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Intelligent transport systems — Communications access for land mobiles (CALM) — IPv6 Networking

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National foreword

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Intelligent transport systems — Communications access for land mobiles (CALM) — IPv6 Networking

Systèmes intelligents de transport — Accès aux communications des services mobiles terrestres (CALM) — Gestion de réseau IPv6

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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 21210 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 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-compliant systems can 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;

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

An introduction to the whole set of International Standards is provided in ISO 21217.

One of the most interesting features of the CALM concept is the ability to use a number of networking protocols designed to meet specific requirements. However, to meet the needs of the majority of anticipated ITS applications and services, IPv6 ('Internet Protocol version 6') is ideally suited. The use of this version of IP scales is to meet the needs of a growing number of vehicles and connected devices, and provides the added functionality necessary in mobile environments [IPv6 mobility support (NEMO), “multiple Care-of Address” (MCoA) support].

This International Standard specifies the IPv6 network protocols and services necessary to support global reachability of ITS stations, continuous Internet connectivity for ITS stations and the handover functionality required to maintain such connectivity. This functionality also allows legacy devices to effectively use an ITS station as an access router to connect to the Internet. Essentially, this specification describes how IPv6 is configured to support ITS stations and provides the necessary management functionality.

Intelligent transport systems — Communications access for land mobiles (CALM) — IPv6 Networking

1 Scope

This International Standard specifies networking protocol functionalities related to IPv6 networking between two or more ITS stations communicating over the global Internet communication network.

The International Standard assumes that the reader is familiar with IETF specifications found in "Request for Comments" (RFCs) of individual IPv6 protocol blocks used within this International Standard. This International Standard does not define a new protocol, a new exchange of messages at the IPv6 layer, or new data structures. It defines how standard IETF protocols are combined so that ITS stations can communicate with one another using the IPv6 family of protocols. Procedures defined to share information between the IPv6 layer and other components of the ITS station architecture are defined in ISO 24102. In addition to the requirements specified within this International Standard, a number of notes and examples are provided to illustrate IPv6 addressing configuration and IPv6 mobility management.

2 Conformance

This International Standard specifies the use of IPv6 networking for ITS stations conforming to the CALM architecture (ISO 21217). A set of protocols specified by the IETF are selected. At minimum, all implementations of IPv6 in the context of ITS stations have to conform with IETF RFC 4294 *IPv6 Node Requirements*.

"Protocol implementation conformance statements" (PICS) will be provided at a later stage in a later document and will complement the IPv6 conformance tests such as those defined for the IPv6-ready logo program (http://www.ipv6ready.org). The IPv6-ready logo program provides conformance tests for individual IPv6 protocols or sets of IPv6 protocols on an individual protocol basis.

3 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 21217:2010, *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*

IETF Request for Comments (RFC) 2460, *Internet Protocol, Version 6 (IPv6) Specification*

IETF Request for Comments (RFC) 3587, *IPv6 Global Unicast Address Format*

IETF Request for Comments (RFC) 3963, *Network Mobility (NEMO) Basic Support Protocol*

IETF Request for Comments (RFC) 4291, *IP Version 6 Addressing Architecture*

IETF Request for Comments (RFC) 4294, *IPv6 Node Requirements*

IETF Request for Comments (RFC) 4493, *The AES-CMAC Aligorithm*

IETF Request for Comments (RFC) 4861, *Neighbor Discovery for IP Version 6 (IPv6)*

IETF Request for Comments (RFC) 4862, *IPv6 Stateless Address Autoconfiguration*

IETF Request for Comments (RFC) 5648, *Multiple Care-of Addresses Registration*

4 Terms and definitions

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

NOTE Wherever terms like "address", "host", "node", "router", "mobile network", "interface", "link" and "subnet", are used in the text without the IPv6 modifier, the IPv6 modifier should be assumed to be present (e.g. IPv6 address, IPv6 interface). Most of the definitions are taken from RFC 2460; RFC 3753 and RFC 4885.

4.1
care-of address
CoA
'IPv6 address' associated with a mobile node while attached on a 'foreign IPv6 link'

4.2
egress IPv6 interface
interface of an MR attached to the 'home IPv6 link' if the 'IPv6 mobile router' is at home, or attached to a 'foreign IPv6 link' if the 'IPv6 mobile router' is in a foreign network

[SOURCE: RFC 3753]

4.3
external IPv6 interface
'IPv6 interface' of an 'ITS-S IPv6 router' in an ITS station used to connect to another ITS station or the Internet

4.4
foreign IPv6 link
'IPv6 link' other than the mobile node's 'home IPv6 link'

4.5
global IPv6 address
'IPv6 address' corresponding to 'Global Unicast Addresses' as specified in RFC 4291

4.6
home address
HoA
'IPv6 address' assigned to a mobile node, used as the permanent address of the mobile node

NOTE The term 'home address' is defined in RFC 3753. This 'IPv6 address' is within the mobile node's 'home IPv6 link'. Standard IP routing mechanisms deliver packets destined for a mobile node's 'home address' to its 'home IPv6 link'.

4.7
home IPv6 link
'IPv6 link' on which a mobile node's 'home IPv6 prefix' is defined

4.8
home IPv6 prefix
'IPv6 prefix' corresponding to a mobile node's 'home address'

4.9
ingress IPv6 interface
interface of an MR attached to an 'IPv6 link' inside the 'IPv6 mobile network'

[SOURCE: RFC 3753]

4.10
home ITS-S IPv6 LAN
'ITS-S IPv6 LAN' providing Internet reachability functions to 'mobile ITS-S IPv6 LANs'

4.11
IPv6 subnet
logical group of connected network nodes

NOTE Nodes in an 'IPv6 subnet' share a common network prefix.

[SOURCE: RFC 3753]

4.12
IPv6 Access Network
AN
'IP network that includes one or more Access Network Routers'

[SOURCE: RFC 3753]

4.13
IPv6 access router
AR
'Access Network Router residing on the edge of an Access Network and connected to one or more Access Points'

NOTE This definition of "access router" is taken from RFC 3753. An 'IPv6 Access Router' offers IP connectivity to Mobile Nodes, acting as a default IPv6 router to the mobile nodes it is currently serving. The 'IPv6 Access Router' may include intelligence beyond a simple forwarding service offered by ordinary IPv6 routers.

4.14
IPv6 address
IPv6-layer identifier for an interface or a set of interfaces

NOTE IPv6 addresses are assigned to network interfaces, not to nodes.

[SOURCE: RFC 2460]

4.15
IPv6 home agent
HA
'IPv6 router' on a mobile node's 'home IPv6 link' with which the mobile node (MN) has registered its current Care-of Address.

NOTE This definition of 'home agent' is taken from RFC 3753. While the mobile node is away from home, the home agent intercepts packets on the 'home IPv6 link' destined to the mobile node's Home Address (HoA), encapsulates them, and tunnels them to the mobile node's registered Care-of Address (CoA).

4.16
IPv6 host
any 'IPv6 node' that is not a 'IPv6 router'

[SOURCE: RFC 2460]

4.17
IPv6 interface
node's attachment to an 'IPv6 link'

NOTE Each interface is configured with at least one link-local address and possibly other types of IPv6 addresses (global unicast, multicast).

[SOURCE: RFC 2460]

4.18
IPv6 link
communication facility or medium over which nodes can communicate at the link layer, i.e. the layer immediately below IPv6

NOTE A link is the layer immediately below IP. In a layered network stack model, the Link Layer (Layer 2) is normally below the Network (IP) Layer (Layer 3), and above the Physical Layer. Examples are Ethernet (simple or bridged; PPP links; X.25, Frame Relay, or ATM networks; and IP (or higher) layer 'tunnels', such as tunnels over IPv4 or IPv6 itself.

[SOURCE: RFC 2460]

4.19
IPv6 mobile network
entire network, moving as a unit, which dynamically changes its point of attachment to the Internet and thus its reachability in the topology

NOTE This definition of 'mobile network' is taken from RFC 3753.

4.20
IPv6 mobile router
MR
'IPv6 router' capable of changing its point of attachment to the network, moving from one 'IPv6 link' to another 'IPv6 link'

NOTE The mobile IPv6 router is capable of forwarding packets between two or more interfaces, and possibly running a dynamic routing protocol modifying the state by which it does packet forwarding. A mobile IPv6 router acting as a gateway between an entire IPv6 mobile network and the rest of the Internet has one or more egress interface(s) and one or more ingress interface(s). Packets forwarded upstream to the rest of the Internet are transmitted through an egress interface; packets forwarded downstream to the IPv6 mobile network are transmitted through an ingress interface (RFC 3753).

