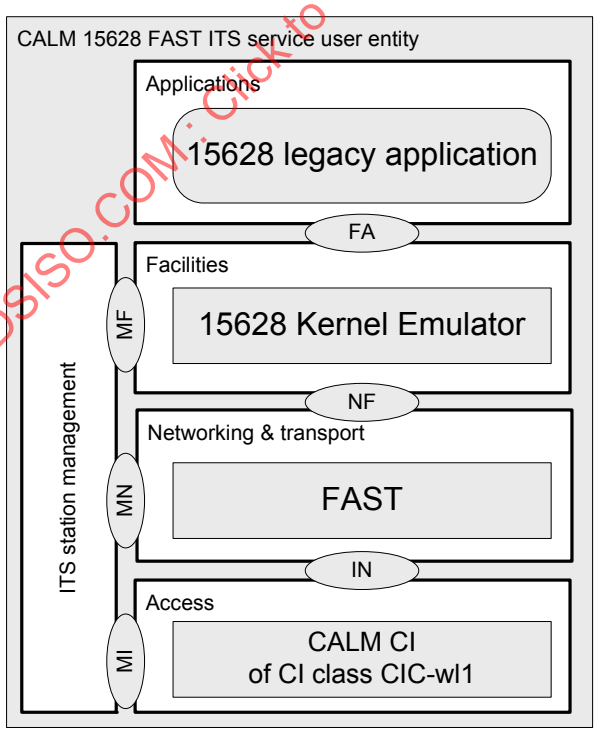

Figure 2 — 15628 legacy service

The 15628 initialization phase shall be implemented with the groupcast functionality specified in this International Standard and in ISO 24102.

The “15628 Kernel Emulator” shall perform the following tasks:

— register at server groupcast manager for periodic transmission of BST, if applicable;

— register at client groupcast manager for transmission of VST, if applicable;

— emulate the 15628 T-Kernel interface for usage by applications;

— map the 15628 “FlowControl” on BC-VCI and UC-VCI.

The purpose of 15628 LID shall be served by CI-ID.

Detailed procedures are specified in Clause 8.

6.3 Communication scenarios

6.3.1 General

The protocols of the ITS-S networking & transport layer specified in this International Standard apply to two basic communication scenarios:

— single-hop communications between ITS stations, regardless of where the stations are installed;

— multi-hop communications between ITS stations.

Subsequent hops may be managed either by services or by network/transport protocol extensions.

6.3.2 Single-hop communication scenario

Single-hop communications as specified in this International Standard involves communication between two ITS stations as described in ISO 21217.

Examples of single-hop communication scenarios are illustrated in Figure 3.

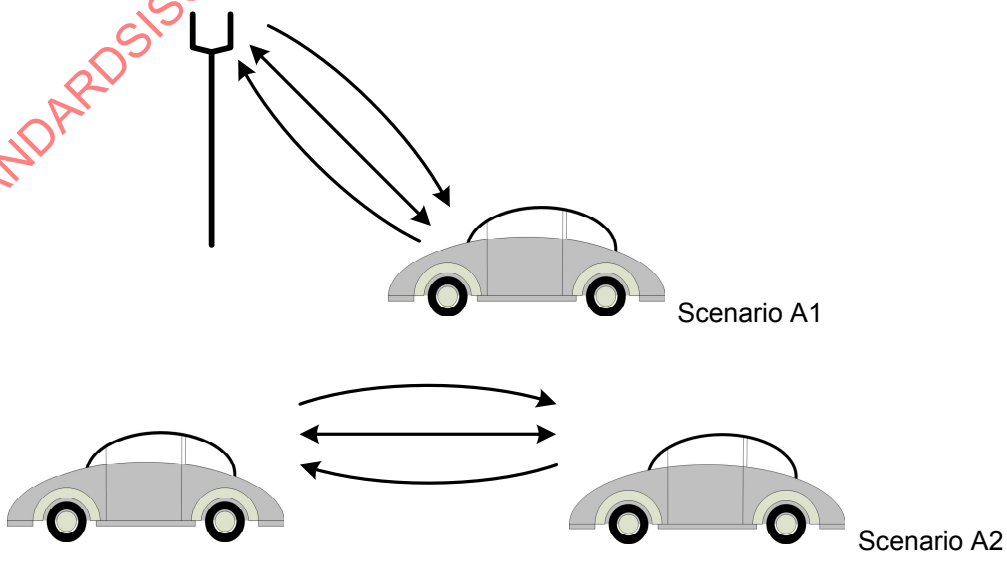

Figure 3 — Examples of single-hop communications

Scenario A1 is a typical scenario for anouncement of ITS services provided by roadside service providers. Further on, this is needed for traffic efficiency and road safety services.

Scenario A2 mainly is for road safety and traffic efficiency services.

6.3.3 Multi-hop communication scenarios

Multi-hop communications as specified in this International Standard involves communication between two ITS stations using forwarding capabilities provided by one or more other ITS stations.

Multi-hop (N-hop) communications is supported, for example, by the GeoNetworking protocol currently being developed at ETSI, which is based on the geo-address information of stations, and by the FAST networking & transport layer protocol specified in this International Standard.

NOTE A new work item at ISO/TC204/WG16 is developing an International Standard on how to apply GeoNetworking in an ITS station compliant with CALM. The development of GeoNetworking protocols at ETSI is based on the results of the GeoNet project funded by the European Commission (see Reference [7]).

N-hop broadcast was presented in Reference [1] and named “Topologically Scoped Broadcast”. An example of N-hop broadcast is illustrated in Figure 4. It provides data dissemination from a source node to all nodes reachable with a limited number of subsequent hops. The number of subsequent hops shall be set by the service. In Figure 4 the maximum number of hops is two.

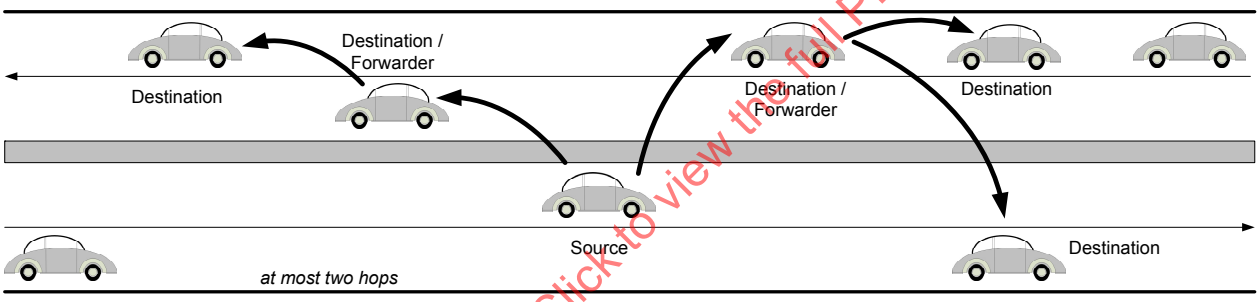

Figure 4 — N-hop broadcast (example with N=2)

6.4 Groupcasting

Groupcast communications includes broadcast communications and multicast communications. The definition and maintenance of multicast groups and the related MAC multicast addresses is outside the scope of this International Standard. Groupcasting is applicable to all kinds of networking protocols and to CIs of the CI classes CIC-wl1, CIC-wl3 and CIC-wl5 specified in ISO 21218.

Three basically different types of groupcasting are given:

a) event-driven groupcasting;

b) repetitive event-driven groupcasting;

c) registered periodic groupcasting.

Groupcast transmissions may be requested by, for example,

— a service for dissemination of

  — LDM data and other groupcast pool data,

  - ITS service announcement information,
  - “forwarding data”,
- any networking protocol for dissemination of
  - “forwarding data”,
  - “ITS Station Information” (ITSSI),
  - other network-protocol-specific groupcast data,
- an ITS-S management entity for dissemination of
  - CI management data,
  - ITS station management data,
  - ITSSI,
- the MAC-sublayer of a CI for dissemination of
  - medium-specific MAC management data.

ITS-S management groupcasting shall be as specified in ISO 24102, if applicable.

MAC-sublayer groupcasting is medium-specific and shall be specified in the media standards, if applicable.

A communication medium, e.g. CALM M5, may accept control from the ITS station management entity with respect to transmission and reception of management frames commanded via the MI-SAP. Such functionality is expected to be specified in the related medium standard rather than in this International Standard.

All periodic groupcast communications except for those carried on MAC management frames, independent of the basic networking protocol used, may be processed by the ITS-MUX virtual network service, as specified in this International Standard.

NOTE 1 The main design goal of groupcasting via ITS-MUX is to minimize the load in the wireless communication channels by mapping as many groupcast transmission requests as possible onto a single frame.

NOTE 2 In simple implementations with only one networking protocol, ITS-MUX forwards data packets between the networking protocol and the IN-SAP.

The overall groupcasting architecture is presented in Figure 5. The building blocks are:

d) “Groupcasting Registration Handler” located in the “ITS Facilities Layer”;

e) “Groupcasting Manager” located in the “ITS station management entity” and specified in ISO 24102;

f) “Groupcasting Schedulers” located in the networking & transport layer;

g) CIs supporting MAC groupcast frames.

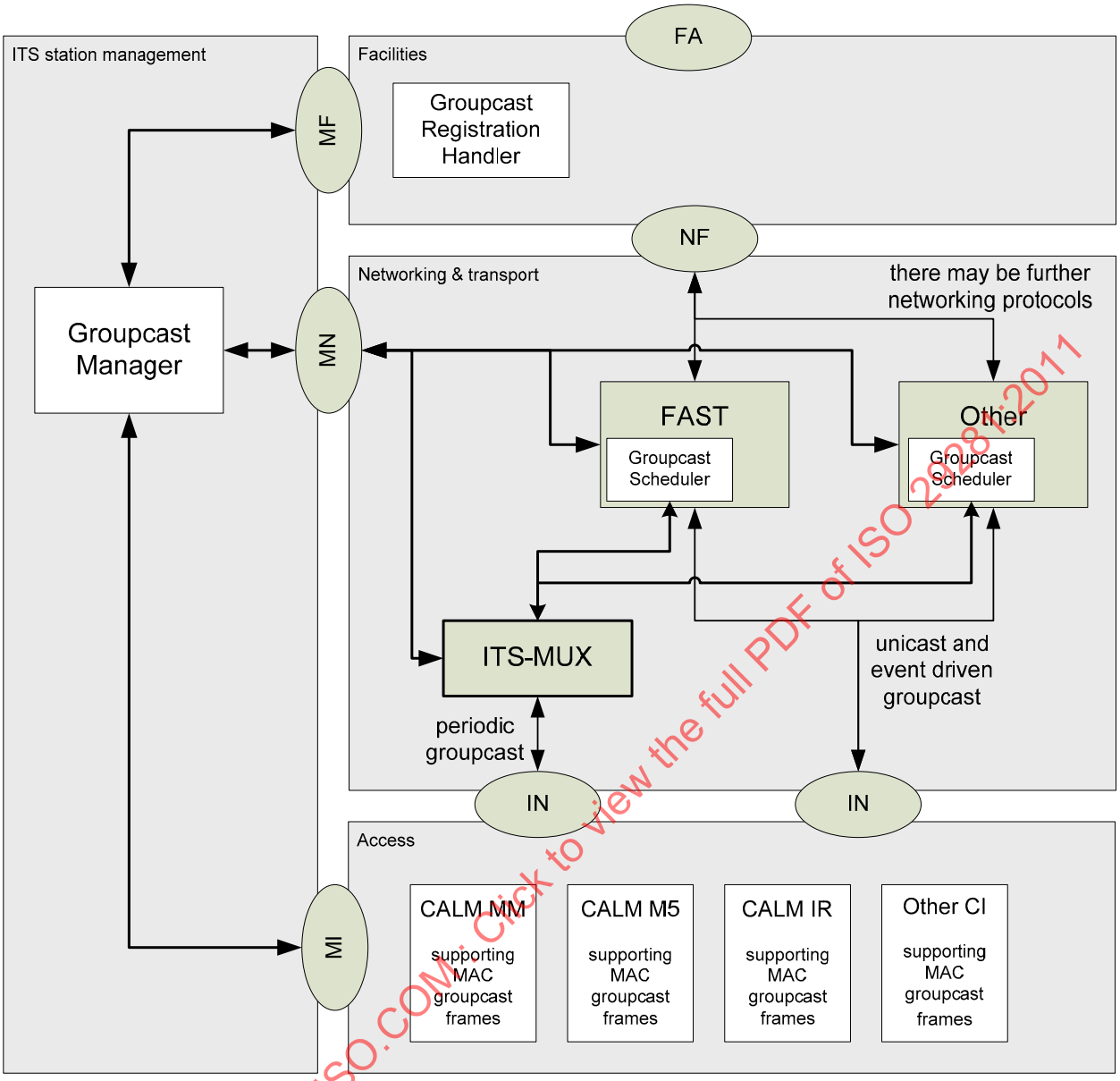

Figure 5 — Global groupcasting architecture with Geo-Routing as an example

NOTE 3 Required mechanisms for security related to groupcasting are outside the scope of this International Standard.

