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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport System (ITS).

The present document is part 3 of a multi-part deliverable. Full details of the entire series can be found in part 1 [i.13].

Introduction

The present document specifies the network architecture for communication-based Intelligent Transport Systems (ITS) using different ITS access technologies, such as ITS-G5. The network architecture provides - in combination with the description of scenarios - a basis for the technical specification of the network and transport protocols, in particular for GeoNetworking and its related protocols.

The present document first introduces a generic, high-level system view of the network architecture and defines four basic deployment scenarios. Based on the system view, it identifies and describes the main network components and specifies network reference points among them. Central component of the architecture is the ITS station. For this component, an overview of its protocol architecture is given and different options of using the GeoNetworking protocol in combination with transport protocols and protocols of the IP suite are described. Finally, the present document defines frameworks for different aspects of networking and data transport, such as ad hoc communication, addressing, resource management and data congestion control, integration with protocols of the IP suite and others.

The network architecture is based on the ITS architecture specified in [1] and represents the networking viewpoint of the overall architecture.

Sources of input for the present document are [i.1], [i.2] and [i.3].

1 Scope

The present document specifies the network architecture for communication-based Intelligent Transport Systems (ITS). The network architecture is focused on, but not limited to, vehicular communication. The architecture enables a wide range of ITS applications for road safety, traffic efficiency as well as for infotainment and business.

The present document defines the framework for network and data transport protocols that provide data exchange among ITS stations. A particular aspect is the GeoNetworking protocol that provides ad hoc and multi-hop communication over short-range wireless technologies utilizing geographical positions.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] ETSI EN 302 665: "Intelligent Transport Systems (ITS); Communications Architecture".

[2] ISO/IEC 7498-1: "Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model".

[3] ISO/IEC 8802-2: " Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements; Part 2: Logical Link Control".

[4] IETF RFC 791: "Internet Protocol".

[5] IETF RFC 2460: "Internet Protocol, Version 6 (IPv6) Specification".

[6] IETF RFC 3775: "Mobility Support in IPv6".

[7] IETF RFC 768: "User Datagram Protocol".

[8] IETF RFC 793: "Transmission Control Protocol".

[9] IETF RFC 3963: "Network Mobility (NEMO) Basic Support Protocol".

[10] IETF RFC 5213: "Proxy Mobile IPv6".

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] COMeSafety Deliverable 3.1 - Version 2.0 - March 2009: "European ITS Communication Architecture - Overall Framework - Proof of Concept Implementation.

[i.2] PRE-DRIVE C2X Deliverable 1.4 - Version 1.2 - August 2009: "Refined Architecture". .

[i.3] GeoNet Deliverable 1.1 - Version 1.0 - March 2009: "Preliminary Architecture Design".

[i.4] ITU-R Recommendation M.687-2: "International Mobile Telecommunications 2000 (IMT-2000)".

[i.5] IETF RFC 3753: "Mobility Related Terminology".

[i.6] 3GPP: "UMTS Standard, Release 08 Specification".

NOTE: Available at: http://www.3gpp.org.

[i.7] IETF RFC 4213: "Basic Transition Mechanisms for IPv6 Hosts and Routers".

[i.8] IETF RFC 2185: "Routing Aspects of IPv6 Transition".

[i.9] ETSI TS 102 637-1: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements".

[i.10] ETSI TS 102 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Co-operative Awareness Basic Service".

[i.11] ETSI TS 102 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Application; Part 3: Specification of Decentralized Environmental Notification Basic Service".

[i.12] ETSI ES 202 663: "Intelligent Transport Systems (ITS); European profile standard for the physical and medium access control layer of Intelligent Transport Systems operating in the 5 GHz frequency band".

[i.13] ETSI TS 102 636-1: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 1: Requirements".

[i.14] ETSI TS 102 731: "Intelligent Transportation Systems (ITS); Security; Security Services and Architecture".

[i.15] ETSI TS 102 723 (all parts): "Intelligent Transport Systems; OSI cross-layer topics".

[i.16] ETSI TS 102 636-5: "Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking; Part 5: Transport Protocols".

[i.17] ETSI TS 102 636-4-1: "Intelligent Transportation System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Subpart 1: Media independent functionalities".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [1] and [2] and the following apply:

access router: IPv6 router that provides access to other networks, such as to the ITS access network

NOTE: The definition is taken from [i.5] and adapted to the ITS network architecture.

access network gateway: router at the edge of a network that connects an ITS station-internal network to the ITS access network, the public access network, and the private access network

ad hoc network: wireless networks based on self-organization without the need for a coordinating infrastructure

application unit: physical unit in an ITS station that executes applications and uses the communication services of a communication & control unit (CCU)

communication & control unit: physical communication unit located in an ITS station that implements communication protocols and provides communication services

GeoNetworking: network service that utilizes geographical positions and provides ad hoc communication without the need for a coordinating communication infrastructure

GeoNetworking protocol: network protocol that provides the GeoNetworking service

legacy roadside infrastructure: road infrastructure, e.g. road sensors, loops, networks, switches, router, processing entities, etc.

legacy services: legacy Internet services, such as WWW, email, Internet access, file transfer, etc.