4.21
IPv6 node
device that implements IPv6

[SOURCE: RFC 2460]

4.22
IPv6 prefix
bit string that consists of some number of initial bits of an 'IPv6 address'

NOTE The prefix of length 64 (/64) of an IPv6 'Global Unicast Address' (RFC 3587) identifies a specific IPv6 subnet and its position in the Internet hierarchy

[SOURCE: RFC 3753]

4.23
IPv6 router
'IPv6 node' that forwards IPv6 packets not explicitly IPv6 addressed to itself

[SOURCE: RFC 2460]

4.24
'ITS-S IPv6 access router'
'IPv6 router' implementing communication functions of an ITS station and offering access to 'mobile ITS-S IPv6 LANs'

4.25
'ITS-S IPv6 border router'
IPv6 router implementing communication functions of an ITS station and connecting 'ITS-S IPv6 LANs' to the Internet and other networks

4.26
ITS-S IPv6 home agent
'IPv6 home agent' implementing communication functions of an ITS station and maintaining access to 'mobile ITS-S IPv6 LANs'

4.27
ITS-S IPv6 host
'IPv6 host' implementing non-routing capabilities of an ITS station

4.28
ITS-S IPv6 LAN
IPv6 LAN composed of one or more IPv6 subnets comprising one or more ITS station(s) and 0 or more legacy IPv6 node(s) deployed in an ITS sub-system

NOTE An 'ITS-S IPv6 router' with no 'ITS-S IPv6 LAN interface' is considered as a simple case of an 'ITS-S IPv6 LAN' comprising only one 'IPv6 node'. Considering only 'ITS-S IPv6 LANs' simplifies this International Standard and ensures compatibility among ITS sub-systems equipped to meet different design choices.

4.29
ITS-S IPv6 LAN interface
'IPv6 interface' of an 'IPv6 node' in an ITS station used to connect to the 'ITS-S IPv6 LAN'

NOTE All 'IPv6 interfaces' are either 'external IPv6 interfaces' or 'ITS-S IPv6 LAN interfaces'.

4.30
ITS-S IPv6 LAN node
node on an 'ITS-S IPv6 LANITS-S IPv6 LAN'

NOTE Any 'ITS-S IPv6 node' or 'legacy IPv6 node'.

4.31
'ITS-S IPv6 mobile router'
'IPv6 router' implementing communication functions of an ITS station and deployed in a 'mobile ITS-S IPv6 LAN'

4.32
ITS-S IPv6 node
'IPv6 node' ('IPv6 host' or 'IPv6 router') implementing functions of an ITS station

NOTE The ITS station comprises a communication function and application functions. These functions may be split into physically separated nodes communicating over an LAN.

4.33
ITS-S IPv6 router
'IPv6 router' implementing routing capabilities of an ITS station

4.34
ITS-S IPv6 router serving an ITS-S IPv6 LAN
'ITS-S IPv6 router' that is connecting an 'ITS IPv6 LAN' to other 'ITS IPv6 LANs' or the global Internet

4.35
legacy IPv6 node
'IPv6 node' in accordance with RFC 4294 (IPv6 node requirements) and functions without additional IPv6 networking capabilities

4.36
link-local IPv6 address
'IPv6 address' corresponding to a 'link-local IPv6 unicast address' as specified in RFC 4291

4.37
mobile edge multihoming
possibility for a mobile node ('IPv6 host' or 'IPv6 router' serving an 'IPv6 mobile network') to connect simultaneously to the Internet through multiple points of attachment, either using multiple communication media or using multiple interfaces of the same communication medium, or through multiple 'IPv6 mobile routers' serving the same 'IPv6 mobile network'

NOTE Mobile edge multihoming mechanisms are known as MonAmi6 support within the IETF as a reference to the former MonAmi6 Working Group where these mechanisms were first defined before being taken over by the MeXT Working Group. For a comprehensive understanding of the mobile edge multihoming issues, it is recommended that the user read RFC 4980.

4.38
mobile ITS-S IPv6 LAN
'ITS-S IPv6 LAN' having the capability of changing its point of attachment to the ITS domain or the Internet

4.39
mobile ITS-S IPv6 LAN node
'IPv6 node' on a 'mobile ITS-S IPv6 LAN'

4.40
network mobility support
network function allowing an entire mobile 'IPv6 subnet' or 'IPv6 mobile network' to change its point of attachment to the Internet and, thus, its reachability in the topology, without interrupting IP packet delivery to or from this 'IPv6 mobile network'

NOTE This terminology associated with this support function is defined in RFC 3753 and RFC 4885.

4.41
tunnel
forwarding path between two nodes on which the payload consists of encapsulated packets

5 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 21218, ISO 24102, IETF RFC 3753 and IETF RFC 4885.

AR IPv6 access router

BR IPv6 border router

CoA IPv6 'Care-of Address'

DHCP Dynamic Host Configuration Protocol

DNS Dynamic Name Server

HA IPv6 home agent

HoA	IPv6 home address
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPsec	Internet Protocol security
ITS-S	ITS station
L2TP	Layer Two Tunneling
LAN	Local Area Network
MCoA	Multiple Care-of Addresses
MIB	Management Information Base
MNN	IPv6 mobile network node (by extension an abbreviation for 'mobile ITS-S IPv6 LAN nodes')
MNP	IPv6 mobile network prefix
MR	IPv6 mobile router
NEMO	NEtwork Mobility

6 Requirements

6.1 Categories

Clause 6 explains the relation between the five categories of requirements.

— The first category (see 6.2) contains requirements applying to all IPv6 nodes and requirements applying to different types of IPv6 nodes in each ITS sub-system.

— The second category (see 6.3) contains requirements defining the IPv6 functional modules that are particular to 'ITS-S IPv6 nodes'. Five different modules are detailed. They may be combined in different ways according to the functions of the IPv6 nodes defined in 6.2. How they are combined is the purpose of the third category (see 6.4).

— The third category (see 6.4) contains requirements defining which of the IPv6 functional modules specified in 6.3 are combined for each particular 'ITS-S IPv6 node' specified in 6.2.

— The fourth category (see 6.5) contains IPv6 addressing requirements applying to 'ITS-S IPv6 nodes' according to the functions listed in 6.2.

— The fifth category (see 6.6) contains optional features and functions. Their actual specification is not within the scope of this International Standard.

6.2 ITS-S nodes implementing IPv6

Figure 1 provides an illustration of the connectivity of ITS stations in IPv6-based ITS sub-systems and their peer-to-peer relationship.

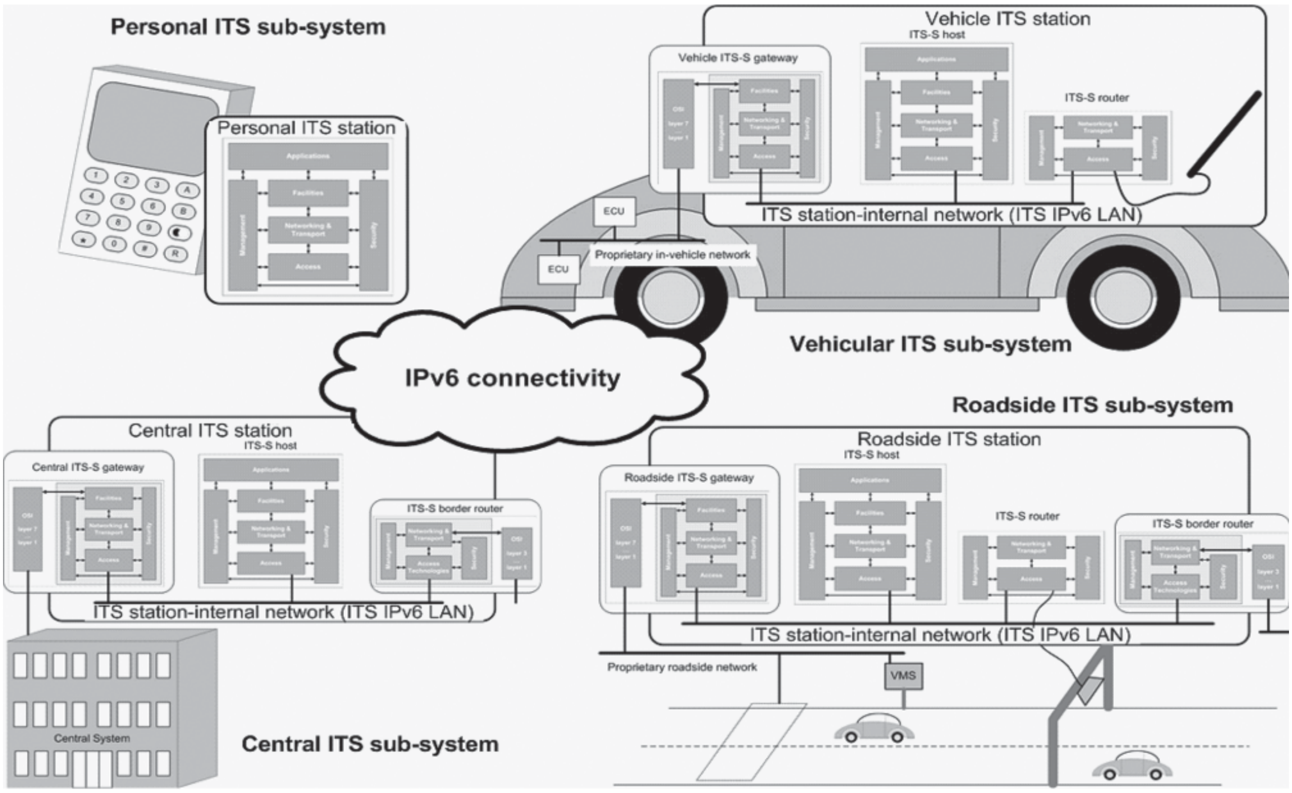

Figure 1 — Illustration of ITS station connectivity in IPv6-based ITS sub-systems