6.5 Networking & transport layer protocols

This International Standard specifies the following ITS networking & transport layer protocols:

— FAST networking & transport layer protocol:

  — single-hop between ITS stations;

  — N-hop broadcast;

  — ITS station-internal forwarding;

— ITS-MUX virtual networking & transport layer service.

6.6 Management of ITS-S communication layers

Details of the ITS-S management entity are specified in ISO 24102.

6.7 FAST implementation architectures

The FAST networking & transport layer protocol is primarily designed for single-hop communications, i.e. without automatic forwarding of packets at nodes between the source node and the destination node. However, FAST also supports local forwarding which is needed in installations, where ITS-S host functionality and ITS-S router functionality are implemented in distinct physical units. The implementation architectures presented in Figures 6, 7 and 8 are supported.

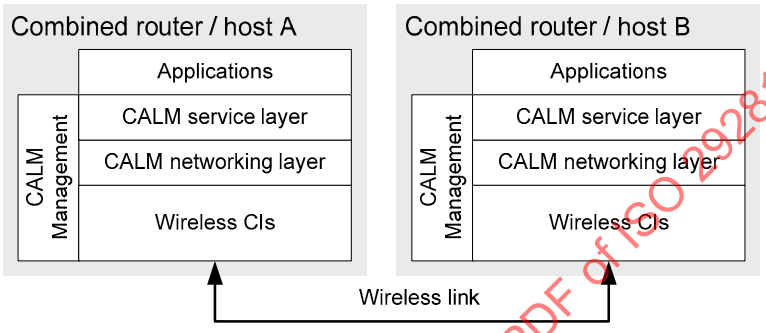

Figure 6 — FAST implementation architecture A

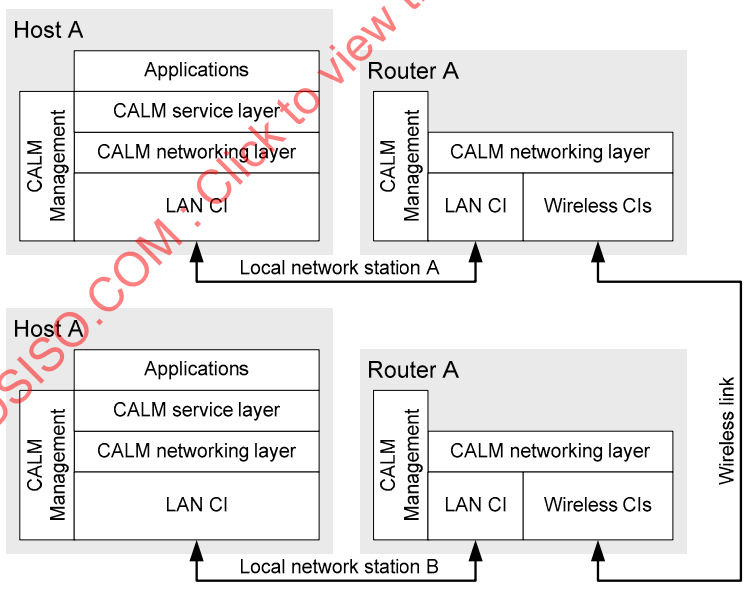

Figure 7 — FAST implementation architecture B

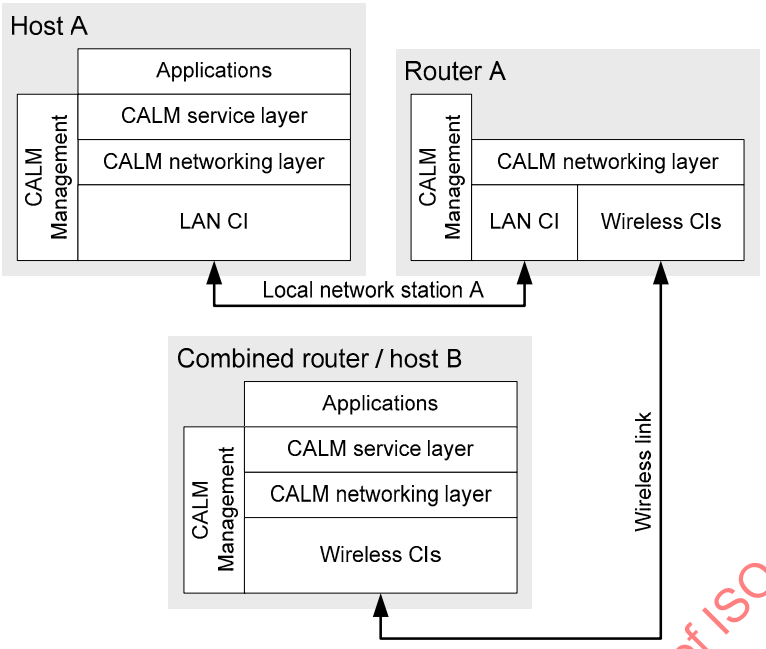

Figure 8 — FAST implementation architecture C

Informative Annex C provides networking protocol examples for the three implementation architectures.

7 Networking & transport layer protocols

7.1 Basics

The networking & transport layer protocols shall be identified in the IN-SAP with the appropriate SAP address as specified in ISO 21218. The networking & transport layer protocols shall use the service DL-UNITDATA as specified in ISO 21218.

A networking protocol may imply a dedicated transport layer protocol. The network/transport layer protocols shall provide an NF-SAP to the facilities layer specified in ISO 21217.

Networking & transport layer protocols shall be managed via the MN-SAP specified in ISO 24102.

Networking & transport layer protocols may be secured via the SM interface specified in ISO 21217. Details are outside the scope of this International Standard.

7.2 FAST networking & transport layer protocols

7.2.1 Elements and basic procedures

The FAST networking & transport layer protocol is a slim protocol designed primarily for single-hop communications that uses a two-octet FAST basic header (networking header) as shown in Figure 9. A FAST networking & transport layer protocol extension is included to support additional functionality:

— “Local Port Protocol” (LPP);

— multiple hops (N-hop broadcast) in the wireless link.

FAST basic header	
sourceAddress NWref	destinationAddress NWref

Figure 9 — FAST basic header

The sourceAddress and destinationAddress fields shall contain the NWref of source and destination, respectively, i.e. indicating end points as specified in Table 2. Values used in the wireless link shall be assigned by the router ITS-SCU under the responsibility of the NWref handler (see Figure 10).

NWref values used in the sourceAddress and destinationAddress fields of the FAST basic header shall be mapped to NWref values as assigned to the service in the host ITS-SCU under the responsibility of the NWref handler. A unique NWref numbering scheme in an ITS station is achieved by ServiceNWref. ServiceNWref shall be the concatenation of NWref as assigned to the service in the host ITS-SCU and the ITS-SCU-ID of the host ITS-SCU (see Figure 10).

NOTE 1 If a service resides in the router ITS-SCU, the NWref values used in the FAST network/transport header and in the ServiceNWref might be the same.

ServiceNWref	
Host NWref	Host CCK-ID

Figure 10 — ServiceNWref

Every router ITS-SCU shall maintain a look-up table (see Figure 11) for ServiceNWref and NWref as assigned by the local router ITS-SCU for usage in the FAST basic header.

Local router	ServiceNWref (local host)	
Link NWref	Host NWref	Host CCK-ID

Figure 11 — NWref look-up table

In receive mode, the destinationAddress NWref contained in the FAST basic header shall be used to search in the column “Link NWref”. The related entry in the column “ServiceNWref” can then be used to check the forwarding table.

In transmit mode, the “ServiceNWref” information shall be used to identify the proper value for NWref to be used in the sourceAddress field of the FAST basic header.

NOTE 2 This look-up table can be favorably integrated in the forwarding tables (see Figure 12).

The NWref handler shall be responsible for the unique assignment of NWref values as specified in Table 2.

Table 2 — NWref values

NWref	Description
0	Groupcast manager
1-251	General services including “15628 Port Manager” and “15628 Kernel Emulator”
252	FAST networking & transport layer protocol extension used. This value is prohibited in the sourceAddress field of the FAST basic header. It shall be used in the destinationAddress field of the FAST basic header in order to indicate usage of the FAST networking & transport layer protocol extension. If the FAST networking & transport layer protocol extension is used, the destination address NWref shall be contained in the first element of the FAST extension header as specified in Figure 25.
253	FAST networking & transport layer protocol-router ITS-SCU; only for local forwarding between a host ITS-SCU and a router ITS-SCU in an ITS station.
254	FAST networking & transport layer protocol-host ITS-SCU; only for local forwarding between a host ITS-SCU and a router ITS-SCU in an ITS station.
255	Unknown/don't care (logical NULL)

The network protocol shall maintain information as shown in the forwarding table according to Figure 12.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	

Figure 12 — FAST networking & transport layer protocol forwarding table — Format

The elements below “Remote service” allow access to the ITS-S application in the peer (remote) ITS station.

— The elements “Link NWref” shall carry the NWref values as used in the FAST basic header in the link. It is unique only in combination with the element “CI-ID”.

— The element “CI-ID” shall carry the CI-ID of the UC-VCI which connects to the peer station.

— The element “CI Status” shall contain the CI status as specified in ISO 21218.

The elements below “Local service” allow access to the ITS-S application in the local ITS station.

— The element “Link NWref” shall carry the NWref values as used in the FAST basic header in the link. It is unique only at the local router ITS-SCU.

— The element “ServiceNWref” shall be as specified in Figure 10.

— The element “User Priority” shall contain the user priority as specified in ISO 21218. The value of “User Priority” for an unknown priority shall be zero.

The element “Timeout” contains time information on the validity of this entry.

7.2.2 Initial settings of forwarding tables in host ITS-SCUs

7.2.2.1 Activation of a LAN VCI

Upon activation of a VCI to interconnect local ITS-SCUs, entries in the forwarding tables of the FAST networking & transport layer protocol, as presented in Figure 13, shall be created in host ITS-SCU upon request of the ITS station management entity via MN-SAP in order to enable FAST local forwarding.

NOTE These entries are not needed for implementations without local area network, i.e. where host and router functionality is combined in a single ITS-SCU.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
253	UC-VCI, no peer relation	"active" (see ISO 21218)	254	(255, 2)	255	none
	BC-VCI					

Figure 13 — FAST networking & transport layer protocol forwarding table— Creation of LAN VCI in a host ITS-SCU

7.2.2.2 Creation and deregistration of a socket

Upon creation of a socket, the FAST networking & transport layer protocol in the host ITS-SCU shall create an entry in the forwarding table as presented in Figure 14.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
255	"don't know"		255 or 254	(of service, 0)	of service	none

Figure 14 — FAST networking & transport layer protocol forwarding table — Creation of a socket in a host ITS-SCU

The Link NWref of the local service shall show the value 255. If the FAST networking & transport layer protocol knows that local forwarding of packets to the router ITS-SCU is needed, the value 254 may also be used alternately.

Upon deregistration of the socket, the entry shall be deleted.

7.2.2.3 FAST ITS service registration

Upon registration of a FAST ITS service at the groupcast manager in an ITS service provider host ITS-SCU, the groupcast manager shall request the setting of an entry in the forwarding table for every requested CI as presented in Figure 15, which is actually an update of the entry presented in Figure 14.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
255	CI requested for this service NOTE The CI might be in another local ITS-SCU.		255 or 254	(of service, 0)	of service	none

Figure 15 — FAST networking & transport layer protocol forwarding table — Registration of FAST ITS service provider in a host ITS-SCU

The Link NWref of the local service shall show the value assigned to the service by the router ITS-SCU, if ITS-S router and ITS-S host functionality are contained in the same ITS-SCU, or the value 254 to indicate host ITS-SCU and the need for local forwarding, or the value 255 “unknown”.

Upon deregistration of the service, the entry shall be deleted.

7.2.3 Initial settings of forwarding tables in router ITS-SCUs

7.2.3.1 Activation of wireless VCI

Upon activation of a wireless VCI (see the CI state “active” in ISO 21218), which supports the FAST networking & transport layer protocol (see parameter 23 “NWsupport” in ISO 21218), entries in the forwarding table of the FAST networking & transport layer protocol in the router ITS-SCU, as presented in Figure 16, shall be created, if applicable. Details of the creation of such entries shall be as specified in ISO 24102.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
255	UC-VCI, no peer relation	“active” (see ISO 21218)	255	(255, 0)	“unknown” 0	none
	BC-VCI					
	MC-VCI					

Figure 16 — FAST networking & transport layer protocol forwarding table — Creation of wireless VCIs

7.2.3.2 Reception of frame from peer station

Upon reception of a frame from a new peer station, identified by a new MAC address in the CI, the CI-ID field of the related entry without peer relation in the forwarding table shall be assigned the relation to this new peer station. Then a new entry for a UC-VCI with unknown peer relation shall be created in the forwarding table.

