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

Systèmes intelligents de transport — Accès aux communications des services mobiles terrestres (CALM) — Architecture

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Foreword

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The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

This second edition cancels and replaces the first edition (ISO 21217:2010) which has been technically revised.

Introduction

"Communications Access for Land Mobile" (CALM) is the acronym used to refer to ISO TC204 WG16 work items. This acronym is used in the titles of the set of International Standards on communication for "Intelligent Transport Systems" (ITS). These International Standards focus on specifying open interfaces with regard to the functionalities required for all relevant layers and entities of the ITS station reference architecture specified in this International Standard. Note that these International Standards may also specify implementation details in situations where such specifications are deemed essential to interoperability of interface protocols.

The set of CALM International Standards is designed to allow interoperable instantiations of ITS stations which are based on the concept of abstracting applications and services from the underlying communication layers of the ITS station. This abstraction and the functionalities and services that can be easily implemented make the ITS station architecture described herein also well-suited to the development and deployment of ITS applications and services that share information amongst each other to improve the safety, sustainability and efficiency of transport systems.

The set of CALM International Standards include specifications for

— ITS station management,

— ITS communications security,

— ITS station facilities layer protocols,

— ITS station networking and transport layer protocols,

— communication interfaces (CIs) designed specifically for ITS applications and services such as those designed specifically for safety of life and property,

— interfacing existing access technologies into ITS stations,

— distributed implementations of ITS stations, and

— interfacing ITS stations to existing communication networks and communicating with nodes thereon.

This International Standard describes the common architectural framework around which ITS stations are instantiated and provides references to relevant International Standards, including access technology support standards, various networking and transport protocol standards, facilities standards, and ITS station management and security standards. It also describes the general architecture of peer-to-peer communications over various communication networks between ITS communication nodes. These nodes may be ITS stations as described in this International Standard or any other reachable nodes.

The set of CALM International Standards is complemented by ITS communication International Standards from other International Standards development organizations which together form the basis for implementation of ITS communications networks around the world.

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

1 Scope

This International Standard describes the communications reference architecture of nodes called "ITS station units" designed for deployment in intelligent transport systems (ITS) communication networks. The ITS station reference architecture is described in an abstract way. While this International Standard describes a number of ITS station elements, whether or not a particular element is implemented in an ITS station unit depends on the specific communication requirements of the implementation.

This International Standard also describes the various communication modes for peer-to-peer communications over various networks between ITS communication nodes. These nodes may be ITS station units as described in this International Standard or any other reachable nodes.

This International standard specifies the minimum set of normative requirements for a physical instantiation of the ITS station based on the principles of a bounded secured managed domain.

2 Normative references

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

None.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
access technology
technology employed in a communication interface to access a specific medium

3.2
application data unit
data unit exchanged between ITS-S application processes

3.3
communication adaptation layer
set of protocols and functions to adapt access technologies to the ITS-S networking and transport layer

3.4
communication interface
instantiation of a specific access technology and ITS-S access layer protocol

3.5
communication path
directed sequence of nodes connected by links, starting at a source node and ending at one or more destination nodes

3.6
FA interface
interface between the ITS-S facilities layer and the ITS-S applications entity

3.7
IN interface
interface between the ITS-S access layer and the ITS-S networking and transport layer

3.8
in-vehicle network
generic term for a network in a vehicle which is not an ITS station-internal network

3.9
ITS application
instantiation of an ITS service that involves an association of two or more complementary ITS-S application processes

Note 1 to entry: Fragments of an application may also reside in nodes that are not ITS stations.

3.10
ITS message set
set of messages designed for an ITS-related purpose

3.11
ITS service
functionality provided to users of intelligent transport systems designed e.g. to increase safety, sustainability, efficiency, or comfort

3.12
ITS station
functional entity comprised of an ITS-S facilities layer, ITS-S networking and transport layer, ITS-S access layer, ITS-S management entity, ITS-S security entity, and ITS-S applications entity providing ITS services

Note 1 to entry: From an abstract point of view, the term "ITS station" refers to a set of functionalities. The term is often used to refer to an instantiation of these functionalities in a physical unit. Often, the appropriate interpretation is obvious from the context. The proper name of the physical instantiation of an ITS-S is ITS station unit (ITS-SU).