6.2.1 Requirements on all ITS-S IPv6 LAN nodes

This subclause specifies the functional requirements of any instantiation of an ITS station capable of supporting communication classes 3, 4, 7 or 8 as specified in ISO 21217. An IPv6 local area network in an ITS station implemented according to these specifications is referred to as an 'ITS-S IPv6 LAN'. 'ITS-S IPv6 LAN' are components of various ITS sub-systems as illustrated in Figure 1.

An 'ITS-S IPv6 LAN node' shall implement IPv6 in accordance with IETF RFC 2460, RFC 4291, RFC 4493, RFC 4861 and RFC 4294.

NOTE 1 Additional features are required according to the role played by the 'ITS-S IPv6 LAN node' (ITS-S IPv6 mobile router, ITS-S IPv6 access router, ITS-S IPv6 border router, ITS-S IPv6 home agent, ITS-S IPv6 host) and whether it is deployed in the vehicle ('mobile ITS-S IPv6 LAN'), in the roadside or in the central ITS sub-systems.

'ITS-S IPv6 LANs' deployed in vehicles, roadside, personal and central ITS stations shall be part of the global public Internet.

'ITS-S IPv6 LANs' shall all be IPv6 islands inter-connected over the public Internet either using native IPv6, or tunneled in IPv4 networks or some combination of both.

Transition mechanisms may be deployed so that IPv6 entities can also communicate with public Internet entities not able yet to communicate in IPv6.

NOTE 2 Being part of the global Internet, IPv6 nodes deployed in 'ITS-S IPv6 LANs' can communicate with IPv6 third parties not located in 'ITS-S IPv6 LANs'. It is necessary that IPv6 in ITS stations be backward compatible with all legacy IPv6 nodes connected to the ITS station, either in the 'ITS-S IPv6 LAN' or anywhere in the Internet.

The functions of an ITS station may be distributed among various nodes on an ITS-S IPv6 LAN. There shall be at least one 'ITS-S IPv6 router' on the 'ITS-S IPv6 LAN'.

An 'ITS-S IPv6 router' shall have at least one external IPv6 interface.

An 'ITS-S IPv6 router' may have an ITS LAN IPv6 interface. In such a situation, the ITS-S IPv6 router is said to be an 'ITS-S IPv6 router serving an ITS-S IPv6 LAN'.

An 'ITS-S IPv6 router serving an ITS-S IPv6 LAN' may provide means for legacy IPv6 nodes deployed in its attached 'ITS-S IPv6 LAN' to connect to the Internet.

An 'ITS-S IPv6 host' deployed in an 'ITS-S IPv6 LAN' shall implement the modules of an 'ITS-S IPv6 host' as indicated in 6.4.2.

NOTE 3 If desired in a particular implementation, the functions of the ITS-S IPv6 host can be performed by an 'ITS-S IPv6 router'.

An 'ITS-S IPv6 border router' deployed in an 'ITS-S IPv6 LAN' and connected to the Internet shall implement the modules of an 'ITS-S IPv6 border router' in accordance with 6.4.5.

NOTE 4 The functions of the 'ITS-S IPv6 border router' can be performed by an 'ITS-S IPv6 access router' and the functions of an ITS-S IPv6 host can be performed by an 'ITS-S IPv6 router'.

NOTE 5 An 'ITS-S gateway' deployed in an 'ITS-S IPv6 LAN' and acting as a firewall isolating non-IPv6 devices from other devices reachable over IPv6 can be implemented as an 'ITS-S IPv6 IPv6 host' (in accordance with 6.4.2) or as an 'ITS-S IPv6 router' (in accordance with 6.4.1, 6.4.3 or 6.4.5).

6.2.2 ITS-S IPv6 LAN nodes deployed in vehicle ITS sub-systems

In addition to 6.2.1, which applies to all ITS sub-systems, the provisions of 6.2.2 apply to vehicle ITS sub-systems. Figure 1 illustrates 'ITS-S IPv6 LAN nodes' deployed in the vehicle ITS sub-systems.

A vehicle ITS station capable of supporting communication classes 3, 4, 7 or 8 as specified in ISO 21217 shall comprise a 'mobile ITS-S IPv6 LAN'.

An 'ITS-S IPv6 router' deployed in a 'mobile ITS-S IPv6 LAN' and used to attach to a foreign 'ITS-S IPv6 LAN' shall implement the modules of an 'ITS-S IPv6 mobile router' as specified in 6.4.1.

A 'mobile ITS-S IPv6 LAN' shall at least contain one 'ITS-S IPv6 mobile router'.

NOTE The configuration of 'mobile ITS-S IPv6 LANs' with several 'ITS-S IPv6 mobile routers' can require additional mechanisms that are not specified in this International Standard.

6.2.3 ITS-S IPv6 LAN nodes deployed in roadside ITS sub-systems

In addition to 6.2.1 which applies to all ITS sub-systems, the provisions in 6.2.3 apply to roadside ITS sub-systems. Figure 1 illustrates 'ITS-S IPv6 LAN nodes' deployed in the roadside ITS sub-systems.

A roadside ITS station may contain one or more IPv6 routers, referred to as 'ITS-S IPv6 routers', to access the Internet and to provide access to vehicle ITS sub-systems.

— An 'ITS-S router' deployed in an 'ITS-S IPv6 LAN' and used to provide access to 'mobile ITS-S IPv6 LAN' shall implement the modules of an 'ITS-S IPv6 access router' in accordance with 6.4.3.

— An 'ITS-S IPv6 router' deployed in an 'ITS-S IPv6 LAN' and used to connect the roadside 'ITS-S IPv6 LAN' to the Internet shall implement the modules of an 'ITS-S IPv6 border router' in accordance with 6.4.4.

6.2.4 ITS-S IPv6 LAN nodes deployed in central ITS sub-systems

In addition to 6.2.1, which applies to all ITS sub-systems, the provisions of 6.2.4 apply to central ITS sub-systems. Figure 1 illustrates 'ITS-S IPv6 LAN nodes' deployed in the central ITS sub-systems.

An 'ITS-S IPv6 router' deployed in an 'ITS-S IPv6 LAN' and used to connect the central 'ITS-S IPv6 LAN' to the Internet shall implement the modules of an 'ITS-S IPv6 border router' in accordance with 6.4.4.

A central ITS station supporting communication classes 3, 4, 7 and 8 as defined in ISO 21217 shall implement a 'home ITS-S IPv6 LAN' that implements the IPv6 host functions necessary for 'mobile ITS-S IPv6 LANs' to maintain their reachability at a global IPv6 address. Functions that shall be provided by the 'home ITS-S IPv6 LAN' include IPv6 prefix allocation and domain name registration.

For communication classes 4 and 8 as defined in ISO 21217, 'ITS-S routers' deployed in the 'home ITS-S IPv6 LAN' used to perform the functions necessary for 'mobile ITS-S IPv6 LANs' to maintain session continuity while performing handovers, shall implement the modules of an 'ITS-S IPv6 home agent' in accordance with 6.4.4.

NOTE The functions of the IPv6 home agent can be implemented as a legacy IPv6 node.

6.2.5 ITS-S IPv6 LAN nodes deployed in personal ITS sub-systems

The provisions of 6.2.1 apply to all personal ITS subsystems.

NOTE While not specified in this International Standard, future versions will specify how nomadic devices are attached to and integrated in ITS stations.