Whether creation of a new entry for a UC-VCI with unknown peer relation shall require a previous creation of a new UC-VCI, or whether such a UC-VCI will be created only upon need, even directly by the CI on its own receiving a DL-UNITDATA.request service primitive, depends on implementation.

7.2.3.3 Groupcast manager

In support of the groupcast manager, entries in the forwarding table of the FAST networking & transport layer protocol in the router ITS-SCU, as presented in Figure 17, shall be created. Details of the creation of such entries shall be as specified in ISO 24102.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
0	UC-VCI, no peer relation	"active" (see ISO 21218)	0	(0, 0)	255	none

Figure 17 — FAST networking & transport layer protocol forwarding table — Groupcast manager

7.2.3.4 Activation of a LAN VCI

Upon activation of a VCI to interconnect local ITS-SCUs, entries in the forwarding tables of the FAST networking & transport layer protocol, as presented in Figure 18, shall be created in a router ITS-SCU upon request of the ITS station management entity via MN-SAP in order to enable FAST local forwarding.

NOTE These entries are not needed for implementations without local area network, i.e. where host and router functionality is combined in a single unit.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
254	UC-VCI, wired, no peer relation	"active" (see ISO 21218)	253	(255, 1)	255	none
	BC-VCI, wired					

Figure 18 — FAST networking & transport layer protocol forwarding table — Creation of LAN VCI in a router ITS-SCU

7.2.3.5 Registration of FAST ITS service

Subsequent to registration of a FAST ITS service at the groupcast manager in the ITS service provider host ITS-SCU, applying inter-ITS-SCU communication by the groupcast manager in the host ITS-SCU as specified in ISO 24102, if applicable, the groupcast managers in the selected router ITS-SCU shall request the creation of an entry in the forwarding table for every selected CI, as presented in Figure 19.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI Status	Link NWref	ServiceNWref	User Priority	
255	CI requested for this service		as assigned by router	(of service, of host)	of service	none

Figure 19 — FAST networking & transport layer protocol forwarding table — Registration of FAST ITS service provider in a router ITS-SCU

Upon deregistration of the service, the entry shall be deleted.

7.2.4 Maintenance of forwarding tables for FAST ITS service initialization

7.2.4.1 Introduction

FAST ITS service initialization shall be as specified in ISO 24102.

7.2.4.2 Service provider ITS station

Upon reception of the first frame from a client ITS station in response to a Service Advertisement Frame (SAF), as specified in ISO 24102, an entry in the forwarding table, as presented in Figure 20, shall be created in the forwarding tables of the host ITS-SCU and the selected router ITS-SCU.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI status	Link NWref	ServiceNWref	User Priority	
of service user	UC-VCI, relation to client	"connected" (see ISO 21218)	of service			

Figure 20 — FAST networking & transport layer protocol forwarding table — First frame from client

An entry shall be deleted upon timeout of the service.

7.2.4.3 Service user ITS station

Upon acknowledgement of a received SAF for every service supported, an entry in the forwarding table as presented in Figure 21, shall be created in the forwarding tables of the host ITS-SCU and the selected router ITS-SCU, if not already existent.

Remote service			Local service			Timeout
Link NWref	CI-ID	CI status	Link NWref	ServiceNWref	User Priority	
of service provider	UC-VCI, relation to service provider	"connected" (see ISO 21218)	of client			

Figure 21 — FAST networking & transport layer protocol forwarding table — SAF received

An entry shall be deleted upon timeout of the service.

7.2.5 CIP header

The location of the optional CIP header in the FAST NPDU shall be as specified in Figure 22. The content depends on the selected medium and the setting of the CtrlCI bits CIP0, CIP1 and CIP2.

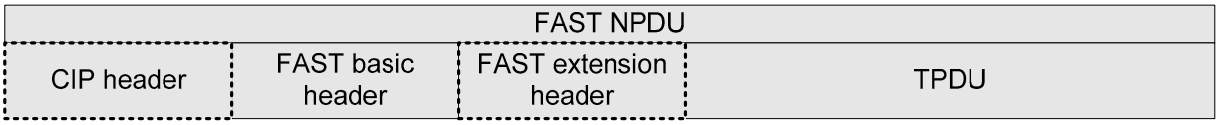

Figure 22 — FAST NPDU

These control bits may be set, for example, by the distributed congestion control algorithm, as specified in ISO 24102, which may overrule other requests.

7.2.6 Transmitting packets

Upon a transmission request, e.g. received via the NF-SAP by means of the service primitive FN-COMM.request, the network protocol shall create the FAST NPDU by concatenating the optional CIP header, the FAST basic header, the optional FAST extension header and the TPDU according to Figure 22.

The FAST networking & transport layer protocol shall check whether the information given in the FAST basic header matches an entry in the forwarding table. A preliminary match is also given, if the NPDU needs to be locally forwarded to the proper router via the wired local network.

The FAST networking & transport layer protocol shall call the CAL service primitive DL-UNITDATA.request with “source_address” and “destination_address” as specified in ISO 21218, according to the forwarding table in Figure 12 and the CtrlCI bits given in the transmission request, with data equal to the NPDU and with priority equal to the user priority given in the forwarding table.

Transmission requests with unknown address information shall be discarded.

7.2.7 Receiving packets

Upon reception of a data packet from a wireless CI by means of the CAL service primitive DL-UNITDATA.indication, or from the ITS-MUX virtual network protocol, the FAST networking & transport layer protocol shall evaluate the network header and, optionally, the first element of the FAST extension header. If the information on sourceAddress NWref, destinationAddress NWref and CI-ID matches an entry in the forwarding table, except where fields are not set, the entry shall be duplicated and complemented. If no entry matches, the received packet shall be discarded.

If the received packet was not discarded as a result of the FAST basic header checking, the packet shall be processed further.

— If the FAST networking & transport layer protocol extension is used, the packet shall be forwarded to the FAST networking & transport layer protocol extension.

— If the ITS-SCU-ID field indicates the local ITS-SCU, the packet shall optionally be processed by the FAST networking & transport layer protocol extension, if applicable, Then the service primitive FN-COMM.indication with CI-ID equal to the CI-ID of the CI that issued the DL-UNITDATA.indication service primitive, data equal to the TPDU, priority equal to the priority provided in the DL-UNITDATA.indication service and other parameters, as applicable, shall be called to pass the received packet via the facilities layer to the service.

— If the ITS-SCU-ID field indicates a remote ITS-SCU in the same station, local forwarding shall apply. Further processing of the packet shall apply in the final destination.

A CALM medium may provide the user priority used at the transmitting station. Usage of user priority is not defined.

7.2.8 Local packet forwarding between ITS-SCUs

7.2.8.1 Basics

Forwarding of packets between ITS-SCUs shall be managed with the FAST forwarding header presented in Figure 23.

FAST Forwarding Header (local forwarding from router to host)			
FAST basic header (253, 254)	ITS-SCU-ID host	CI-ID VCI router	Flags

FAST Forwarding Header (local forwarding from host to router)			
FAST basic header (254, 253)	ITS-SCU-ID host	CI-ID VCI router	Flags

Figure 23 — FAST forwarding header (for ITS station-internal forwarding)

The leading element shall be the FAST basic header. The next element shall be set equal to the ITS-SCU-ID of the host. The next element shall be set equal to the CI-ID of the VCI that connects to the peer station. The flags shall be as specified in Table 3.

Table 3 — FAST forwarding header flags

Bit 0 - bit 6	Bit 7	Description
—	'0'	The NPDU does not contain a CIP header.
—	'1'	The NPDU contains a CIP header.
'xxxxxxx'	—	Cyclic packet counter. Unique in the source ITS-SCU.

7.2.8.2 Forwarding to host ITS-SCU

On reception of a packet from an ITS peer station in an ITS-S router which shall be forwarded to a host ITS-SCU, the FAST networking & transport layer protocol shall create a new NPDU which is the concatenation of the FAST local forwarding header presented in Figure 23 and the NPDU received from the wireless CI, as presented in Figure 24. The FAST networking & transport layer protocol extension shall not be executed at the router ITS-SCU, but only at the final destination.

FAST locally forwarded NPDU							
FAST Forwarding Header				FAST NPDU			
FAST basic header (25x, 25y)	ITS-SCU-ID host	CI-ID VCI router	Flags	CIP header	FAST basic header	FAST extension header	TPDU

Figure 24 — FAST forwarded NPDU

7.2.8.3 Forwarding to router ITS-SCU

On reception of a transmission request from the NF-SAP of a packet to be transmitted via a VCI of another ITS-SCU, the FAST networking & transport layer protocol shall create the NPDU as usual, then add a FAST local forwarding header (see Figure 23) ahead of the NPDU, as presented in Figure 24. The optional FAST

networking & transport layer protocol extension shall be executed prior to executing the FAST networking & transport layer protocol, if applicable.

The cyclic packet counter shall be incremented by 1 for every new FAST local forwarding header. It shall wrap from 127 to zero. The counter value, together with the addresses “ITS-SCU-ID host” and “CI-ID VCI”, shall be used to identify duplicate reception of a forwarded packet. Further details on the usage of the cyclic packet counter are outside the scope of this International Standard.

7.2.8.4 Reception of forwarded packet

Upon reception of a locally forwarded packet, the FAST networking & transport layer protocol shall evaluate the FAST forwarding header, whether it shall be

— processed and forwarded to the service via NF-SAP, or

— processed and forwarded to the VCI via IN-SAP or ITS-MUX, or

— discarded because it was already received before, or

— discarded due to invalid address information in the FAST forwarding header.

NOTE Meshed local networks are not supported by FAST local forwarding.

7.2.9 Local IPv6 service initialization

The FAST ITS service announcement specified in ISO 24102 optionally supports the announcement of IPv6-based services that are available only locally.

At a server station, the IPv6 settings shall be done prior to sending out the advertisement.

At a client station, upon reception of the STA offering IPv6-based services, the groupcasting manager shall

— request setting of the required entries in the IPv6 network forwarding tables,

— request creation of the required sockets,

— request creation of the required VCI, if not already existent, and

— notify the client application.

Further details shall be as specified in ISO 21210.

7.2.10 Management

The FAST networking & transport layer protocol shall be managed by the ITS station management entity via the MN-SAP.

All changes in the forwarding tables performed by the FAST networking & transport layer protocol shall be notified to the ITS station management entity.

The management shall be as specified in ISO 24102.

7.2.11 NF-SAP

7.2.11.1 Services

NF-SAP shall provide the service FTN-SOCKET with the service primitives:

— FTN-SOCKET.request;

— FTN-SOCKET.confirm.

FTN-SOCKET.request shall be used by the facilities layer to request creation, modification or deletion of a socket, including binding information.

FTN-SOCKET.confirm shall provide a descriptor allowing the service to use the FN-COMM service and the FT-COMM service, and shall be used to report success or failure of a FTN-SOCKET.request.

NF-SAP shall provide the service FN-COMM for the FAST networking & transport layer protocol with the three service primitives:

— FN-COMM.request;

— FN-COMM.confirm;

— FN-COMM.indication.

FN-COMM.request shall be used by the facilities layer to request transmission of a data packet with the FAST networking & transport layer protocol, without using the FAST networking & transport layer protocol extension.

FN-COMM.confirm shall be used by the FAST networking & transport layer protocol to indicate success or failure of a previous FN.COMM.request to the facilities layer.

FN-COMM.indication shall be used by the FAST networking & transport layer protocol to indicate reception of a data packet to the facilities layer.

7.2.11.2 Service primitives

7.2.11.2.1 FTN-SOCKET.request

The service primitive

FTN-SOCKET.request (
serviceRef,
operation,
priority
)

shall be used by the facilities layer to request creation or deletion of a FAST socket for a FAST ITS service.

Parameter “serviceRef” shall be a number uniquely identifying the service at this host.

Parameter “operation” shall indicate creation or deletion of a socket.

Parameter “priority” shall be the user priority of the service as specified in ISO 21218.

Upon reception of this service primitive, the FAST networking/transport protocol extension shall perform the required operation. Creation of a socket shall provide a NWref number to the requesting service. This NWref number shall be unique at this host.

The facilities layer shall be in charge to continuously monitor whether a service is alive. If a service is no longer alive, the facilities layer shall delete the related socket.

7.2.11.2.2 FTN-SOCKET.confirm

The service primitive

FTN-SOCKET.confirm (
serviceRef,
descriptor
)

shall be used by the FAST networking/transport protocol extension to acknowledge a FTN-SOCKET.request.