3.13
ITS-S access layer
protocol layer in the ITS-S reference architecture containing the OSI physical and data link layer protocols for ITS communications

3.14
ITS-S access layer protocol data unit
protocol data unit exchanged between peer ITS-S access layers

3.15
ITS-S access layer service data unit
service data unit exchanged between ITS-S access layer and ITS-S networking and transport layer

3.16
ITS-S access router
ITS-S border router with additional functionality that provides other ITS communication nodes a point of attachment to an external network

3.17
ITS-S access technology
access technology dedicated to operation in an ITS-S

3.18
ITS-S application
ITS-S application process residing in the ITS-S application entity

3.19
ITS-S application process
element in an ITS station that performs information processing for a particular application and uses ITS-S services to transmit and receive information

3.20
ITS-S border router
ITS-S router with additional functionality that provides connectivity to other ITS communication nodes over external networks

3.21
ITS-S communication unit
physical unit in an ITS-SU containing a part or all of the functionality of an ITS-S

Note 1 to entry: In case an ITS-SU consists of a single physical unit, the ITS-SU and the ITS-SCU are identical. In case an ITS-SU consists of more than one ITS-SCU, then these ITS-SCUs are interconnected via the ITS station-internal network of the ITS-SU.

3.22
ITS-S facilities layer
layer in the ITS-S reference architecture containing OSI layers 5, 6, and 7 that connects applications to the ITS-S networking and transport layer

3.23
ITS-S facilities layer protocol data unit
protocol data unit exchanged between peer ITS-S facility layers

3.24
ITS-S facilities layer service data unit
service data unit exchanged between ITS-S facilities layer and ITS-S application entity

3.25
ITS-S facility application
ITS-S application process residing in the ITS-S facilities layer

3.26
ITS-S gateway
ITS-S node used to interconnect two different OSI protocol stacks at layers 5 through 7

Note 1 to entry: An ITS-S gateway may convert between different protocols.

3.27
ITS-S host
ITS-S node comprised of ITS-S functionalities other than the functionalities of an ITS-S router, ITS-S border router, ITS-S mobile router, or an ITS-S gateway

3.28
ITS-S internal router
ITS-S router that connects two or more ITS station-internal networks

3.29
ITS-S management application
ITS-S application process residing in the ITS-S management entity

3.30
ITS-S mobile router
ITS-S border router with additional functionality that allows a change of point of attachment to an external network while maintaining session continuity

3.31
ITS-S networking and transport layer protocol data unit
protocol data unit exchanged between peer ITS-S networking and transport layers

3.32
ITS-S networking and transport layer service data unit
service data unit exchanged between ITS-S networking and transport layer and ITS-S facilities layer

3.33
ITS-S networking and transport layer
layer in the ITS-S reference architecture containing OSI layers 3 and 4 that connects the ITS-S facilities layer to the ITS-S access layer

3.34
ITS-S node
node comprised of a set of functionalities in an ITS station unit that is connected to the ITS station-internal network or comprises an entire ITS station unit

3.35
ITS-S router
ITS-S node comprised of routing functionalities of an ITS station unit used to connect two networks and to forward packets not explicitly addressed to itself

3.36
ITS-S security application
ITS-S application process residing in the ITS-S security entity

3.37
ITS-S service
communication functionality of an ITS-S that provides the capability to connect to other nodes

3.38
ITS station unit
implementation of an ITS-S

3.39
MA interface
interface between the ITS-S management entity and ITS-S applications

3.40
medium
physical entity that supports the transmission of signals carrying information between ITS communication nodes, e.g. a set of wires supporting Ethernet signals or the space between two antennas that supports electromagnetic, optical, or acoustical transmissions