6.3 IPv6 functional modules

This subclause specifies what IPv6 functions it is required to use. These functions are put together in five different modules. In 6.4, then, is specified which of these modules are required for each type of ITS-S IPv6 node specified in 6.2. This separation into modules makes the specification of IPv6 functions much easier. Figure 2 illustrates how these functional modules are mapped to the IPv6 networking functional block of the ITS station reference architecture.

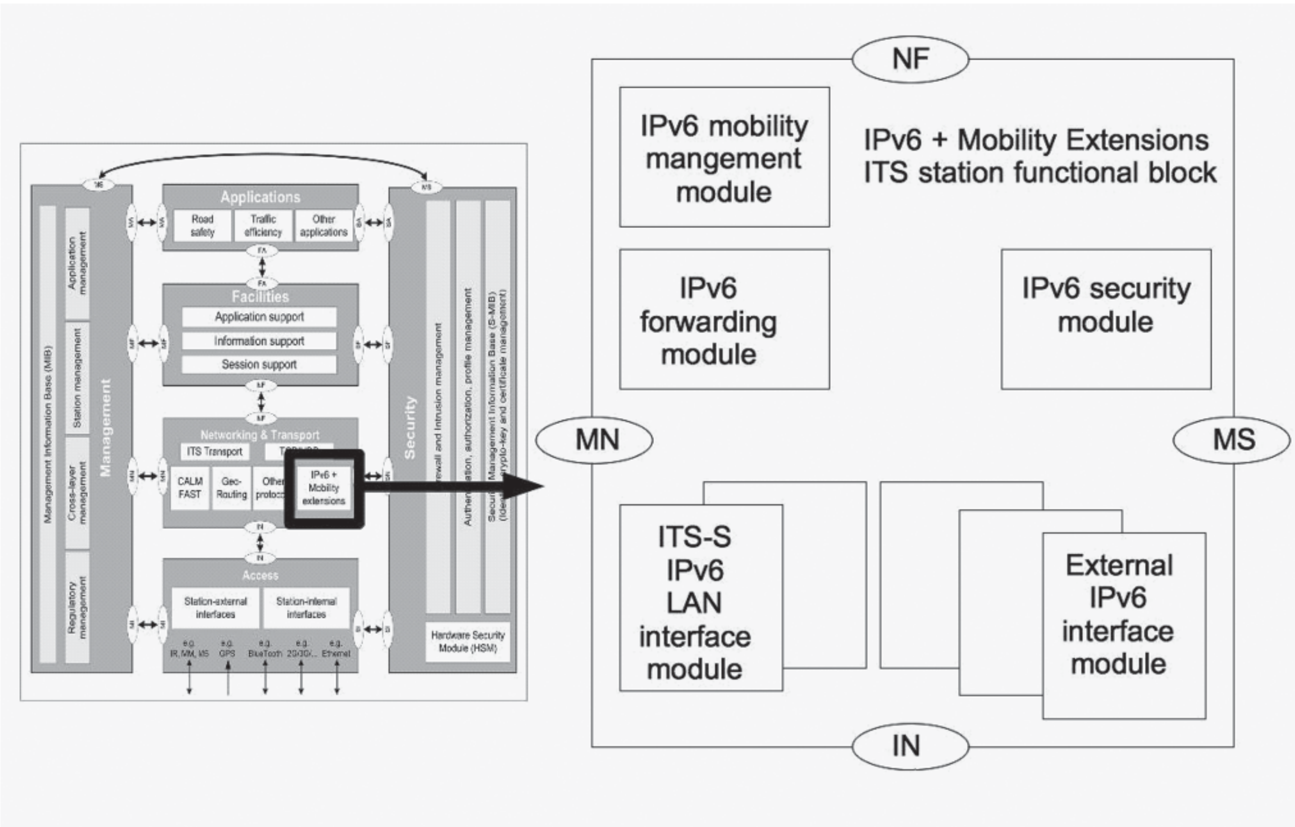

Figure 2 — IPv6 functional modules

6.3.1 IPv6 forwarding module

The 'IPv6 forwarding' module receives IPv6 packets from its 'external IPv6 interface(s)', its 'ITS LAN IPv6 interface(s)' or the layer above through the 'NF interface'

- The 'IPv6 forwarding' module shall maintain the information necessary about IPv6 neighbors in order to determine the next IPv6 hop towards a destination reachable through an IPv6 interface to perform the forwarding function.

- Whenever the 'IPv6 forwarding' module receives an IPv6 packet, it shall perform IP next hop determination and IPv6 address resolution and forward the packet to the appropriate interface (or the layer above if intended for itself) as specified in its forwarding table.

The forwarding table shall be updated by the 'ITS station management entity of the ITS station reference architecture (ISO 21217:2010, Figure 13) based on the availability of communication interfaces and needs of the applications.

a) Default settings of the forwarding table shall be requested from the 'ITS station management entity through the MN-SAP using N-COMMAND.request instructions as specified in ISO 24102.

b) Whenever the 'IPv6 forwarding' module receives N-COMMAND.request instructions from the 'ITS station management entity through the MN-SAP, it shall modify the forwarding table as specified in ISO 24102.

NOTE 1 As a result of the notification to the 'ITS station management entity of a change in the IPv6 address by the 'external IPv6 interface' module or a tunnel set-up from the IP 'mobility management' module, the 'ITS station management entity could notify new forwarding table entries to the 'IPv6 forwarding' module.

NOTE 2 The default settings are particularly important so that the 'IPv6 forwarding' module is able to route flows originated from 'non CALM-Aware' applications. Rules are configurable by stakeholders, e.g. users, device vendors, service providers, OEMs, car manufacturers. These rules are competitive factors among stakeholders, so the definitions of these policies are outside the scope of this International Standard. The default routing procedures can be pre-registered in any manner the manufacturer wishes to implement or can be performed based on the source and destination IPv6 addresses indicated in the IPv6 header and protocol and port numbers. A more advanced method can be to use the 'Flow Id' field in the IPv6 header (legacy applications would continue to work as is) and exchanging rules between the applications and the MR (this would require the modification of applications) in order to express preferences based on application requirements. The specification of this method is outside the scope of this International Standard.

NOTE 3 The IPv6 Forwarding module exchanges packets with the above layer if the IPv6 source or destination address in the packet belongs to the ITS-S IPv6 node. According to the ITS station design (ISO 21217:2010, Figure 14), traditional OSI network and transport layers are merged into a single layer. No transport layer functions specific to CALM are necessary. If there are any, their specification is out of the scope of this International Standard. However, in principle, the packets can be transmitted to some transport layer function before they are transmitted through the NF interface.

6.3.2 ITS-S IPv6 LAN interface module

The 'ITS-S IPv6 LAN interface' module shall provide a mechanism for transmitting IPv6 packets between the 'IPv6 forwarding' module and the layer below IP through the 'IN interface'.

The 'ITS-S IPv6 LAN interface' module shall configure its IPv6 addresses according to 6.5 'IPv6 Address Configuration'.

Whenever an IPv6 address changes, the 'external IPv6 interface' module shall notify the 'ITS station management entity' through the MN-SAP using N-REQUEST.request instructions as specified in ISO 24102.

Whenever required, the 'ITS-S IPv6 LAN interface' module shall perform the functions specified in RFC 4861.

6.3.3 External IPv6 interface modules

The 'external IPv6 interface' module shall provide a mechanism for transmitting IPv6 packets between the 'IPv6 forwarding' module and the layer below IP through the 'IN interface'.

The 'external IPv6 interface' module shall configure its IPv6 addresses in accordance with 6.5.

Whenever an IPv6 address changes, the 'external IPv6 interface' module shall notify the 'ITS station management entity' through the MN-SAP using N-REQUEST.request instructions as specified in ISO 24102.

Whenever required, the 'external IPv6 interface' module shall perform the functions specified in RFC 2461.

A physical interface can become temporarily unavailable. For example, a 3G interface can be down for a few seconds when driving under a tunnel. Such events should not result in immediate de-activation. Implementing a delay in de-activation allows the IPv6 node to maintain the associated global IPv6 address and, thus, does not require 'Duplicate Address Detection' as specified in RFC 2462 (DAD) or RFC 4429 (ODAD) when the communication IPv6 link is re-established at layer 2.

6.3.4 IPv6 mobility management module

The 'mobility management module' shall implement mobility support functions for Internet reachability and session continuity as specified in RFC 3963. The operation of NEMO Basic Support is described in Annex B and illustrated in Figure 3.

A bidirectional tunnel shall be established between the 'ITS-S IPv6 mobile router' and the 'ITS-S IPv6 home agent' for every global IPv6 address available on any 'external IPv6 interface'.