Parameter “serviceRef” shall contain the same value as provided in parameter “serviceRef” in the related FTN-SOCKET.request.

Parameter “descriptor” shall be the NWref assigned by the FAST networking/transport protocol extension.

Failure to create a socket shall be notified by assigning the value 255 to the parameter “descriptor”.

Deletion of a socket shall be notified by assigning the value 255 to the parameter “descriptor”.

7.2.11.2.3 FN-COMM.request

The service primitive

FN-COMM.request (
descriptor,
commRef,
remoteNWref,
cI-ID,
data
)

shall be used by the facilities layer to request transmission of a data packet using the FAST networking & transport layer protocol.

Parameter “commRef” shall be a cyclic counter identifying this request. A value shall be assigned under the responsibility of the application.

Parameter “descriptor” shall identify the socket to be used for transmission of the packet.

Parameter “remoteNWref” shall indicate the NWref of the peer service.

Parameter “cI-ID” shall identify the VCI to be used to transmit the packet.

Parameter “data” shall contain the APDU.

This service primitive shall be generated upon transmission request from the service that requested creation of the socket.

Upon reception of this service primitive, the FAST networking & transport layer protocol shall create the NPDU and request transmission of the NPDU via the selected VCI, with user priority as defined at the time of creation of the socket.

7.2.11.2.4 FN-COMM.confirm

The service primitive

FN-COMM.confirm (
descriptor,
commRef,
errStatus
)

shall be used by the FAST networking & transport layer protocol to notify failure of a previous FN-COMM.request. It may be used to notify success of a previous FN-COMM.request.

The parameters “descriptor” and “commRef” shall have the same values as in the related FN-COMM.request.

Success or failure shall be indicated with parameter “errStatus”, as specified in Table 4.

Table 4 — FTN-COMM.confirm error status

errStatus	ENUMERATED	0: SUCCESS	success
		1: UNSPECIFIED FAILURE	failure with unknown error code
		2: CI BUSY FOR TX	packet cannot be delivered to the CI immediately
		254: NO FORWARDING INFO	don't know where to deliver the packet
		255: CI SUSPENDED	CI is currently in the state “suspended”, as specified in ISO 21218.

The handling of errStatus by the facilities layer with a value different to zero indicating an error is not specified in this International Standard.

7.2.11.2.5 FN-COMM.indication

The service primitive

FN-COMM.indication (
descriptor,
remoteNWref,
cI-ID,
data,
priority
)

shall be used by the FAST networking & transport layer protocol to indicate to the facilities layer reception of a packet for the service that created the selected socket.

Parameter “descriptor” shall identify the socket of the service.

Parameter “remoteNWref” shall indicate the NWref of the peer service.

Parameter “cI-ID” shall identify the VCI used for reception of the packet.

Parameter “data” shall contain the APDU provided by the peer service.

Parameter “priority” shall be the user priority of the peer service as specified in ISO 21218.

The service primitive shall be created upon successful reception of an NPDU from a VCI.

7.3 FAST networking & transport layer protocol extension

7.3.1 Introduction

The FAST networking & transport layer protocol extension enables extensions of the basic FAST networking & transport layer protocol. Extensions specified in this International Standard enable

— N-hop broadcast communications, and

— LPP.

7.3.2 NF-SAP

7.3.2.1 Services

NF-SAP shall provide the service FTN-SOCKET as specified for the FAST networking & transport layer protocol, to be used also for the FAST networking & transport layer protocol extension.

NF-SAP shall provide the service FT-COMM for the FAST networking & transport layer protocol extension with the three service primitives:

— FT-COMM.request;

— FT-COMM.confirm;

— FT-COMM.indication.

FT-COMM.request shall be used by the facilities layer to request transmission of a data packet with the FAST networking & transport layer protocol extension.

FT-COMM.confirm shall be used by the FAST networking & transport layer protocol extension to indicate success or failure of a previous FT.COMM.request to the facilities layer.

FT-COMM.indication shall be used by the FAST networking & transport layer protocol extension to indicate reception of a data packet by the facilities layer.

7.3.2.2 Service primitives

7.3.2.2.1 FT-COMM.request

The service primitive

FT-COMM.request (
descriptor,
commRef,
remoteNWref,
cl-ID,
hopCount,
lppCtrl,
data
)

shall be used by the facilities layer to request transmission of a data packet using the FAST networking & transport layer protocol extension.

Parameter “commRef” shall be a cyclic counter identifying this request. A value shall be assigned under the responsibility of the application.

Parameter “descriptor” shall identify the socket to be used for transmission of the packet.

Parameter “remoteNWref” shall indicate the NWref of the peer service.

Parameter “cI-ID” shall identify the VCI to be used to transmit the packet.

Parameter “hopCount” shall indicate the initial value to be put into the element “hop count” of the FAST extension header specified in Figure 25. For MAC unicast transmission, this parameter shall be set to zero.

Parameter “lppCtrl” shall contain information needed for the FAST networking & transport layer protocol extension LPP.

Parameter “data” shall contain the APDU.

This service primitive shall be generated upon transmission request from the service that requested creation of the socket.

Upon reception of this service primitive, the FAST networking & transport layer protocol extension shall create the TPDU and shall forward the TPDU to the FAST networking & transport layer protocol. The FAST networking & transport layer protocol shall create the NPDU and shall request transmission of the NPDU via the selected VCI, with user priority as defined at the time of creation of the socket.

7.3.2.2.2 FT-COMM.confirm

The service primitive

FT-COMM.confirm (
descriptor,
commRef,
errStatus
)

shall be used by the FAST networking & transport layer protocol extension to notify failure of a previous FT-COMM.request. It may be used to notify success of a previous FT-COMM.request.

The parameters “descriptor” and “commRef” shall have the same values as in the related FT-COMM.request.

Success or failure shall be indicated with parameter “errStatus”, as specified in Table 4.

The handling of errStatus by the facilities layer with a value different to zero indicating an error is not specified in this International Standard.

7.3.2.2.3 FT-COMM.indication

The service primitive

FT-COMM.indication (
descriptor,
remoteNWref,
cI-ID,
data,
priority
)

shall be used by the FAST networking & transport layer protocol extension to indicate to the facilities layer reception of a packet for the service that created the selected socket.

Parameter “descriptor” shall identify the socket of the service.

Parameter “remoteNWref” shall indicate the NWref of the peer service.

Parameter “cI-ID” shall identify the VCI used for reception of the packet.

Parameter “data” shall contain the APDU provided by the peer service.

Parameter “priority” shall be the user priority of the peer service as specified in ISO 21218.

The service primitive shall be created upon successful reception of an NPDU from a VCI.

7.3.3 Header

The optional FAST networking & transport layer protocol extension uses the FAST extension header presented in Figure 25.

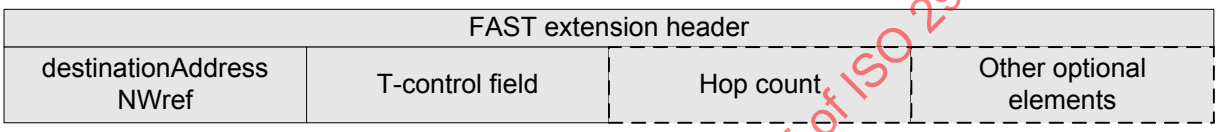

Figure 25 — FAST extension header

The first two elements in the FAST extension header are mandatory, i.e. the destinationAddress NWref and the T-control field.

The destinationAddress NWref field contains the NWref value contained in the destinationAddress NWref field in case no FAST networking & transport layer protocol extension is used.

The T-Control field indicates which optional elements are present in the FAST extension header and which actions shall be performed. Details of the T-control field are specified in Table 5.

Table 5 —T-control field

B7	B6	B5	B4	B3	B2	B1	B0	Description
x	x	x	x	x	x	x	**0**	No hop count element present
x	x	x	x	x	x	x	**1**	Hop count element present. The FAST networking & transport protocol extension shall perform the multi-hop broadcast procedure.
x	x	x	x	x	x	**0**	x	No LPP header present
x	x	x	x	x	x	**1**	x	LPP header present. The FAST networking & transport layer protocol extension LPP shall be performed as specified in ARIB STD-T88.
						x	x	Reserved

7.3.4 Multi-hop broadcast

Multi-hop broadcast with a given number, N, of hops was presented in Reference [1] by the name of "Topologically Scoped Broadcasting" (see Figure 4). Data transmission shall use a MAC broadcast frame.

Every receiving ITS station

— shall act as destination, if applicable,

— shall act as a forwarder depending on the actual hop count.

Decision on forwarding of a packet shall be in the FAST networking & transport layer protocol extension on the basis of the actual value of the hop counter contained in the element "hop count" in the FAST extension header. Initial setting of the hop-counter shall be under the responsibility of the service requesting transmission of the data packet. The initial value of the hop counter shall indicate the number of subsequent hops, i.e. the value 0 shall disable multi-hopping. Every receiving entity shall read the hop counter. If the value is 0, the packet shall no longer be forwarded. If the value is greater than 0, it shall be decremented and the packet broadcast again.

The FAST networking & transport layer protocol extension may limit the value of the hop count according to operational needs or regulatory requirements.

7.3.5 Local Port Protocol

The LPP shall be as specified in ARIB STD-T88.

The LPP header shall be as specified in Figure 26.

Local Port Protocol header			
PDU type	PDU parameter	Transaction identifier	Extensional parameter (optionally)

Figure 26 — LPP header structure

LPP is a transaction-oriented protocol that enables efficient execution of applications and makes data transactions robust.

LPP provides the following transaction services:

a) transaction service entity:

   1) data exchange functions per transaction;

   2) unidirectional data-sending transaction service;

   3) request-response-type transaction service;

   4) data resend function (optional);

   5) message segmentation/re-assembly function (optional);

   6) transaction abortion function;

b) connection management service entity:

   — communication connection query service;

— communication disconnection notice service;

— accept port query service.

LPP provides the following transaction service primitives to applications.

— Invoke

The invocation of the “Invoke” service results in the generation of a new transaction. Every transaction is started by calling this primitive.

— Abort

The invocation of the “Abort” service results in the abortion of an active transaction.

LPP also provides the following connection management service primitives to applications:

— Connect (transaction start query/notification primitive);

— Disconnect (DSRC disconnection notification primitive);

— RegisterPort (Port registration primitive);

— DeregisterPort (Port deregistration primitive).

7.4 ITS-MUX

7.4.1 Functionality

ITS-MUX is an optional feature for concatenating groupcast PDUs which can be used for efficient groupcasting.

In transmit mode, it performs concatenation of NPDUs prepared for MAC groupcasting by different networking protocols, e.g. FAST, Geo-Routing and ITS-MUX. In receive mode, it de-concatenates NPDUs received in a single packet contained in a DL-UNITDATA.indication service primitive.

Figure 27 shows the architecture of ITS-MUX.

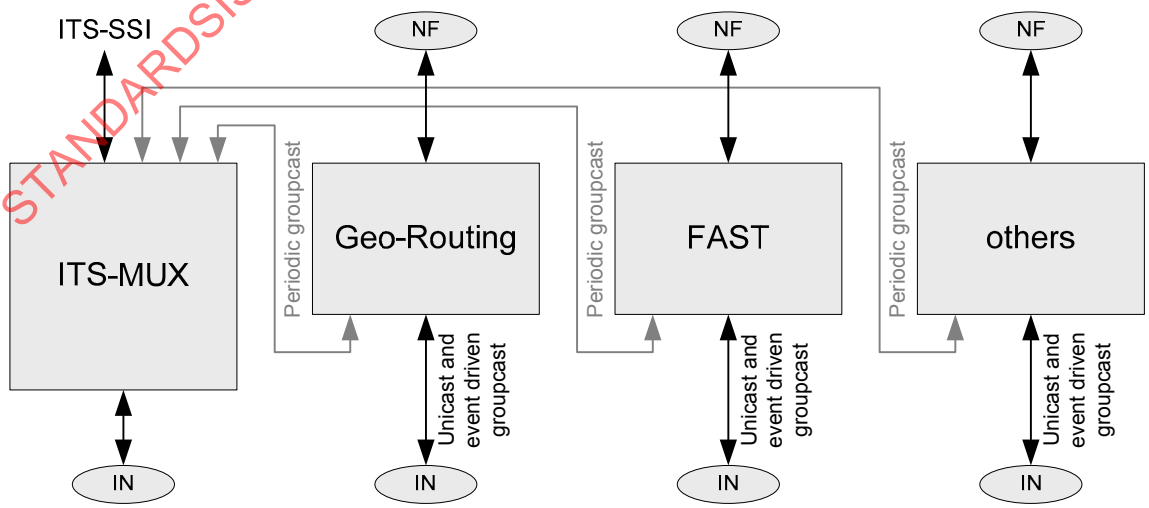

Figure 27 — ITS-MUX architecture

7.4.2 ITS-MUX NPDU

The structure of the ITS-MUX NPDU is presented in Figure 28.