ITS access network: communication network that interconnects roadside ITS stations among each other in an ITS specific way and optionally interconnects them to the core network (e.g., the Internet)

ITS ad hoc network: network of the ITS architecture that enables self-organized communication among ITS stations without the need for a coordinating communication infrastructure

ITS operational support service: service for operation of the ITS, such as the provision of security credentials to users/ vehicle drivers

ITS station internal network: network that interconnects the different components of an ITS station

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

mobile router: IPv6 router that acts as getway between a IPv6 mobile network and another IP-based network, and capable of changing its point of attachment to the network, moving from one link to another link

private access network: network that provides data services to a closed user group for a secured access to another system

proprietary local network: communication network attached to an ITS station, for example a controller area network (CAN) in a vehicle or a network of roadside legacy infrastructure

public access network: network that provides access to general purpose networks that are publicly accessible

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in [1] and [2] and the following apply:

AU	Application Unit
CAN	Controller Area Network
CCU	Communication and Control Unit
DCC	Decentralized Congestion Control
GPRS	General Packet Radio Service
IMT	International Mobile Telecommunications
IP	Internet Protocol
NEMO	Network Mobility
PDCP	Packet Data Convergence Protocol
TCP	Transmission Control Protocol
TIC	Transmit Interval Control
TPC	Transmit Power Control
UDP	User Datagram Protocol
UE	User Equipment

UMTS	Universal Mobile Telecommunication System
WIMAX	Worldwide Interoperability for Microwave Access
WWW	World Wide Web

4 Network architecture for ITS stations

The network architecture comprises external and internal networks. External networks interconnect ITS stations among each other or connect ITS stations to other instances. The following external networks are identified:

- ITS ad hoc network.
- Access network (ITS access network, public access network, private access network).
- Core network (e.g. the Internet).

Additionally, an ITS station can have an internal network that interconnects the components of the ITS station.

The different networks shall provide support for various use cases of road safety, traffic efficiency, infotainment and business applications. However, it is presumed that the communication within a single network does not meet all the requirements of all applications and use cases. Instead combinations of networks are envisioned, in which multiple ITS access and networking technologies are applied.

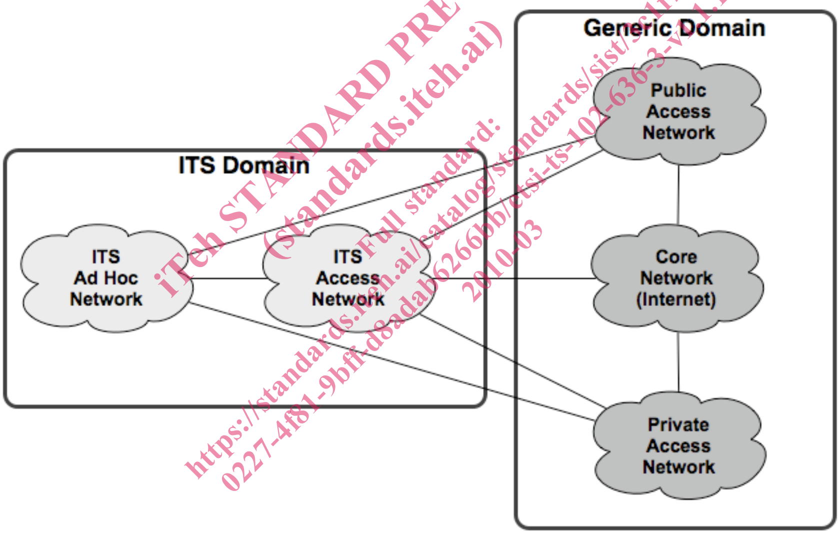

Figure 1: External networks involved in the ITS architecture and their interconnections

Figure 1 represents the highest level of abstraction of the ITS network architecture, where the external networks, represented by clouds are connected. The networks can be categorized into an ITS domain and a generic domain as specified in [1]. The external networks can be described as follows:

The *ITS ad hoc network* enables ad hoc communication among vehicle, roadside and personal ITS stations. The communication is based on wireless technologies, that typically provide a limited communication range (referred to as 'short-range wireless technology') and allow for mobility of the ITS stations forming arbitrary network topologies without the need for a coordinating communication infrastructure. An example of an *ITS ad hoc network* is a network of vehicle, roadside and personal ITS stations interconnected by ITS-G5 [10] wireless technology.

Generally, an *access network* enables ITS stations to access networks.

An *ITS access network* is a dedicated network that provides access to specific ITS services and applications and can be operated by a road operator or other operators. The ITS access network also interconnects roadside ITS stations and provides communication in between these as well as among vehicle ITS stations via the roadside ITS stations that are interconnected in the *ITS access network*. This local network can then enable the vehicle ITS stations to communicate via a roadside infrastructure communication network instead directly in ad hoc mode. As an example, an ITS access network can connect roadside ITS stations along a highway with a central ITS station (e.g. a road traffic management centre). In the case that short-range wireless technology is used for communication via roadside ITS stations, the connectivity to the *ITS access network* is typically provided intermittently.