The maintenance of multiple tunnels simultaneously available between the 'ITS-S IPv6 mobile router' and the 'ITS-S IPv6 home agent' (HA) shall be achieved in accordance to RFC 5648. The operation of MCoA is described in Annex B and illustrated in Figure 4.

Whenever the IPv6 address of tunnel end-point changes, the 'mobility management' module shall notify the 'ITS station management entity' through the MN-SAP using N-REQUEST.request instructions as specified in ISO 24102.

When multiple tunnels exist, 'ITS-S IPv6 mobile router' and the 'ITS-S IPv6 home agent' shall be synchronized in order to make decisions based on the same criteria (user choices, network availability, media characteristics and type of flow) in both directions. This shall be achieved by an exchange between the 'ITS-S IPv6 mobile router' and 'ITS-S IPv6 home agent' of the rules notified by the 'ITS station management entity' to the 'IPv6 forwarding' module.

6.3.5 IPv6 security module

In 6.3.5.1 to 6.3.5.3 are specified the security features and functions that are provided by the IPv6 security module to 'ITS-S IPv6 LAN nodes'. The specification of required security functions and features and their usage is out of the scope of this International Standard and will be given in a companion International Standard dealing with security issues.

6.3.5.1 Encryption, anti-replay and anti-forgery

In all implementations of 'ITS-S IPv6 LAN nodes', the IPv6 security module shall provide the necessary functionality that allows IPv6 packets transmitted over the 'external IPv6 interface' to be encrypted.

NOTE 'IPsec' (see RFC 2401) is a protocol providing basic functionality corresponding to this requirement. 'IPsec' is necessary but not sufficient to provide full security support.

In all implementations of 'ITS-S IPv6 LAN nodes', the IPv6 security module shall provide the necessary functionality to prevent replay attacks and forgery of IPv6 packet headers.

6.3.5.2 Authentication

In all implementations of 'ITS-S IPv6 LAN nodes', the IPv6 security module may be comprised of mechanisms allowing IPv6 nodes deployed in different ITS sub-systems or in the Internet to authenticate their communication peers. Such authentication can be necessary for certain ITS services and not others.

NOTE Protocols such as 'RADIUS' or 'DIAMETER' have been designed to meet such a requirement.

6.3.5.3 Location privacy

When implemented in 'mobile ITS-S IPv6 LAN nodes', the security module can provide means to prevent unauthorized third parties from determining the physical location of 'mobile ITS-S IPv6 LAN' nodes by examining the header of IPv6 packets.

NOTE For 'mobile ITS-S IPv6 LAN' using NEMO Basic Support as specified in “Module 4 mobility management”, a topologically correct Care-of Address (CoA) is used as a locator and the Mobile Network Prefix is used as an identifier. Only the CoA is used in the outer header of IPv6 packets sent to or from the 'mobile ITS-S IPv6 LAN'. This provides a reasonable amount of anonymity since the location of the vehicle cannot be determined from IP-layer information.

6.4 Modules implemented in ITS-S IPv6 nodes

In 6.4.1 to 6.4.5 are identified which of the modules specified in 6.3 shall be implemented for each type of 'ITS-S IPv6 node' ('Mobile IPv6 router', 'Access IPv6 router', 'Border IPv6 router', 'Vehicle Host', 'Roadside Host', 'Central Hos't, 'Home Agent', 'Vehicle Gateway', 'Central Gateway', 'Roadside Gateway', as described in ISO 21217), comprising a subset of the modules specified in 6.3. Basic IPv6 functions (such as IPv6 addressing or transmission over Ethernet or network management) are omitted because these are features with which all IPv6 nodes shall conform in order to be in accordance with RFC 4294.

6.4.1 'ITS-S IPv6 mobile router' modules

6.4.1.1 Modules required for non-continuous Internet connectivity

The 'ITS-S IPv6 mobile router' supporting non-continuous Internet connectivity (for communication classes 3 and 7 as defined in ISO 21217:2010) shall include the following modules:

— IPv6 forwarding module;

— IPv6 external interface module(s);

— IPv6 security module.

There shall be an 'IPv6 external interface' module for each communication interface.

The 'ITS-S IPv6 LAN interface' module shall be implemented if 'ITS-S IPv6 LAN nodes' are attached.

NOTE Referring to ISO 21217:2010, Table 1, “Communication Classes“, non-continuous Internet connectivity means Internet connectivity with no network layer handover support (communication classes 3 and 7).

6.4.1.2 Modules required for continuous Internet connectivity

The 'ITS-S IPv6 mobile router' supporting continuous Internet connectivity (for communication classes 4 and 8 as defined in ISO 21217) shall include the following modules:

— IPv6 forwarding module;

— IPv6 external interface module(s);

— IPv6 mobility management module;

— IPv6 security module.

There shall be an 'IPv6 external interface' module for each communication IPv6 interface.

The 'ITS-S IPv6 LAN interface' module shall be implemented if 'ITS-S IPv6 LAN nodes' are attached.

NOTE Referring to ISO 21217:2010, Table 1, “Communication Classes“, continuous Internet connectivity means Internet connectivity with handover support (communication classes 4 and 8).

6.4.2 'ITS-S IPv6 hosts' modules

'ITS-S IPv6 hosts' (i.e. 'Vehicle Hosts', 'Roadside Hosts', 'Central Hosts', 'Vehicle Gateway', 'Roadside Gateway' and 'Central Gateway' as referred to in ISO 21217) shall implement only the non-routing capabilities of an ITS station and shall include the following modules:

- ITS-S IPv6 LAN interface module;
- IPv6 security module.

6.4.3 'ITS-S IPv6 access router' modules

The 'ITS-S IPv6 access router' shall include the following modules:

- IPv6 forwarding module;
- IPv6 external interface module(s);
- IPv6 security module.

There shall be an 'IPv6 external interface' module for each communication IPv6 interface.

The 'ITS-S IPv6 LAN interface' module shall be implemented if 'ITS-S IPv6 LAN nodes' are attached.

6.4.4 'ITS-S IPv6 home agent' modules

The 'ITS-S IPv6 home agent' shall include the following modules:

- IPv6 forwarding module;
- IPv6 mobility management module;
- IPv6 security module.

The 'ITS-S IPv6 LAN interface' module or the 'IPv6 external interface' module shall be implemented if 'ITS-S IPv6 LAN nodes' are attached.

6.4.5 'ITS-S IPv6 border router' modules

The 'ITS-S IPv6 border router' shall include the following modules:

- IPv6 forwarding module;
- ITS-S IPv6 LAN interface module(s);
- IPv6 external interface module(s);
- IPv6 security module.

There shall be an 'IPv6 external interface' module for each communication interface.

6.5 IPv6 address configuration

6.5.1 IPv6 address configuration for all 'ITS-S IPv6 LAN nodes'

All 'ITS-S IPv6 LAN nodes' shall configure a 'link-local IPv6 address' on each of their IPv6 interfaces following the methods specified in RFC 4862.

All 'ITS-S IPv6 LAN nodes' shall configure a 'global IPv6 address' following the methods specified in RFC 4862 and RFC 3587.

NOTE 1 There is no relation between the IPv6 link-local and global addresses. As required by IPv6 RFCs, it is necessary that a link-local address be first configured on each IPv6 interface before a global address is configured. The global address is necessary for communication beyond the physical reach of the interface (i.e. beyond the next IP hop).

NOTE 2 Rules are required to determine how addresses are allocated (either dynamically or statically), by whom, for what use, and with what lifetime. It is necessary that the uniqueness of the address and location privacy of the user be guaranteed. These are operational considerations that are outside the scope of this International Standard.

6.5.2 IPv6 address configuration for 'mobile ITS-S IPv6 LAN nodes'

6.5.2.1 An 'ITS-S IPv6 mobile router' shall be allocated an IPv6 prefix of a maximum length of 64 bits (/64 or smaller) and be configured with all necessary network parameters (either statistically or dynamically), the specification of which is outside the scope of this International Standard.

A 'mobile ITS-S IPv6 LAN' comprising more than one IPv6 subnet shall be allocated a prefix length smaller than 64 bits.

NOTE 1 A /64 IPv6 prefix is sufficient for a 'mobile ITS-S IPv6 LAN' comprising only one IPv6 subnet.

NOTE 2 The topological meaning of the IPv6 addresses and the lifetime have an impact on the maintenance of session continuity since 'mobile ITS-S IPv6 LANs' typically change their point of attachment to the Internet (possibly using the same or a distinct medium, i.e. IPv6 interfaces). Given that IPv6 addresses are used to identify the node itself and its position in the Internet topology, this would presumably require the 'mobile ITS-S IPv6 LAN nodes' to change their IPv6 prefix each time the external IPv6 interface of the MR is attached to a different AR. This is inefficient and prevents nodes deployed in these mobile ITS-S IPv6 LANs from being easily reachable from the Internet at a permanent IPv6 address and possibly retrieved by peer communicating nodes through the DNS by referring to the domain name. A set of protocols has, therefore, been specified in order to deal with these matters, which is referred to as 'mobility support'.