NPDU container for ITS-MUX (optional)	NPDU containers for Geo-Routing (optional)	NPDU containers for FAST (optional)	NPDU containers for other NW protocols (optional)

Figure 28 —ITS-MUX frame elements

The detailed structure of an NPDU container shall be as presented in Figure 29. The NPDU container carries an NPDU, a single SAP address indicating the type of networking protocol of the NPDU, as specified in ISO 21218, and a control field indicating length of the D/S-SAP field and the NPDU in multiples of an octet and presence of a further container in the ITS-MUX NPDU.

Length Indicator	D/S-SAP	NPDU

x x x x x x x x x x x x x x x	Length of NPUD in multiples of an octet, including D/S-SAP field
y	Next NPDU indicator y=0: This is the last NPDU y=1: There is a next NPDU

Figure 29 — General ITS-MUX NPDU container

The NPDU container for ITS-MUX shall be the first container in the ITS-MUX NPDU, if present. The only information contained in this container shall be ITSSI, as presented in Figure 30:

a) station ID, which is preferably globally unique;

b) time stamp, indicating time of generation of ITSSI;

c) position of ITS station — three dimensions;

d) speed of ITS station — scalar value;

e) heading of ITS station, i.e. direction of movement — two dimensions;

f) further optional elements.

Station ID	Time	Position	Speed	Heading	Optional elements

Figure 30 — ITSSI

Depending on the installation, ITSSI may also be provided in another NPDU container, e.g. by the Geo-Routing protocol. ITSSI shall be present only in a single NPDU container of an ITS-MUX NPDU. Details on how ITSSI is delivered to which networking protocol and which entity shall process the received ITSSI are

outside the scope of this International Standard and may be defined by implementation. If ITSSI is not carried in the ITS-MUX NPDU container, source and destination addresses for ITSSI shall be reported in the NPDU of the related networking protocol.

7.4.3 Procedures

7.4.3.1 Transmit mode

Available NPDUs shall be put into ITS-MUX NPDU containers as presented in Figure 29. D/S-SAP shall indicate the type of networking protocol as specified for the IN-SAP address in ISO 21218.

Forwarding of an ITS-MUX LSDU to the IN-SAP shall occur at regular time intervals, as requested by the service at time of registration at the groupcast manager.

Details on how ITS-MUX communicates with other networking protocols are outside the scope of this International Standard.

7.4.3.2 Receive mode

Upon reception of a DL-UNITDATA.indication service primitive from the IN-SAP (see ISO 21218, every existent NPDU container shall be processed such that the NPDU contained in it shall be forwarded to the networking protocol indicated in D/S-SAP.

Details on how ITS-MUX communicates with other networking protocols are outside the scope of this International Standard.

8 Facilities layer protocols

8.1 General

The facilities layer comprises OSI layers five, six and seven as specified in ISO 21217.

The facilities layer shall provide an MF-SAP with service primitives for management purposes, as specified in ISO 24102.

The facilities layer shall be connected to services via an API (FA interface specified in ISO 21217). Details of the API are outside the scope of this International Standard.

The facilities layer shall use the services provided in the NF-SAP by the networking & transport layer.

8.2 Groupcast registration handler

The groupcast registration handler shall be as specified in ISO 24102.

8.3 Repetitive packet transmission handler

The facilities layer shall be responsible for repetitive transmission of data packets, as requested by the service.

8.4 Legacy CI Port Manager

Upon registration of a legacy CI at the ITS station management entity as specified in ISO 24102, the ITS station management entity notifies the “Legacy CI Port Manager” of the presence of this legacy CI, indicating the CI-ID and the type of legacy CI as specified in ISO 24102.

The “Legacy CI Port Manager” shall

a) create a socket for the FAST networking & transport protocol, which includes assignment of a host NWref number from the NWref handler, and

b) notify availability of a socket to the ITS station management entity, indicating the host NWref number and the CI-ID of the related legacy CI.

The “Legacy CI Port Manager” shall maintain a separate host NWref number for each legacy CI registered in the ITS station.

Details on ISO 15628 legacy CIs are provided in Annex B.

8.5 15628 Kernel Emulator

8.5.1 15628 legacy applications

The 15628 legacy application “option 3” shall be treated in the same way as ITS-S applications designed for the FAST protocol.

NOTE The functionality of ACn commands specified is not supported.

8.5.2 CI classes

The “15628 Kernel Emulator” enables ITS applications built on ISO 15628:2007 to be operated over a CALM wireless CI of CI class CIC-wl1 specified in ISO 21218, based on the FAST networking & transport layer protocol. Usage of CIs of CI class CIC-wl5 specified in ISO 21218 are prohibited.

8.5.3 Registration of 15628 applications

In a server station the “15628 Kernel Emulator” shall register available 15628 applications at the groupcast manager using A-REQUEST 1 “GCregServer”, with parameters as specified in Table 6.

Table 6 — Registration of 15628 server application at groupcast manager

Parameter Name	Value
ApplicationID	As specified in ISO 24102
GCschedule	As specified in ISO 24102
Priority	As specified in ISO 24102
ServiceDataReg.fastService.**serviceID**	“aid” as contained in “ApplicationList” specified in ISO 15628:2007
ServiceDataReg.fastService.**Data**	not present
ServiceDataReg.fastService.**NWref**	As specified in ISO 24102
ServiceDataReg.fastService.**serviceChannel**	As specified in ISO 24102

The purpose of “BeaconID” specified in ISO 15628:2007 shall be given by the “serverID” contained in the “STA”.

In a client station the “15628 Kernel Emulator” shall register available 15628 applications at the groupcast manager using A-REQUEST 4 “GCregClient”, with parameters as specified in Table 7.

Table 7 — Registration of 15628 server application at groupcast manager

Parameter Name	Value
ApplicationID	As specified in ISO 24102
Priority	As specified in ISO 24102
ServiceID	“aid” as contained in “ApplicationList” specified in ISO 15628:2007
ContextData	“eid” and “parameter” as contained in “ApplicationList” and “obeConfiguration” as contained in “VST”; “eid”, “parameter” and “VAT” as specified in ISO 15628:2007.

8.5.4 Operation phase

In the operation phase, the PDUs of the 15628 services GET, SET, ACTION and EVENT-REPORT, as specified in ISO 15628:2007, shall be exchanged.

The “data” element in the “Data Exchange” PDU specified in ISO 24102 shall carry the T-APDU as specified in ISO 15628:2007. Concatenation and chaining shall be supported.

The “messageType” element shall be as specified in Table 8.

Table 8 — Selection of “messageType”

15628 service primitive	15628 parameter “mode”	FAST “messageType”
SET.request, ACTION.request, EVENT-REPORT.request	0	5
GET.request	—	6
SET.request, ACTION.request, EVENT-REPORT.request	1	6
GET.response, SET.response, ACTION.response, EVENT-REPORT.response	—	7

The 15628 parameters “FlowControl” and “LID” are not supported explicitly. “FlowControl” and “LID” shall be considered in the operation phase as specified in Table 9.

Table 9 — 15628 “FlowControl” and “LID”

15628				CALM	
FlowControl	**LID**	**Mode**	**Purpose**	**messageType**	**VCI**
1	broadcast	0	Broadcast transmission	5	TX via BC-VCI
1, 4	private	0	Data transmission	5	TX via UC-VCI
7	private	1	Data exchange — Request	6	TX via UC-VCI
10	private	—	Data exchange — Response	7	TX via UC-VCI
2, 3, 5, 6, 8, 9, 11	—	—	—	—	—

The purpose of 15628 “LID” shall be served by CI-ID.

8.6 Basic primitive application functions

Basic primitive application functions are an essential element of legacy CIs according to option 2 specified in Annex B. They are related to on-board unit resources such as human–machine interface, IC card interface and so on. Each basic primitive application function is uniquely addressed by a port number. A roadside station selects and combines basic primitive application functions (see Figure B.2) in order to realize a specific service.

Examples of the basic primitive application functions are shown in Annex D.

NOTE Basic primitive application functions are executed on LPP.

9 Common elements and procedures

9.1 CIP management

CIP management is the process to include CIP information in the NPDU, i.e. in the “data” element of the DL-UNITDATA service specified in ISO 21218, for the following purposes:

— Request setting of TX CIP to the values provided in the CIP header of the “data” element of the DL-UNITDATA.request service primitive prior to transmission of the frame:

  — remove CIP header from NPDU prior to transmission;

  — do not remove CIP header from NPDU prior to transmission.

— Notify presence of a CIP header in the DL-UNITDATA.indication service primitive:

  — TX parameters of the peer station are present;

  — RX parameters of the receiving station are present;

  — both TX and RX parameters are present.

Details of RX and TX CIPs depend on the medium.

CtrlCI bits C1 to C4 of the CI-ID (see ISO 21218) shall be used to indicate the presence of CIPs in data packets passed via the IN-SAP. CIP0, CIP1, CIP2 shall select in a medium-specific way which RX and TX CIP are included in the NPDU. CtrlCI bits not being used shall be set to zero.

For transmission of packets, the setting of the related CtrlCI bits shall be done by the distributed congestion control protocol in the CALM networking layer in the field “destination_address” of the DL-UNITDATA.request service primitive (see Table 10).

Table 10 — “destination_address” field CtrlCI bits in DL-UNITDATA.request

C4	C3	C2	C1	Command / notification
'0'	'0'	'0'	'0'	Nothing to be done
CIP2	CIP1	CIP0	'0'	Evaluate and apply TX CIP parameters and remove them from NPDU prior to transmission of the frame.
CIP2	CIP1	CIP0	'1'	Evaluate and apply TX CIP parameters and keep them in the NPDU for transmission in the frame.

For reception of packets, the setting of the related CtrlCI bits for TX parameters shall be done by CAL in the field “source_address” of the DL-UNITDATA.indication service primitive (see Table 11).

Table 11 — “source_address” field CtrlCI bits in DL-UNITDATA.indication

C4	C3	C2	Command / notification
'0'	'0'	'0'	No TX CIP parameters are present.
CIP2	CIP1	CIP0	TX CIP parameters are present in received NPDU.

For reception of packets, the setting of the related CtrlCI bits for RX parameters shall be done by CAL in the field “destination_address” of the DL-UNITDATA.indication service primitive (see Table 12).

Table 12 — “destination_address” field CtrlCI bits in DL-UNITDATA.indication

C4	C3	C2	Command / notification
'0'	'0'	'0'	No RX CIP parameters are present.
CIP2	CIP1	CIP0	RX CIP parameters are present in received NPDU.

The setting of C1 to C7 in the field “source_address” of the DL-UNITDATA.request service primitive is not specified so far in this International Standard. The bits shall be set to zero if not specified differently in the relevant International Standard on CALM.

The MAC header transmitted in the air needs to report the type of frame, i.e. whether it contains a CIP header or not. How this information shall be transmitted in the frame is outside the scope of this International Standard. Only selected CALM media may support CIP management.

9.2 NF-SAP

The NF-SAP shall provide services to

— create a socket,

— delete a socket,

— request transmission of a packet, and

— notify reception of a packet.

Details depend on the networking & transport layer protocols.

9.3 MN-SAP

The CALM networking layer shall provide an MN-SAP with service primitives for management purposes, as specified in ISO 24102.

10 Conformance

Protocol Implementation Conformance Statements (PICS) shall be made based on the Technical Specification TS 102 985-1 on Intelligent Transport Systems (ITS), currently under development at ETSI.

11 Test methods

Conformance tests shall be performed based on the Technical Specifications TS 102 985-2 on Test Suite Structure and Test Purposes (TSS&TP) for ITS and TS 102 985-3 on Abstract Test Suite (ATS) for ITS, both under development at ETSI.

Annex A
(normative)

ASN.1 definitions

A.1 Use of modules

The ASN.1 modules specified in Clause A.2 shall be used. ASN.1 BASIC-PER, UNALIGNED as specified in ISO/IEC 8825-2 shall apply. The definitions are made such that every ASN.1 element has a length of an integer multiple of a byte.