3.41
MF interface
interface between the ITS-S management entity and the ITS-S facilities layer

3.42
MI interface
interface between the ITS-S management entity and the ITS-S access layer

3.43
MN interface
interface between the ITS-S management entity and the ITS-S networking and transport layer

3.44
MS interface
interface between the ITS-S management entity and the ITS-S security entity

3.45
NF interface
interface between the ITS-S networking and transport layer and the ITS-S facilities layer

3.46
SA interface
interface between the ITS-S security entity and ITS-S applications

3.47
SF interface
interface between the ITS-S security entity and the ITS-S facilities layer

3.48
SI interface
interface between the ITS-S security entity and the ITS-S access layer

3.49
SN interface
interface between the ITS-S security entity and the ITS-S networking and transport layer

4 Symbols and abbreviated terms

ADU	Application Data Unit
API	Application Programming Interface
BSMD	Bounded Secured Managed Domain
BSME	Bounded Secured Managed Entity
CAL	Communication Adaptation Layer
CALM	Communications Access for Land Mobiles
CI	Communication Interface
C-ITS	Cooperative ITS
DSRC	Dedicated Short-Range Communication
ETSI	European Telecommunications Standards Institute
FA	name of interface between ITS-S facilities layer and ITS-S application entity
IN	name of interface between ITS-S access layer and ITS-S networking and transport layer
IP	Internet Protocol
IPv6	IP version 6
IR	Infra-Red
ISO	International Standards Organization
ITS	Intelligent Transport Systems
ITS-APDU	ITS Station Access layer Protocol Data Unit
ITS-ASDU	ITS Station Access layer Service Data Unit
ITS-FPDU	ITS Station Facility layer Protocol Data Unit
ITS-FSDU	ITS Station Facility layer Service Data Unit

ITS-NTPDU	ITS Station Networking and Transport layer Protocol Data Unit NOTE The deprecated term ITS-NPDU is in use in published standards with the same meaning as ITS-NTPDU.
ITS-NTSDU	ITS Station Networking and Transport layer Service Data Unit
ITS-S	ITS Station
ITS-SCU	ITS-S Communication Unit
ITS-SU	ITS-S Unit
IVN	In-Vehicle Network
LCH	Logical Channel
LTE	Long Term Evolution
MA	name of the interface between the ITS-S management entity and ITS-S applications
MAE	Management Adaptation Entity
MAP	name of an ITS message set used to carry information on digital maps covering the area of intersections
MF	name of the interface between the ITS-S management entity and the ITS-S facilities layer
MI	name of the interface between the ITS-S management entity and the ITS-S access layer
MIB	Management Information Base
MN	name of the interface between the ITS-S management entity and the ITS-S networking and transport layer
MS	name of the interface between the ITS-S management entity and the ITS-S security entity
NF	name of the interface between the ITS-S networking and transport layer and the ITS-S facilities layer
PCH	Physical Channel
PDM	Probe Data Management; name of an ITS message set
PDU	Protocol Data Unit
POI	Point of Interest
PVD	Probe Vehicle Data; name of an ITS message set
SA	name of the interface between the ITS-S security entity and ITS-S applications
SAP	Service Access Point
SDU	Service Data Unit
SF	name of the interface between the ITS-S security entity and the ITS-S facilities layer
SI	name of the interface between the ITS-S security entity and the ITS-S access layer
SMIB	Security Management Information Base
SN	name of the interface between the ITS-S security entity and the ITS-S networking and transport layer

SOA	Service Oriented Architecture
SPaT	Signal Phase and Timing; name of an ITS message set
SRM	Signal Request Message; name of an ITS message set
SSM	Signal Status Message; name of an ITS message set
TOPO	name of an ITS message set used to carry information on digital maps covering the area of intersections
UMTS	Universal Mobile Telecommunication System

5 Requirements

A physical instantiation of an ITS-S shall provide as a minimum

— the functionality of an ITS-S host specified in 7.2.2, i.e. acting as a terminal only or

— the functionality of an ITS-S host and ITS-S router specified in 7.2.2.

This includes a minimum set of related security procedures and principles that can be verified by an appropriate ITS-related authority described in Reference [54]. These security procedures and principles are used to allow the BSME to assert a level of trust to other BSMEs in the communication network.

6 Overview of ITS communications

6.1 ITS services and applications

The wide variety of services and applications to be deployed in the ITS sector and the global time-varying nature of transportation itself lead to challenges in the design of communication systems to support these services and applications. One of the challenges is to support widely disparate communication requirements with respect to reliability, security, latency, and other performance parameters.

Furthermore, the possibility of having multiple applications in an ITS station unit (ITS-SU) simultaneously competing for communication resources leads to the need for a controlled access to these resources. Useful means for addressing this issue are e.g. application and message prioritization and logical channels.

6.2 ITS communication means

ITS communications involves communications between a wide variety of ITS communication nodes on different platforms, e.g. vehicles, roadside equipment, portable devices, control centres, using various means and methods as illustrated in Figure 1. The various access and networking technologies illustrated are used to interconnect stations on a peer-to-peer basis serving a range of ITS service domains. For example, any of the vehicles in Figure 1 connected to an RSE via 5 GHz or IR could communicate with the vehicle connected to the wireless LAN hotspot.