NOTE 3 Although the term “permanent” mentioned in Note 2 is usually used at the IETF, no IPv6 prefix can be assumed to be allocated for the lifetime of the equipment (e.g. a vehicle). The reason is that the provider of the IPv6 address space ('Internet Service Provider') leases IPv6 addresses and can renumber its network or can itself be allocated a new IPv6 prefix. Also, the IPv6 prefix allocated to vehicles, in particular, can be changed once the vehicle is sold to another user, when it crosses national boundaries or possibly on the fly in order to, for example, provide for anonymity.

NOTE 4 The provisions for communication class 8 (continuous Internet connectivity) allow recording IPv6 addresses of 'mobile ITS-S IPv6 LAN nodes' in the DNS, whereas the provisions for communication class 7 (non-continuous Internet connectivity) do not. However, registering an IPv6 address in the DNS is useful in communication class 7 for sessions not initiated from the 'mobile ITS-S IPv6 LAN'. The difference of the IPv6 address initialization between continuous and non-continuous Internet connectivity is the adoption of NEMO (as defined in RFC 3963) or not. NEMO is required to maintain sessions during handovers. As such, it provides seamless cross-access network handover. In NEMO, the MR has two types of IPv6 addresses known as the 'Home Address (HoA)' and 'Care-of Address (CoA)'. HoA is assigned whatever the topological location of the MR. On the other hand, CoA is assigned temporarily at the network visited (e.g. the AR on the roadside). The MR registers the pair of HoA and CoA to the HA. The HA knows the topological location of the MR and forwards the packet addressed to 'mobile ITS-S IPv6 LAN' nodes (MNNs) using encapsulation. In addition to handover, NEMO is recommended to maintain a globally unique IPv6 prefix within a 'mobile ITS-S IPv6 LAN'. It provides continuous Internet access and reachability to IPv6 'mobile ITS-S IPv6 LANs'. Using this protocol to maintain a globally unique IPv6 prefix in both communication classes 7 and 8 eases deployment and ensures interoperability between vehicles equipped differently to meet distinct design goals.

NOTE 5 Multiple IPv6 address spaces can be deployed within a 'mobile ITS-S IPv6 LAN', thereby allowing the use of a particular IPv6 address space for a particular requirement (e.g. a globally unique IPv6 prefix can be used for infotainment, whereas another globally unique IPv6 prefix can be used by the car manufacturer for remote monitoring). Specification of this option is outside the scope of this International Standard.

6.5.2.2 For communication classes 3, 4, 7 and 8 as defined in ISO 21217:

— an 'ITS-S IPv6 mobile router' shall be allocated an IPv6 prefix, known as an MNP from a 'home ITS-S IPv6 LAN' located in a remote Central ITS sub-system. This MNP may be allocated dynamically using

DHCPv6 'Prefix Delegation for NEMO' or using any other method according to the operator of the given Central ITS sub-system;

— an 'ITS-S IPv6 mobile router' shall announce the MNP and other necessary network parameters (default router, DNS server, etc.) on each of its 'ITS-S IPv6 LAN interface(s)' using the method specified in RFC 4861 in order for all 'mobile ITS-S IPv6 LAN nodes' to configure their own global IPv6 addresses in accordance with 6.5.1. 'mobile ITS-S IPv6 LAN nodes' shall retain the same global address that has been configured originally from the MNP irrespective of their location in the IP network topology. 'mobile ITS-S IPv6 LAN nodes' shall change their IPv6 address only if the 'ITS-S IPv6 mobile router' advertises a new MNP.

NOTE 1 The term MNP is usually associated with the use of RFC 3963 but in this International Standard, it is paraphrased to mean an IPv6 prefix allocated to a 'mobile ITS-S IPv6 LAN' whether RFC 3963 is used or not for a particular communication class.

NOTE 2 The MNP belongs to the Central ITS sub-system. It is taken from the 'home ITS-S IPv6 LAN' prefix (home link) and can be changed dynamically, for instance, for security reasons, or if the 'ITS-S IPv6 mobile router' changes its 'home ITS-S IPv6 LAN', or if the IPv6 address configuration of the 'home ITS-S IPv6 LAN' is changed.

6.5.2.3 For communication classes 4 and 8 as defined in ISO 21217:

— an 'ITS-S IPv6 mobile router' shall be configured with a global IPv6 address known as a 'Home Address' (HoA) belonging to its 'home ITS-S IPv6 LAN' following the methods specified in RFC 3963, and shall retain it even if connectivity to the 'home ITS-S IPv6 LAN' is lost;

— an 'ITS-S IPv6 mobile router' shall configure a global IPv6 address known as a 'Care-of Address' (CoA) on each of its 'external IPv6 interfaces' and for each IPv6 prefixes advertised by visible 'IPv6 access router' ('ITS-S IPv6 access router' or legacy IPv6 access router). The configuration of the CoA shall be achieved in accordance with RFC 8462. There may be medium-specific methods (e.g. PPP link in cellular networks). The 'Duplicate Address Detection' (DAD) mechanism as specified in RFC 8462 may be replaced by RFC 4429 'Optimistic Duplicate Address Detection' (ODAD).

For communication class 7 (non-continuous Internet connectivity) as defined in ISO 21217, an 'ITS-S IPv6 mobile router' may be allocated its IPv6 prefix using the same method as for communication class 8 'Continuous Internet Connectivity' (preferred method) or by any other mechanism. This prefix shall be announced on the 'mobile ITS-S IPv6 LAN' for MNNs to configure their own addresses.

NOTE Other methods include VPN, or the allocation of a new prefix from an 'IPv6 access router'. This second option requires the 'ITS-S IPv6 mobile router' to, in turn, announce new MNPs, thus forcing MNNs to renumber at each subsequent visited 'IPv6 access router' and specific support in the 'roadside ITS sub-system' (e.g. DHCPv6) not defined in this International Standard.

6.5.3 IPv6 address configuration for 'ITS-S IPv6 LAN nodes' deployed in a roadside ITS sub-system

The roadside 'ITS-S IPv6 border router' may be configured to announce a prefix on the 'ITS-S IPv6 LAN'. If such a prefix is announced, roadside 'ITS-S IPv6 LAN nodes' shall configure their IPv6 addresses through stateless autoconfiguration as specified in RFC 4862.

An 'ITS-S IPv6 access router' shall be configured either statically or dynamically by any means (which specification is outside the scope of this International Standard) to announce on each of its 'external IPv6 interfaces' an IPv6 prefix of a maximum length of 64 bits using the methods specified in RFC 4861.

An 'ITS-S IPv6 access router' shall announce on each of its 'external IPv6 interfaces' if Internet access is offered to 'mobile ITS-S IPv6 LAN nodes'.

NOTE The purpose is for 'ITS-S IPv6 mobile routers' to configure an IPv6 global address on their own 'external IPv6 interface(s)' based on the advertised IPv6 prefix (see 6.5.2).

6.5.4 IPv6 address configuration for 'ITS-S IPv6 LAN nodes' deployed in a central ITS sub-system

The central 'ITS-S IPv6 border router' may be configured to announce a prefix on the 'ITS-S IPv6 LAN'. If such a prefix is announced, central 'ITS-S IPv6 LAN nodes' shall configure their IPv6 addresses through stateless auto-configuration as specified in RFC 4862.

6.5.5 Addressing requirement for reachability from the Internet

The provisions in 6.5.5 apply to communication classes 7 and 8 as defined in ISO 21217:

- 'ITS-S IPv6 LAN nodes' shall be reachable at their global addresses from nodes located in another 'ITS-S IPv6 LAN' or the Internet. This shall be achieved by allocating a globally unique IPv6 prefix (MNP) to each ITS-S IPv6 LAN.
- A domain name shall be associated and registered in the DNS to any 'ITS-S IPv6 LAN nodes' whose IPv6 global address it is necessary that communication peers located in another 'ITS-S IPv6 LAN' or the Internet be able to automatically retrieved through name resolution.
- An 'ITS-S IPv6 mobile router' shall implement mobility support functions in accordance with RFC 3963 for maintaining Internet reachability of 'ITS-S IPv6 LAN nodes' at their global IPv6 addresses, whereas the 'mobile ITS-S IPv6 LAN' is attached to an 'ITS-S access router' or legacy IPv6 access router. See 6.3.4.