A.2 ASN.1 modules

```
CALMfast {ISO (1) standard(0) calm-fast(29281) version0(0)} DEFINITIONS::=BEGIN

    IMPORTS

    IN-SAPaddress, Link-ID, CIstatus, MedType, UserPriority FROM CALMllsap
    {ISO (1) standard(0) calm-ll-sap(21218)}

    ITS-scuId FROM CALMmanagement {ISO (1) standard(0) calm-management(24102)
    version1(1)}

    TransportAddressType, TransportAddress FROM TRANSPORT-ADDRESS-MIB;

    -- End of IMPORTS

    ContextData::=OCTET STRING

    DeleteFAST::=SEQUENCE                              -- used in 24102
        {
        reference       INTEGER(0..255)
        }

    DeleteNotFAST::=SEQUENCE                           -- used in 24102
        {
        reference       INTEGER(0..255)
        }

    FastContext::=SEQUENCE                             -- used in 24102
        {
        serviceID       ServiceID,
        contextData     ContextData,
        userNWref       NWref
        }

    FASTtimeout::=INTEGER(0..65535)    -- Used in FAST forwarding tables; in ms
```

```
FastService::=SEQUENCE                              -- used in 24102
    {
    fill              [0] BIT STRING (SIZE(5)),
    serviceID         [1] ServiceID,
    serviceData       [2] ServiceData OPTIONAL,
    serverNWref       [3] NWref OPTIONAL,
    serviceChannel    [4] ServiceChannel OPTIONAL
    }

IpAddressInfo::=SEQUENCE
    {
    addressType       TransportAddressType,
    address           TransportAddress
    }

IpContext::=SEQUENCE                                -- used in 24102
    {
    serviceID         IpServiceID,
    contextData       IpContextData,
    ipInfo            IpInfo
    }

IpContextData::=OCTET STRING

IpInfo::=SEQUENCE
    {
    address           IpAddressInfo
    }

IpService::=SEQUENCE                                -- used in 24102
    {
    fill              [0] BIT STRING (SIZE(6)),
    serviceID         [1] IpServiceID,
    serviceData       [2] IpServiceData OPTIONAL,
    ipInfo            [3] IpInfo,
    serviceChannel    [4] ServiceChannel OPTIONAL
    }

IpServiceData::=OCTET STRING

IpServiceID::=INTEGER(0..127,...)

NPDUcontainer::=SEQUENCE
    {
    header            NPDUcontHead,
    sap               IN-SAPaddress,
    npdu              OCTET STRING                  -- depends on NW protocol
    }

NPDUcontHead::=SEQUENCE
    {
    length            INTEGER(0..32767),
    next              BIT STRING (SIZE(1)) -- next container flag (1=present)
    }

NWref::=SEQUENCE
    {
    lptp              BIT STRING (SIZE(1)), -- LPTP flag (1=used)
    nwRef             INTEGER(0..127)
    }
```

```
Param15628::=CHOICE                         -- parameter of 15628 CI
                                            -- used in 24102
    {
    legacyOption      [0] INTEGER(0..255),
    nWrefPM           [1] NWref,            -- NWref of 15628 Port Manager
    --                [2-254]
    ...
    }

ServiceChannel::= SEQUENCE
    {
    serviceChannel    INTEGER(0..255),
    medium            MedType,
    schParams         OCTET STRING
    }

ServiceData::=OCTET STRING

ServiceID::=INTEGER(0..127,...)

ServiceNWref::=SEQUENCE
    {
    nWref             NWref,
    iTS-scuId         ITS-scuId
    }

SetConfFAST::=SEQUENCE                              -- used in 24102
    {
    reference         INTEGER(0..255)
    }

SetFAST::=SEQUENCE                                  -- used in 24102
    {
    reference         INTEGER(0..255),
    remoteNWref       NWref,
    ciid              Link-ID,
    ciStatus          CIstatus,
    linkNWref         NWref,
    serviceNWref      ServiceNWref,
    priority          UserPriority,
    timeout           FASTtimeout
    }

SetNotFAST::=SEQUENCE                               -- used in 24102
    {
    reference         INTEGER(0..255),
    remoteNWref       NWref,
    ciid              Link-ID,
    ciStatus          CIstatus,
    linkNWref         NWref,
    serviceNWref      ServiceNWref,
    priority          UserPriority,
    timeout           FASTtimeout
    }


UpdateFAST::=SEQUENCE                               -- used in 24102
    {
    fill              [0] BIT STRING (SIZE(1)),
```

```
    reference          [1] INTEGER(0..255),
    remoteNWref        [2] NWref OPTIONAL,
    ciid               [3] Link-ID OPTIONAL,
    ciStatus           [4] CIstatus OPTIONAL,
    linkNWref          [5] NWref OPTIONAL,
    serviceNWref       [6] ServiceNWref OPTIONAL,
    priority           [7] UserPriority OPTIONAL,
    timeout            [8] FASTtimeout OPTIONAL
    }

UpdateNotFAST::=SEQUENCE                          -- used in 24102
    {
    fill               [0] BIT STRING (SIZE(1)),
    reference          [1] INTEGER(0..255),
    remoteNWref        [2] NWref OPTIONAL,
    ciid               [3] Link-ID OPTIONAL,
    ciStatus           [4] CIstatus OPTIONAL,
    linkNWref          [5] NWref OPTIONAL,
    serviceNWref       [6] ServiceNWref OPTIONAL,
    priority           [7] UserPriority OPTIONAL,
    timeout            [8] FASTtimeout OPTIONAL
    }
```

END

NOTE Terminology has changed since ISO 21218 was published. The above specification of an ASN.1 module considers the latest terminology to be implemented in the second edition of ISO 21218.

Annex B
(normative)

15628 legacy CI

B.1 15628 legacy CIs

This annex specifies further requirements for legacy CIs compliant with ISO 15628:2007.

Two options of handling 15628 legacy CIs are specified. Distinction is made based on the way the 15628 services are implemented.

Option 1: Restricted to CI class CIC-wl5 specified in ISO 21218. Adaptation to CALM performed by means of a “15628 Agent Application” below the IN-SAP being responsible for the quick parts of the service, a “15628 Principal Application” above the NF-SAP being responsible for the slow parts of the service and for global control of the service, and the “15628 Port Manager” (see Figures 1 and B.1).

Option 2: Restricted to CI class CIC-wl5 specified in ISO 21218. Adaptation to CALM performed by means of the LPCP below the IN-SAP, the FAST networking & transport layer protocol extension LPP, and the “15628 Port Manager” (see Figures 1 and B.2).

The “Agent Application” and the LPCP shall provide the functionality of CAL specified in ISO 21218.

The purpose of “LID”, specified in ISO 15628:2007, shall be achieved by means of the CI-ID of a UC-VCI.

B.2 Option 1

Figure B.1 shows the architecture for option 1. Two communication entities are distinguished in Figure B.1:

a) 15628 FAST ITS service provider entity (communication master) typically implemented as 15628 DSRC roadside unit (RSU), and not aware of CALM;

b) CALM 15628 FAST ITS service user entity (communication slave) with a functionality normally available in a 15628 DSRC on-board unit (OBU), implemented in a CALM mobile unit.

NOTE 1 The communication master can also be implemented as presented for the communication slave.

NOTE 2 The term “DSRC” used above does not refer to IEEE DSRC but to ISO 15628:2007.

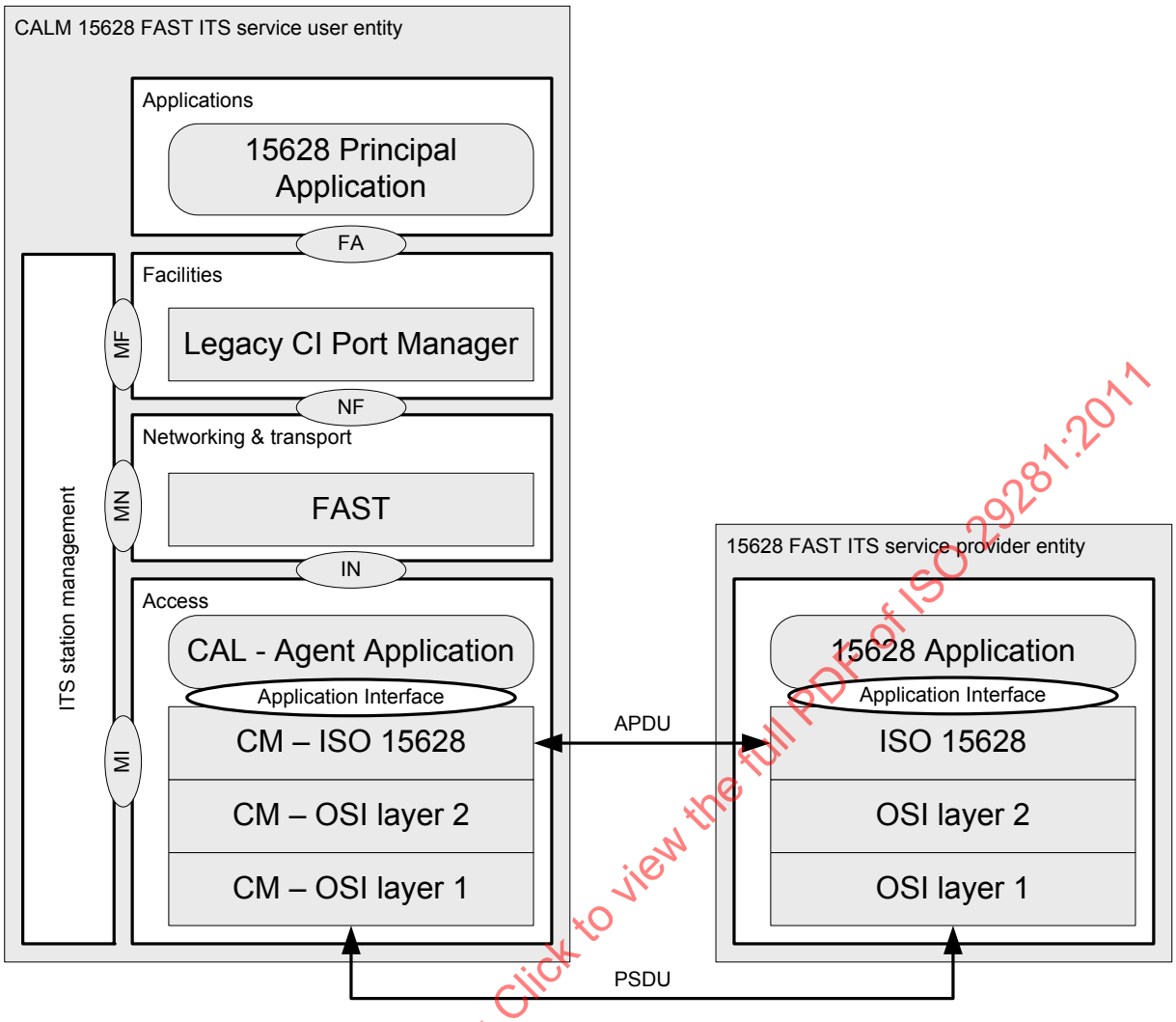

Figure B.1 — CALM 15628 architecture with "Agent Application"

The complete 15628 legacy ITS service is arranged in an "Agent Application" and a "15628 Principal Application". The "Agent Application" shall autonomously handle time-critical packets received via the "Application Interface", i.e. packets received from the FAST ITS service provider application in the RSU. Other packets may be forwarded to the "15628 Principal Application" without execution by the "Agent Application", e.g. packets addressed to the HMI interface or to an OBU component.

The 15628 FAST ITS service user entity contains a CALM 15628 communication module (CM), the "Application Interface", the CAL contained in the "Agent Application", the "Legacy CI Port Manager" interfacing to the MF-SAP, the NF-SAP and the API, and the "CALM 15628 Principal Application".

The "Agent Application" shall interface the communication stack of the CM compliant with ISO 15628:2007 via the "Application Interface". Examples of an "Application Interface" are given in References [2] and [3].

The "Agent Application" shall interface the networking & transport layer via the IN-SAP, providing the functionality of the CAL specified in ISO 21218. The networking protocol used to connect the "Agent Application" to the "15628 Port Manager" shall be FAST. The value of "NWref" selecting the "Legacy CI Port Manager" shall be assigned by the ITS station management entity upon activation of the "CALM 15628 CI".

If service data units (SDUs) are simultaneously received via the "Application Interface" and via the IN-SAP, priority shall be given to the SDUs received via the "Application Interface".

The CALM 15628 CI shall provide an MI-SAP compliant with ISO 21218 and ISO 24102, with restrictions and amendments as specified in this International Standard. The CALM 15628 CI shall be of CI class “CIC-wl5” and of CI access class “CIAC-1” according to ISO 21218. IM-parameter 23 “NWsupport”, specified in ISO 21218, shall indicate a single networking protocol only, i.e. FAST.

In order to register the CI, REQUEST 0 “RegReq”, specified in ISO 21218, shall be used with

— parameter “medType” set to ISO 15628:2007 (128), and

— parameter “macAddress” set to the all-zero locally administered individual address 02-00-00-00-00-00 to indicate a CI without MAC address.

The “G/U” bit in the CI-ID shall always be set to zero. There shall always be only a single UC-VCI. There shall be no BC-VCI and no MC-VCI, although this does not preclude reception of groupcast frames.

Every BST received shall be forwarded to the “Legacy CI Port Manager”.

B.3 Option 2

Figure B.2 shows the architecture for option 2 which consists of equal peer stations.