A *public access network* provides access to general purpose networks that are publicly accessible. An example is an IMT-2000 [i.4] network that connects vehicle ITS stations to the Internet and provides mobile Internet access.

A *private access network*, in contrast to a public access network, provides data services to a closed user group for a secured access to another network. For example, a *private access network* can connect vehicle ITS stations to a company's intranet.

The access networks and the core network provide access to various services:

- legacy services , such as WWW, email and many others;
- ITS services provided by road traffic management centres and backend services;
- ITS operational support services required to operate the ITS, such as security services.

Core component of the architecture is the ITS station, which has two main roles: In its first role, the ITS station is a network node and acts as a communication source or sink. Likewise an ITS station can be a forwarder of data, e.g. in the *ITS ad hoc network*. In its second role, the ITS station is placed at the network edge and connect the different networks via an *ITS station internal network* (see Figure 1).

ITS stations shall be able to communicate via at least one of the following means (see Figure 2):

a) via an ITS ad hoc network;

b) via an ITS access network;

c) via a public access network;

d) via a private access network;

e) via one of the access networks into the core network (e.g. the Internet).

In addition to the networks listed above, an ITS station can also be attached to *proprietary local networks* of e.g. vehicle ITS sub-systems and roadside ITS sub-system as presented in [1]. Typical examples are:

- Controller Area Network (CAN) in a vehicle ITS sub-system.
- Legacy roadside infrastructure in a roadside ITS sub-system.

However, these proprietary networks are outside the scope of the present document.

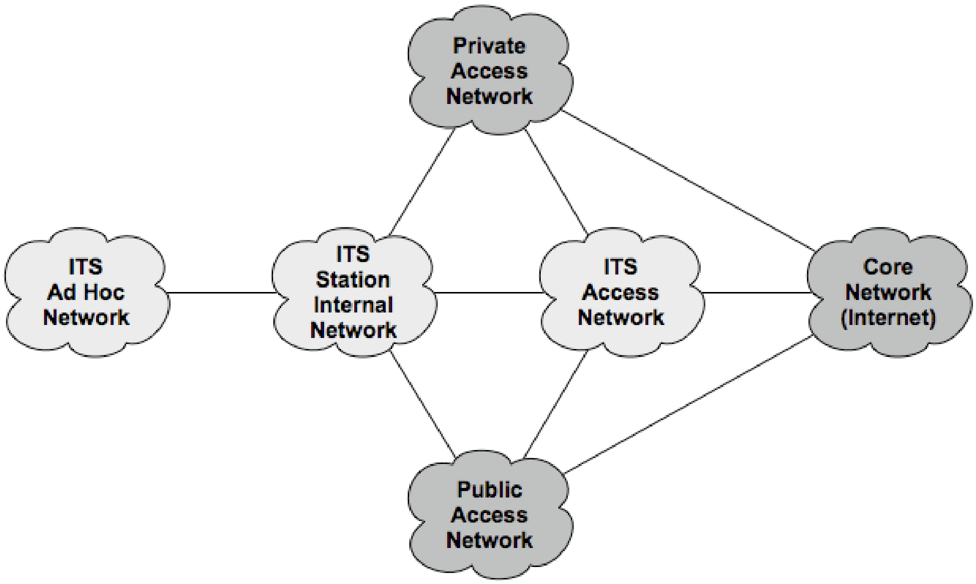

Figure 2: High-level network architecture

5 Deployment scenarios of the generic network architecture

The ITS network architecture can be deployed in different scenarios to adapt to specific economical and regulatory conditions and to facilitate a gradual introduction of ITS. Basically, a deployment scenario is a subset of the overall architecture (see Figure 2) created by a combination of the different network types.

Four basic deployment scenarios can be defined. The basic deployment scenarios can further be extended to hybrid scenarios that combine two or more deployment scenarios. These combinations also include scenarios in which a network is connected to more than a single network simultaneously.

Scenario A establishes an ITS ad hoc network, which can be connected via an ITS access network to the core network (e.g. the Internet) (see Figure 3). Deployment scenario B represents an ITS access network, which can be connected to the core network (e.g. the Internet) (see Figure 4). Deployment scenario C is based on a public access network, which can also provide connectivity to the core network (e.g. the Internet) (see Figure 5). Deployment scenario D uses a private access network to connect to other networks or the core network (e.g. the Internet) (see Figure 6).

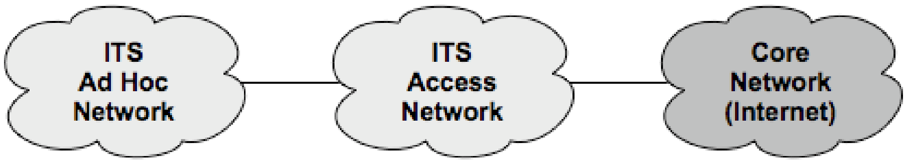

Figure 3: Deployment scenario A: Ad hoc-centric

In Figure 4, the ITS access network connects roadside ITS stations to each other and provides connectivity to a core network (e.g. the Internet). Optionally, the ITS access network can also be replaced by a public or private access network.