NOTE Communication classes 3 and 4 (i.e. no Internet access) do not strictly speaking require capabilities for vehicle ITS stations to communicate with central ITS stations. Maintaining reachability at a global IPv6 address is, thus, not required in such a situation. However, the vehicle ITS stations can, at a later time, be in a situation requiring Internet access (communication classes 7 and 8), for which such capabilities are necessary.

6.6 Optional features and functions

The provisions in 6.6.1 to 6.6.5 are not necessary to support any of the communication classes as specified in ISO 21217, but they can be necessary to ensure specific design choices are not prevented by the specification of IPv6 networking as described in this International Standard.

6.6.1 IPv6-IPv4 interoperability

While all ITS sub-systems are required to support IPv6 for TCP/IP-based communications, IPv6 nodes deployed in an 'ITS-S IPv6 LAN' can be required to communicate with legacy IPv4 nodes that will continue to operate in the Internet for several years. In addition, some access networks will remain accessible using IPv4 only, whereas existing legacy ITS services or non-ITS services, such as web servers can remain accessible in IPv4 only.

'ITS-S IPv6 routers' shall provide IPv4/IPv6 transition mechanisms to transmit packets over IPv4 networks between 'ITS-S IPv6 LANs'.

NOTE 1 IPv6 access over IPv4 access networks for both continuous and non-continuous Internet connectivity can be provided using 'DS-MIPv6' (RFC 5555). This protocol allows 'ITS-S IPv6 mobile routers' to configure an IPv6 address when Internet access is provided by an IPv4 access network. Alternatively, solutions such as L2TP or 'OpenVPN' can also be used. L2TP builds a PPP connection between the 'ITS-S IPv6 mobile router' and the 'ITS-S IPv6 access router' or legacy IPv6 access router. This connection is presented to upper layer as a normal PPP network IPv6 interface. Header and data compression can be used over the PPP link in order to reduce the overhead due to L2TP.

IPv4/IPv6 transition mechanisms shall be offered so that 'ITS-S IPv6 LAN nodes' can communicate with legacy IPv4-only nodes.

NOTE 2 Various transition mechanisms specified by the IETF can be used with support of a server in the network (e.g., 6to4, 'Application Level Gateway', etc.).

NOTE 3 Deploying dual IPv6 and IPv4 stacks in ITS-S IPv6 LANs is not recommended as it does not scale to a large number of ITS-S IPv6 LAN due to the IPv4 address space depletion. IPv6 has been designed to address such IPv4 address shortcomings. In addition, features such as network mobility support and other extensions are not supported in IPv4.

The specification of the necessary functions and features is outside the scope of this International Standard.

6.6.2 IPv6 nomadic devices

Vehicle users may bring nomadic devices in their vehicle. Such devices may be authorized to configure an IPv6 address and to benefit from on-board Internet connectivity provided by the 'ITS-S IPv6 mobile router serving the mobile ITS-S IPv6 LAN'. Specification of the necessary enabling mechanisms is outside the scope of this International Standard.

NOTE Protocols such as 'DHCP', 'DIAMETER', 'RADIUS', 'IPsec' and IPv6 mobility support such as Mobile IPv6 have been designed by the IETF to meet such a requirement and can be reused in a way similar to the definition of a 'mobile ITS-S IPv6 Station'.

6.6.3 IPv6 seamless horizontal handovers

In order to perform horizontal handovers with minimum packet loss and transparently to the applications deployed in vehicle ITS sub-systems, specific support functions are required to shorten the period of time to divert the communication path from one access router to another access router from the same operator and using the same medium. A protocol such as FMIPv6 (RFC 5268) may be deployed in the IPv6 access routers providing access to vehicle ITS sub-systems or public access networks.

6.6.4 IPv6 seamless vertical handovers

In order to perform vertical handovers with minimum packet loss and transparently to the applications deployed in vehicle ITS sub-systems, specific support functions are required to shorten the period of time to divert flows from one medium or one operator to another. Seamless handovers can effectively be performed using mobile edge multihoming features (such as MCoA) implemented in the 'ITS-S IPv6 mobile router' and the 'ITS-S IPv6 home agent'.

6.6.5 IPv6 priority

The ITS-S IPv6 router may implement mechanisms to ensure IPv6 packets with higher priority (time critical, safety, etc.) are sent prior to packets of lower priority as instructed by the management entity. The specification of these methods is outside the scope of this International Standard.

EXAMPLE The 'Flow Label' field in the IPv6 header can be set by CALM-aware applications to differentiate flows with higher priorities and to match flows to particular interfaces based on preferences exchanged between the CALM-aware applications running on 'ITS-S IPv6 hosts' and the 'ITS-S IPv6 mobile router' serving the ITS-S IPv6 LAN.

Annex A
(informative)

Illustration of mobility support

The purpose of this annex is to illustrate how IPv6 mobility management works in the context of the ITS station reference architecture (see ISO 21217). It also provides justification for the choice of the relevant protocols. Figure A.1 illustrates the behaviour of the Network Mobility (NEMO) Basic Support protocol (RFC 3963) whereas Figure A.2 illustrates how it works when multiple communication interfaces are available simultaneously.

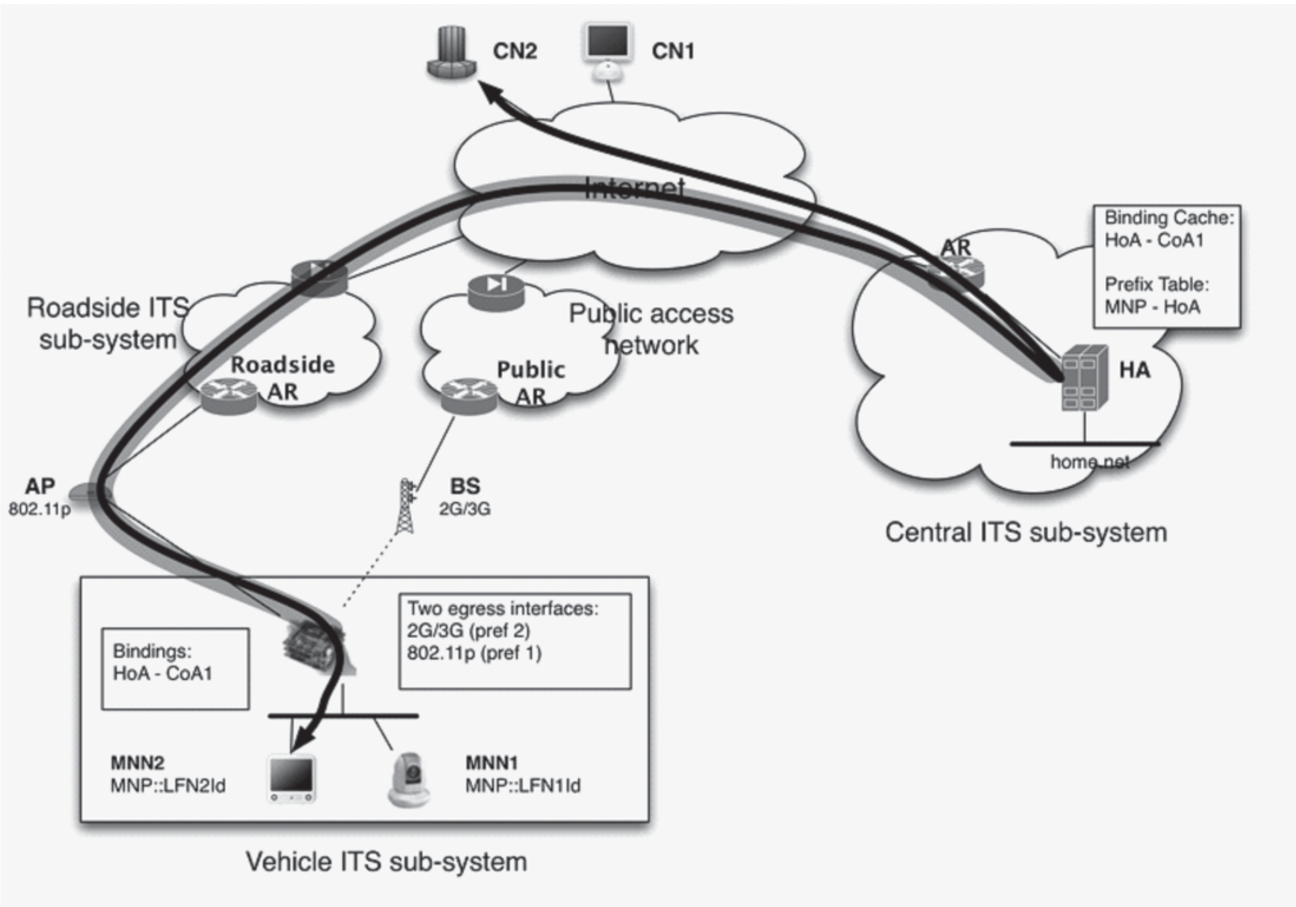

Figure A.1 — IPv6 session continuity with NEMO basic support

As previously indicated, ITS-S IPv6 LANs may just contain a single IPv6 router. In such a situation for a 'mobile ITS-S IPv6 LAN', the NEMO function works the same way whether or not other IPv6 nodes are effectively deployed in the 'mobile ITS-S IPV6 LAN'. Other mobility support solutions designed to support only host mobility fail to support network mobility. Considering RFC 3963 to support all cases simplifies this International Standard and ensures compatibility for the implementation of this International Standard to meet different design choices.