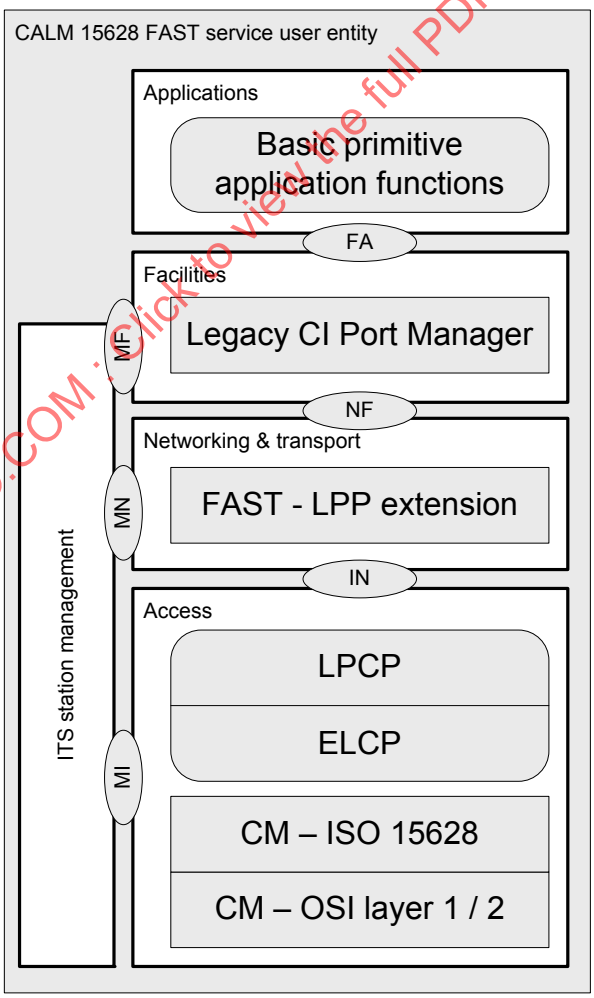

Figure B.2 — Option 2

The “Local Port Control Protocol” (LPCP) performs as an adaptation layer for ISO 15628-type DSRC. It shall be built on top of the “Extended Link Control Protocol” (ELCP) specified in ISO 24103. The ELCP shall be addressed in the BST and VST with the application Id “aid”=18 specified in ISO 15628:2007.

NOTE The ELCP is designed to support IP communications and non-IP communications.

The complete 15628 legacy service is implemented above the facilities layer by means of “Basic primitive application functions”.

The networking protocol used to connect the “Basic primitive application functions” to the LPCP shall be FAST with transport layer extension LPP. The value of “NWref” selecting the “Basic primitive application functions” via the “Legacy CI Port Manager” may be assigned dynamically by the ITS station management entity upon activation of the “CALM 15628 CI” or may be set by implementation.

B.4 Common procedures

B.4.1.1 Link management

Upon reception of a BST which shall result in the creation of a new “LID” in a DSRC OBU, as specified in ISO 15628:2007, the “CALM 15628 CI” shall

— delete the existing UC-VCI,

— create a new UC-VCI,

— associate the CI-ID of this new UC-VCI with the BeaconID contained in the BST, and

— acknowledge the BST by transmission of a VST, if appropriate, in accordance with the rules specified in ISO 15628:2007.

Upon reception of a RELEASE command, as specified in ISO 15628:2007, the “CALM 15628 CI” shall

— forward the RELEASE command to the “Legacy CI Port Manager”, and

— delete the related UC-VCI.

Upon timeout of the validity of a BeaconID, as specified in ISO 15628:2007, the “CALM Legacy CI” shall delete the related UC-VCI.

B.4.1.2 CI states

Possible states of a CALM CI are specified in ISO 21218.

The states “suspended” and “inactive” shall not apply for “CALM Legacy CIs” implemented as back-scatter devices specified in Reference [5].

All state changes are notified to the “Legacy CI Port Manager” as specified in ISO 24102.

B.5 15628 IM-parameters

B.5.1 Applicable parameters

Table B.1 specifies the details of MI-parameters specific to a 15628 “CALM Legacy CI”, and 15628 parameters. MI-parameters specified in ISO 21218 but not contained in Table B.1 are not mandatory for a 15628 “CALM Legacy CI”.

NOTE MI-Param.No equal to 254.128.x identifies 15628-parameter number x.

Table B.1 — 15628 MI-parameters

MI-Param. No	Parameter Name	Range / values	Description	Owner
0	AuxiliaryChannel	0	No support of generic ACH	See ISO 21218
1	ControlChannel	0	No support of generic CCH	See ISO 21218
2	ServiceChannel	0	No support of generic SCH	See ISO 21218
22	Medium	128	Indicating CALM 15628	See ISO 21218
50	ManufacturerDeviceID	same as ISO 21218	Concatenation of ObeConfiguration.equipmentClass and ObeConfiguration.manufacturerID	See ISO 21218
254.128.0	LegacyOption	0, 1-255	0: The CI is not a legacy CI Sequential option number	
254.128.1	NWrefPM	0 - 255	NWref of FAST networking & transport layer protocol pointing to the “Legacy CI Port Manager”	
254.128.2 – 254.128.255			Reserved for future use	

B.5.2 Description

B.5.2.1 ManufacturerDeviceID (MI-Parameter 50)

Table B.2 specifies details of parameter 50 “ManufacturerDeviceID”.

Table B.2 — 15628 parameter type

ASN.1 type	Valid range	Description
MI-Param.**manufacturerDeviceID**	Text string “eeeemmmm”, where eeee presents the hexadecimal equivalent of the equipment class, and mmmm presents the hexadecimal equivalent of the manufacturer ID	Length: 8 characters Equipment class and manufacturer ID used in VST as specified in ISO 15628:2007

B.5.2.2 NWrefPM (Parameter 254.128.1)

Table B.3 specifies details of parameter 254.128.1 “NWref15628PM”.

Table B.3 — Parameter NWref15628PM

ASN.1 type	Valid range	Description
Param15628.**nWrefPM**	As specified in Annex A	NWref of FAST networking & transport layer protocol pointing to the “15628 Port Manager”

Annex C
(informative)

FAST networking & transport layer protocol examples

C.1 Forwarding table management

This annex provides examples of forwarding table management for FAST ITS service provision distinguishing the three implementation architectures A, B and C. Only a single CI is considered.

The forwarding tables presented here only contain selected parameters compared to Figure 12. The semantics of the terms used in the tables of this annex are explained below.

C.2 Implementation architecture A

C.2.1 FAST ITS service with STA and STC

C.2.1.1 No SCH for service operation phase

Implementation architecture A is presented in Figure 6. The example presented here uses a single channel for service advertisement and service operation. It is assumed that there is only a single CI of type “a”.

Initial settings in the forwarding tables are presented in Table C.1

Table C.1 — Initial settings in forwarding tables

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
255	11.a.BC	255	255	0	1) BC-VCI created	255	55.a.BC	255	255	0
255	11.a.10	255	255	0	2) UC-VCI created	255	55.a.20	255	255	0
0	11. any	0	0	0	3) Groupcast manager	0	55.any	0	0	0
255	“don't know”	255	147	0	4) Creation of socket by provider application					
255	11.a.0	147	147	0	5) Registration of provider application					
					6) Transmission of STA using entry 3)					

a) Enables broadcast transmission. Entry shall never be updated. The value NWref = 255 means “don't care”.
11.a.BC: BC-VCI of CI “a” in ITS-SCU 11
55.a.BC: BC-VCI of CI “a” in ITS-SCU 55

b) Enables unicast reception. Update of entries possible. Such an entry shall be present.
11.a.10: UC-VCI 10 of CI “a” in ITS-SCU 11
55.a.20: UC-VCI 20 of CI “a” in ITS-SCU 55

c) Enables forwarding of received packets to the groupcast manager. Entry shall never be updated.
“any” means any CI.
11.any: any CI at ITS-SCU 11
55.any: any CI at ITS-SCU 55

d) Creation of socket by provider application. Enables reception of packets by service. VCI not defined. This entry shall be present during lifetime of service.

e) Enables forwarding of received packets to the provider application via the selected medium (CI). Setting requested by groupcast manager. Update of remote NWref possible. Such an entry shall be present during lifetime of service.

f) FTN-COMM.request(0, 0, 11.a.BC, STA) triggered by groupcast manager via MN-SAP. Transmission of STA shall not change entry 3).

Reception of the STA results in the changes of the client forwarding table as presented in Table C.2.

Table C.2 — Changes of client forwarding table due to reception of STA

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
255	11.BC	255	255	0		255	55.BC	255	255	0
255	11.10	255	255	0	1) Update upon reception of STA	**0**	55.20	**0**	**0**	0
0	11. any	0	0	0		0	55.any	0	0	0
255	“don't know”	255	147	0						
255	11.0	147	147	0						
					2) New UC-VCI created	255	55.21	255	255	0
					3) Creation of socket for client application	255	55.0	247	247	0
					4) Prepare session with station A	147	55.20	247	247	0
					5) Transmission of STC					

g) Existing entry for UC-VCI is updated. Used for transmission of STC.

h) A new UC-VCI is created.

i) Socket for client application is created. Enables forwarding of received packets to the client application via the selected medium (CI). Such an entry shall be present during lifetime of service.

j) Prepare unicast communication during session phase with station A. Setting requested by groupcast manager.

k) FTN-COMM.request(0, 0, 55.a.20, STC) triggered by groupcast manager via MN-SAP. STC is transmitted.

Reception of the STC results in the changes of the provider forwarding table as presented in Table C.3.

Table C.3 — Changes of provider forwarding table due to reception of STC

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
255	11.BC	255	255	0		255	55.BC	255	255	0
0	11.10	**0**	**0**	0	1) Update upon reception of STC	0	55.20	0	0	0
255	11.any	255	0	0		0	55.any	0	0	0
255	“don't know”	255	147	0						
255	11.0	255	147	0						
						255	55.21	255	255	0
						255	55.any	255	247	0
						147	55.20	247	247	0
255	11.11	255	255	0	2) New UC-VCI created					
247	11.10	147	147	0	3) Prepare session with station B					
					4) Notify STC to application					

l) Existing entry for UC-VCI is updated. (Not really needed.)

m) A new UC-VCI is created.

n) Prepare unicast communication during session phase with station B. Setting requested by groupcast manager.

o) Notify reception of STC.

The subsequent service operation phase uses the entries in the forwarding tables presented in Table C.4.

Table C.4 — Networking table entries for FAST ITS service operation phase

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
247	11.10	147	147	0	Session	147	55.20	247	247	0

C.2.1.2 SCH for service operation phase

The example presented here uses the CCH (“a”) for service advertisement and a SCH (“b”) for service operation. It is assumed that there are two CIs “a” and “b”. “a” and “b” can be either of the same medium type, providing orthogonal channels, or of a different medium type.

Initial settings in the forwarding tables are presented in Table C.5.

Table C.5 — Initial settings in forwarding tables

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
255	11.a.BC	255	255	0	1) CCH BC-VCI created	255	55.a.BC	255	255	0
255	11.a.10	255	255	0	2) CCH UC-VCI created	255	55.a.20	255	255	0
255	11.b.BC	255	255	0	3) SCH BC-VCI created	255	55.b.BC	255	255	0
255	11.b.30	255	255	0	4) SCH UC-VCI created	255	55.b.40	255	255	0
0	11. any	0	0	0	5) Groupcast manager	0	55.any	0	0	0
255	“don't know”	255	147	0	6) Creation of socket by provider application					
255	11.b.0	147	147	0	7) SCH registration of provider application					
					8) Transmission of STA using entry 5)					

a) Enables broadcast transmission in CCH. Entry shall never be updated. The value NWref = 255 means “don't care”.

b) Enables unicast reception in CCH. Update of entries possible. Such an entry shall always be present.

c) Enables broadcast transmission in SCH. Entry shall never be updated. The value NWref = 255 means “don't care”.

d) Enables unicast reception in CCH. Update of entries possible. Such an entry shall always be present.

e) Enables forwarding of received packets to the groupcast manager. Entry shall never be updated. “any” means any CI.

f) Creation of socket by provider application. Enables reception of packets by service. VCI not defined. This entry shall be present during lifetime of service.

g) Enables forwarding of received packets to the provider application via the selected medium (CI). Setting requested by groupcast manager. Update of remote NWref possible. Such an entry shall be present during lifetime of service.

h) FTN-COMM.request(0, 0, 11.a.BC, STA) triggered by groupcast manager via MN-SAP. Transmission of STA shall not change entry 5).

Reception of the STA results in the changes of the client forwarding table as presented in Table C.6.