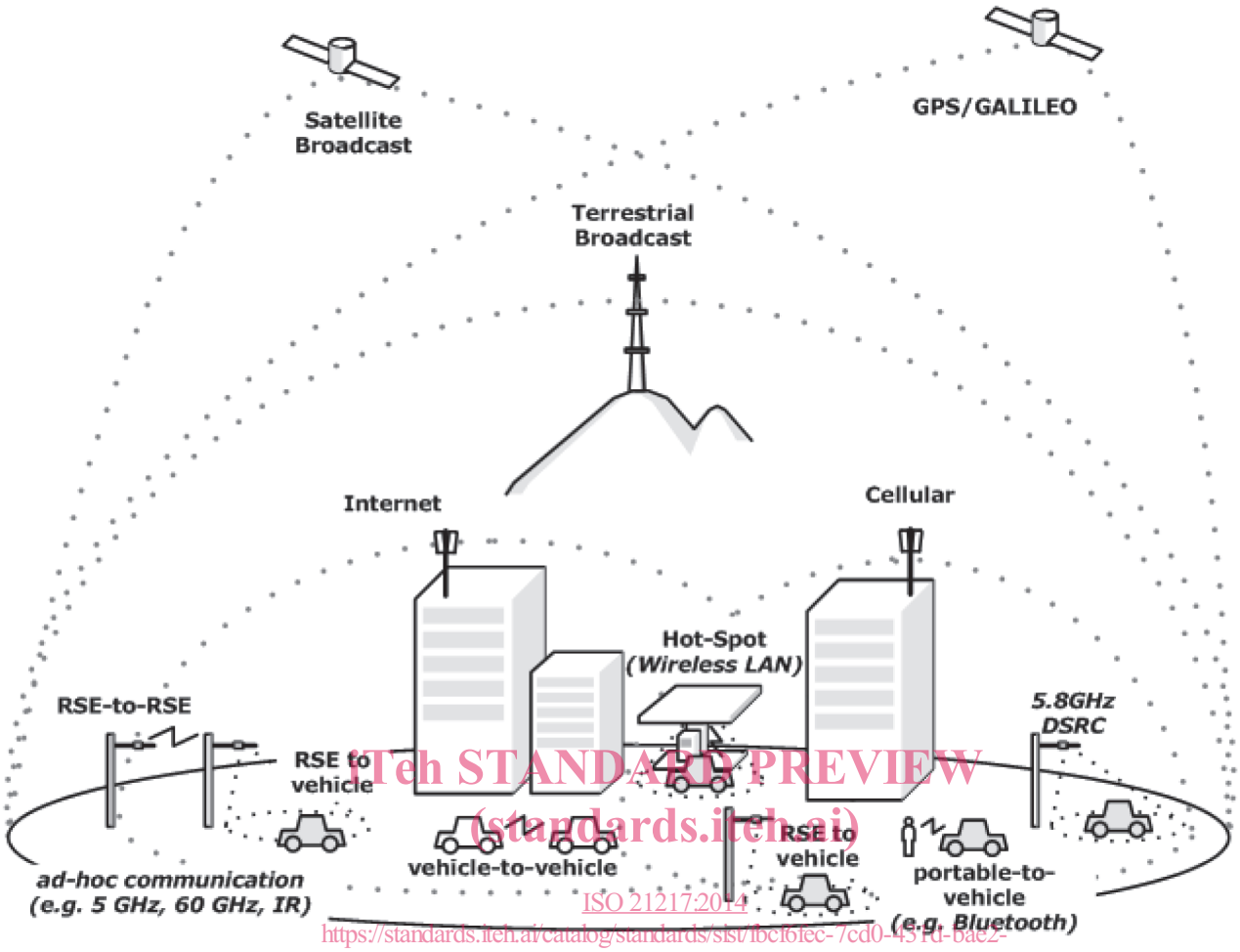

Figure 1 — Examples of ITS communications

6.3 ITS communication characteristics

Characteristics of ITS communications are presented in the following list:

— station mobility leads to complex time-varying networking topologies and time-varying properties of wireless communication channels (fading, hidden-nodes, etc.);