The NEMO 'Basic Support' protocol (RFC 3963) is designed to maintain Internet connectivity between all the nodes in the vehicle and the infrastructure (network mobility support). This is performed without breaking the flows under transmission, and transparently to the nodes located behind the MR (MNNs) and the communication peers (CNs). This is handled by mobility management functions in the MR and a server known as the HA ('Home Agent') located in an IPv6 subnet known to the MR as the 'home IPv6 link'.

The key idea of NEMO Basic Support is that the IPv6 mobile network prefix (known as MNP) allocated to the MR is kept, irrespective of the topological location of the MR, while a binding between the MNP and the newly acquired temporary 'Care-of Address' (CoA) configured on the external IPv6 egress connecting the MR to the Internet is recorded at the HA. This registration is performed by the MR at each subsequent point of attachment to an AR. In order to do this, the MR uses its global address known as the 'Home Address' (HoA).

This allows a node in the vehicle to remain reachable at the same IPv6 address as long as the address is not deprecated. The HA is now able to redirect all packets to the current location of the vehicle. MNNs attached to the MR and it is not necessary to configure a new IPv6 address or to perform any mobility support function to benefit from the Internet connectivity provided by the MR. This mobility support mechanism provided by NEMO is, thus, very easy to deploy at a minimum cost.

The earlier Mobile IPv6 (RFC 3775) mobility support specification provides Internet connectivity to a single moving IPv6 host only (IPv6 host mobility support). Mobile IPv6 is, therefore, inappropriate for the most advanced ITS use cases, which usually consider more than one in-vehicle embedded CPU. Network mobility support using RFC 3963 also supports situations where there is only a single IPv6 node deployed in the vehicle. Indeed, the ability to support an entire network of n nodes includes the ability to support a network of one node only. So just considering 'NEMO Basic Support' and not considering 'Mobile IPv6' makes the CALM architecture much simpler.

The solution requires all packets to transit through the HA using an encapsulation mechanism between the current AR, the MR to which it is attached and the HA. In some cases, this can significantly increase the end-to-end transmission delay. In order to skip the HA and transmit packets over an optimal path, extensions to 'NEMO Basic Support' known as 'Routing Optimization' have been proposed, and implemented, bearing very efficient performance results. However, no solution has been standardized yet at the IETF, though this is ongoing in the MeXT Working Group (see the 'Routing Optimization Problem Statement' and the 'Routing Optimization' taxonomy documents that have been approved as RFC 4888 and RFC 4889). This can be included in the CALM set of standards at a later stage.

For a better understanding of NEMO, the terminology is specified in RFC 4885 and the design goals behind 'NEMO Basic Support' in RFC 4886. These documents are normative documents for how to apply 'NEMO Basic Support' to the CALM architecture.

The tunnel between the MR and the HA may be implemented as a virtual IPv6 interface pointing to a physical egress interface ('external IPv6 interface') where packets are encapsulated. Such an IPv6 virtual interface is then treated by the routing module as the physical external IPv6 interface. The same rules are, thus, applied to the selection of the MR-HA tunnel (see 6.3.1).

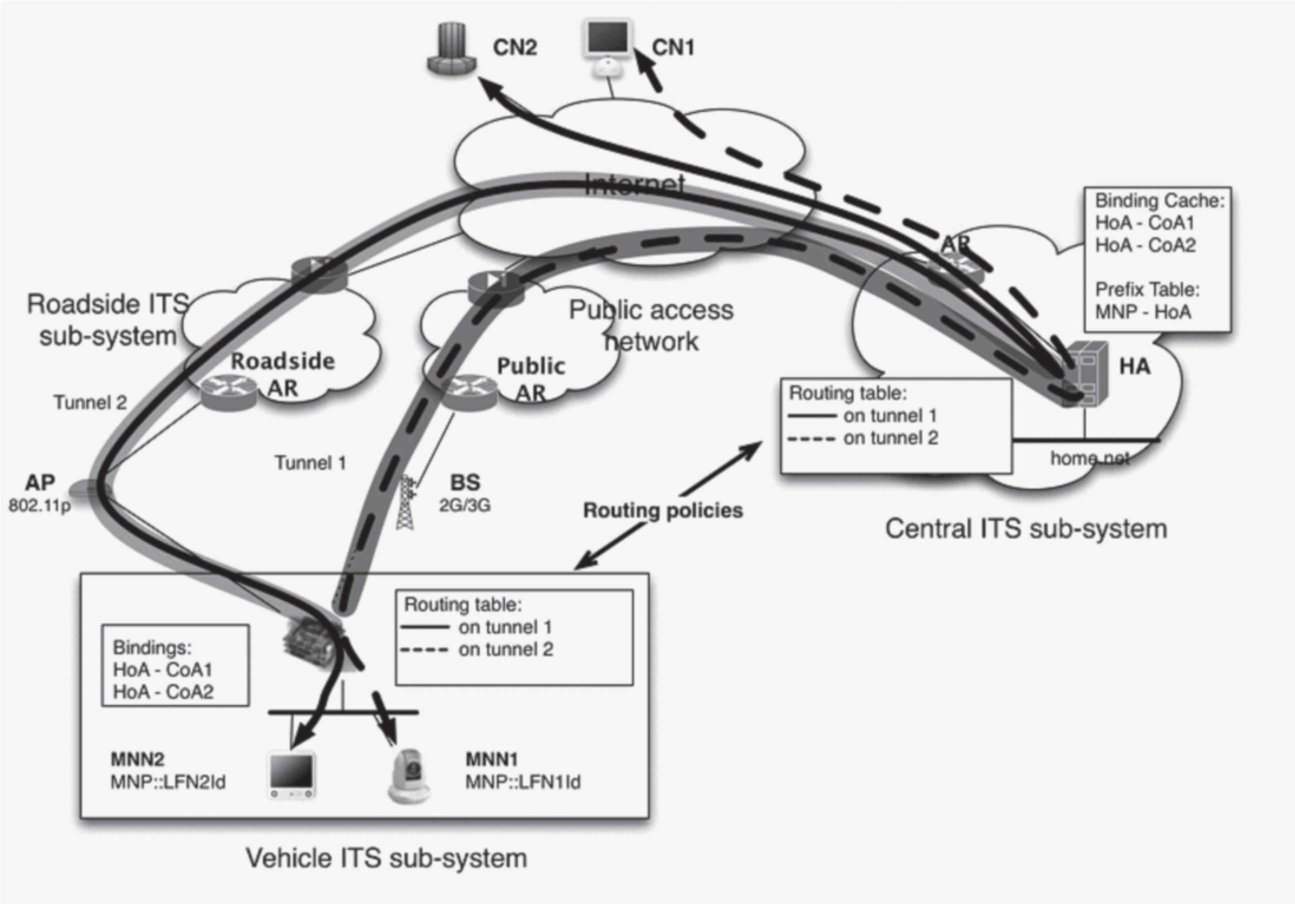

Figure A.2 — IPv6 mobile edge multihoming

RFC 5648 is an extension to Mobile IPv6 (RFC 3775) and NEMO Basic Support (RFC 3963) and allows an MR to register multiple CoAs with its HA.

As a result of the notification of the tunnel set-up from the IP 'mobility management' module to the 'ITS station management entity', the 'ITS station management entity' should notify the 'IPv6 forwarding' module with new forwarding table entries. See the description of the 'IPv6 forwarding' module in 6.3.1.

Different approaches have been proposed at the IETF in the MEXT Working Group for the MR and the HA to synchronize their decisions in choosing the appropriate medium (RFC 6088 and RFC 6089). One such approach is to exchange rules (routing policies) using NEMO signalling messages; another is more generic and uses standard transport layer protocols.

The rules for performing handovers and medium switching are configurable by stakeholders, e.g. users, device vendors, service providers, OEMs, car manufacturers. These rules are competitive factors among stakeholders, so the definition of these rules is outside the scope of the CALM set of International Standards.

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