Table C.6 — Changes of client forwarding table due to reception of STA

Combined host / router station A ITS-SCU-ID = 11 service provider						**Combined host / router station B ITS-SCU-ID = 55 service user**				
Remote		**Local**				**Remote**		**Local**		
NWref	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**		**NWref**	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**
255	11.a.BC	255	255	0		255	55.a.BC	255	255	0
255	11.a.10	255	255	0	1) Update upon reception of STA	**0**	55.a.20	**0**	**0**	0
255	11.b.BC	255	255	0		255	55.b.BC	255	255	0
255	11.b.30	255	255	0		255	55.b.40	255	255	0
0	11. any	0	0	0		0	55.any	0	0	0
255	“don't know”	255	147	0						
255	11.b.0	147	147	0						
					2) New UC-VCI created	255	55.a.21	255	255	0
					3) Creation of socket for client application	255	55.0	247	247	0
					4) Prepare SCH session with station A	147	55.b.40	247	247	0
					5) Transmission of STC in SCH					

i) Existing entry for UC-VCI is updated.

j) A new UC-VCI is created.

k) Socket for client application is created. Enables forwarding of received packets to the client application via the selected medium (CI). Such an entry shall be present during lifetime of service.

l) Prepare SCH unicast communication during session phase with station A. Setting requested by groupcast manager.

m) FTN-COMM.request(0, 0, 55.b.40, STC) triggered by groupcast manager via MN-SAP. STC is transmitted.

Reception of the STC results in the changes of the provider forwarding table as presented in Table C.7.

Table C.7 — Changes of provider forwarding table due to reception of STC

Combined host / router station A ITS-SCU-ID = 11 service provider						**Combined host / router station B ITS-SCU-ID = 55 service user**				
Remote		**Local**				**Remote**		**Local**		
NWref	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**		**NWref**	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**
255	11.a.BC	255	255	0		255	55.BC	255	255	0
255	11.a.10	255	255	0		0	55.20	0	0	0
255	11.b.BC	255	255	0		255	55.b.BC	255	255	0
0	11.b.30	**0**	**0**	0	1) Update upon reception of STC	255	55.b.40	255	255	0
255	11.any	255	0	0		0	55.any	0	0	0
255	“don't know”	255	147	0						
255	11.b.0	255	147	0						
						255	55.21	255	255	0
						255	55.any	255	247	0
						147	55.b.40	247	247	0
255	11.b.31	255	255	0	2) New UC-VCI created					
247	11.b.30	147	147	0	3) Prepare session with station B					
					4) Notify STC to application					

n) Existing entry for UC-VCI is updated. (Not really needed.)

o) A new UC-VCI is created.

p) Prepare unicast communication during session phase with station B. Setting requested by groupcast manager.

q) Notify reception of STC.

The subsequent service operation phase uses the entries in the forwarding tables presented in Table C.8.

Table C.8 — Networking table entries for FAST ITS service operation phase

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
247	11.b.30	147	147	0	Session	147	55.b.40	247	247	0

C.2.2 FAST ITS service with STA and no STC

Implementation architecture A is presented in Figure 6. The example presented here uses a single channel for service advertisement and service operation.

Initial settings in the forwarding tables are presented in Table C.1.

Reception of the STA results in the changes of the client forwarding table as presented in Table C.9.

Table C.9 — Changes of client forwarding table due to reception of STA

Combined host / router station A ITS-SCU-ID = 11 service provider						Combined host / router station B ITS-SCU-ID = 55 service user				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
255	11.BC	255	255	0		255	55.BC	255	255	0
255	11.10	255	255	0	1) Update upon reception of STA	**0**	55.20	**0**	**0**	0
0	11. any	0	0	0		0	55.any	0	0	0
255	“don’t know”	255	147	0						
255	11.0	147	147	0						
					2) New UC-VCI created	255	55.21	255	255	0
					3) Registration of client application	255	55.0	247	247	0
					4) Transmission of first request to station B	147	55.20	247	247	0

a) Existing entry for UC-VCI is updated. Used for transmission of STC.

b) A new UC-VCI is created.

c) Socket for client application is created. Enables forwarding of received packets to the client application via the selected medium (CI). Such an entry shall be present during lifetime of service.

d) FTN-COMM.request(247, 147, 2.20, Request) via NF-SAP.

Reception of the Request results in the changes of the provider forwarding table as presented in Table C.10.

Table C.10 — Changes of provider forwarding table due to reception of Request

Combined host / router station A ITS-SCU-ID = 11 service provider						**Combined host / router station B ITS-SCU-ID = 55 service user**				
Remote		**Local**				**Remote**		**Local**		
NWref	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**		**NWref**	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**
255	11.BC	255	255	0		255	55.BC	255	255	0
247	11.10	**147**	**147**	0	1) Update upon reception of Request	0	55.20	0	0	0
255	11.any	255	0	0		255	55.any	255	0	0
255	“don't know”	255	147	0						
255	11.0	255	147	0						
0	11.BC	0	0	0						
						255	55.21	255	255	0
						255	55.any	255	247	0
						147	55.20	247	247	0
255	11.11	255	155	0	2) New UC-VCI created					

e) Existing entry for UC-VCI is updated.

f) A new UC-VCI is created.

NOTE Instead of the update in 1), a new entry could be generated in 2).

The subsequent service operation phase uses the entries in the forwarding tables presented in Table C.4.

C.3 Implementation architecture B

C.3.1 FAST ITS service with STA and STC

Implementation architecture B is presented in Figure 7. The example presented here uses a single channel for service advertisement and service operation.

Initial settings in the forwarding tables are presented in Table C.11.

Table C.11 — Initial settings in forwarding tables

Host station A ITS-SCU-ID = 11 service provider						Router station A ITS-SCU-ID = 22				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
					1) BC-VCI created	255	22.BC	255	255	0
					2) UC-VCI created	255	22.20	255	255	0
253	11.50	254	255	2	3) LAN VCI created	254	22.50	253	255	1
					4) Groupcast manager	0	22.any	0	0	0
255	“don't know”	255	147	0	5) Creation of socket by provider application					
255	22.0	254	147	0	6) Registration of provider application	255	22.0	111	147	11
					7) Transmission of STA using entry 4)					

Host station B ITS-SCU-ID = 33 service user						Router station B ITS-SCU-ID = 44				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
					1) BC-VCI created	255	44.BC	255	255	0
					2) UC-VCI created	255	44.20	255	255	0
253	33.50	254	255	1	3) LAN VCI created	254	44.50	253	255	2
					4) Groupcast manager	0	44.any	0	0	0

a) Enables broadcast transmission. Entry shall never be updated. The value NWref = 255 means “don't care”.

b) Enables unicast reception. Update of entries possible. Such an entry shall always be present.

c) Enables FAST local forwarding. Entries shall never be updated. Host ITS-SCU-ID is not needed. May be set to any value — proposed: 1 in host and 2 in router.

d) Enables forwarding of received packets to the groupcast manager. Entry shall never be updated.

e) Creation of socket by provider application. Enables reception of packets by service. VCI not defined. This entry shall be present during lifetime of service.

f) Enables forwarding of received packets to the provider application via the selected medium (CI). Update of remote NWref possible. Such an entry shall be present during lifetime of service.

g) FTN-COMM.request(0, 0, 11.BC, STA) triggered by groupcast manager in router via MN-SAP.

Reception of the STA results in the changes of the client forwarding table as presented in Table C.12.

Table C.12 — Changes of client forwarding table due to reception of STA

Host station B ITS-SCU-ID = 33 service user						Router station B ITS-SCU-ID = 44				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
						255	44.BC	255	255	0
					1) Update upon reception of STA	**0**	44.20	**0**	**0**	0
253	33.50	254	255	1		254	44.50	253	255	2
						0	44.any	0	0	0
					2) New UC-VCI created	255	44.21	255	255	255
255	44.0	254	247	33	3) Creation of socket by client application	255	44.0	222	247	33
111	44.20	254	247	0	4) Prepare session with station A	111	44.20	222	247	33
					5) Transmission of STC					

h) Existing entry for UC-VCI is updated. Used for transmission of STC.

i) A new UC-VCI is created.

j) Socket for client application is created at host upon notification of STA. Setting entry in router requires inter-ITS-SCU communication. Enables forwarding of received packets to the client application via the selected medium (CI). Such an entry shall be present during lifetime of service.

k) Prepare unicast communication during session phase with station A. NWref = 111 will be reported in STC. Setting requested by groupcast manager. Setting entry in host requires inter-ITS-SCU communication.

l) FTN-COMM.request(0, 0, 44.20, STC) triggered by groupcast manager via MN-SAP. STC is transmitted.

Reception of the STC results in the changes of the provider forwarding table as presented in Table C.13.

Table C.13 — Changes of provider forwarding table due to reception of STC

Host station A ITS-SCU-ID = 11 service provider						**Router station A ITS-SCU-ID = 22**				
Remote		**Local**				**Remote**		**Local**		
NWref	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**		**NWref**	**CI-ID**	**Link NWref**	**Host NWref**	**Host ITS-SCU-ID**
						255	22.BC	255	255	0
					1) Update upon reception of STC	**0**	22.20	**0**	**0**	0
253	11.50	254	255	2		254	22.50	253	255	1
						0	22.any	0	0	0
255	“don't know”	255	147	0						
255	22.0	254	147	0		255	22.0	111	147	11
					2) New UC-VCI created	255	22.21	255	255	0
					3) Prepare session with station B	222	22.20	111	147	11
222	22.20	254	147	0	4) Notify STC to application					

m) Existing entry for UC-VCI is updated. (Not really needed.)

n) A new UC-VCI is created.

o) Prepare unicast communication during session phase with station B. Settings requested by groupcast manager.

p) Notify reception of STC to groupcast manager in host. Groupcast manager requests setting of entry in forwarding table. Groupcast manager in host notifies service.

The subsequent service operation phase uses the entries in the forwarding tables presented in Table C.14.

Table C.14 — Networking table entries for FAST ITS service operation phase

Host station A ITS-SCU-ID = 11 service provider						Router station A ITS-SCU-ID = 22				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
222	22.20	254	147	0	Session					
253	11.50	254	255	2		254	22.50	253	255	1
						222	22.20	111	147	11

Host station B ITS-SCU-ID = 33 service user						Router station B ITS-SCU-ID = 44				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
111	44.20	254	247	0	Session					
253	33.50	254	255	1		254	44.50	253	255	2
						111	44.20	222	247	33

C.3.2 FAST ITS service with STA and no STC

Implementation architecture B is presented in Figure 7. The example presented here uses a single channel for service advertisement and service operation.

Initial settings in the forwarding tables are presented in Table C.11.

Reception of the STA results in the changes of the client forwarding table as presented in Table C.15.

Table C.15 — Changes of client forwarding table due to reception of STA

Host station B ITS-SCU-ID = 33 service user						Router station B ITS-SCU-ID = 44				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
						255	44.BC	255	255	0
					1) Update upon reception of STA	**0**	44.20	**0**	**0**	0
253	33.50	254	255	1		254	44.50	253	255	2
						0	44.any	0	0	0
					2) New UC-VCI created	255	44.21	255	255	255
255	44.0	254	247	33	3) Creation of socket by client application	255	44.0	222	247	33
111	44.20	254	247	0	4) Prepare session with station A	111	44.20	222	247	33
					5) Transmission of first request to station A					

a) Existing entry for UC-VCI is updated. Used for transmission of STC.

b) A new UC-VCI is created.

c) Socket for client application is created at host upon notification of STA. Setting entry in router requires inter-ITS-SCU communication. Enables forwarding of received packets to the client application via the selected medium (CI). Such an entry shall be present during lifetime of service.

d) Prepare unicast communication during session phase with station A. NWref = 111 will be reported in STC. Setting requested by groupcast manager. Setting entry in host requires inter-ITS-SCU communication.

e) FTN-COMM.request(247, 111, 44.20, Request) issued by the service, locally forwarded to the host and transmitted to station A.

Reception of the Request results in the changes of the provider forwarding table as presented in Table C.13.

Table C.16 — Changes of provider forwarding table due to reception of Request

Host station A ITS-SCU-ID = 11 service provider						Router station A ITS-SCU-ID = 22				
Remote		Local				Remote		Local		
NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID		NWref	CI-ID	Link NWref	Host NWref	Host ITS-SCU-ID
						255	22.BC	255	255	0
					1) Update upon reception of Request	222	22.20	111	147	11
253	11.50	254	255	2		254	22.50	253	255	1
						0	22.any	0	0	0
255	“don't know”	255	147	0						
255	22.0	254	147	0		255	22.0	111	147	11
					2) New UC-VCI created	255	22.21	255	255	0
222	22.20	254	147	0	3) Forward Request to host					

f) Existing entry for UC-VCI is updated.

g) A new UC-VCI is created.

h) Forward Request to host

The subsequent service operation phase uses the entries in the forwarding tables presented in Table C.14.