— variety of stations connected via various networking and access technologies including the Internet, various public and private networks, Bluetooth and WiFi, dedicated technologies, such as 5,8 GHz DSRC for road tolling:

  — a station with multiple access and networking technologies can maintain session continuity through a change of either or both;

  — two stations with different access technologies can establish end-to-end connectivity

— variety of communication requirements resulting from different ITS applications with different priorities, e.g. road safety, traffic efficiency, mobility and infotainment, e.g. with respect to communications capacity (data rate), communications reliability, communications availability;

— variety of communication requirements resulting from user needs, e.g. with respect to communications cost (in terms of money), communications privacy, communications security;

— variety of communication requirements resulting from regional regulations and policies;

— global applicability, where intended.

6.4 ITS communication networks

An illustration of the various networks used in ITS communications is presented in Figure 2.

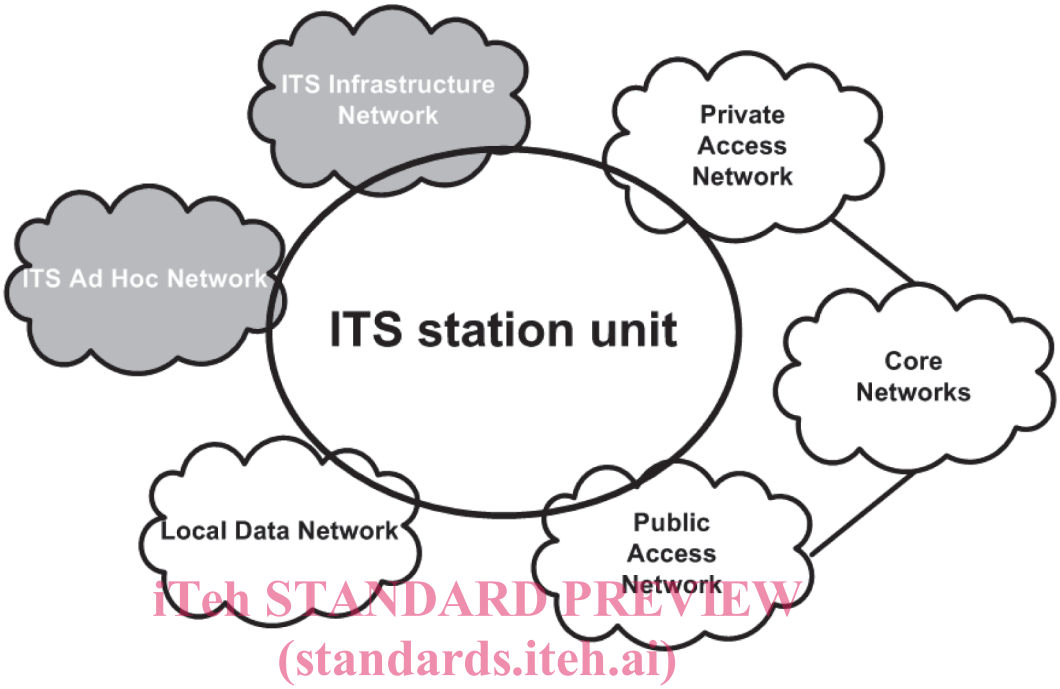

Figure 2 — Networking view of ITS communications

Figure 2 illustrates the following networks:

— an ITS infrastructure network comprised of ITS-SUs with a (quasi-) static topology, e.g. a collection of roadside stations connected via a fibre backbone;

— an ITS ad hoc network comprised of ITS-SUs in which the topology may change rapidly, e.g. a mesh network of (vehicle) stations connected via microwave technologies;

— a local data network, e.g. a proprietary in-vehicle network based on CAN bus technology or a 6LoWPAN wireless sensor network;

— a public access network, e.g. WiFi hotspot or cellular networks;

— a private access network, e.g. a proprietary road operator network;

— a core network, e.g. the Internet, a virtual private network.

NOTE An ITS station-internal network is not presented in Figure 2; however, it is necessary in implementations illustrated in Figures 14 and 15.

ITS infrastructure and ITS ad hoc networks are networks specifically designed to accommodate and implement ITS services and applications. They are connected to each other and to public access, private access, and local data networks through an ITS-SU as shown in Figure 2. The concept of an ITS-SU is described in Clause 7.