ETSI TS 102 894-1 V1.1.1 (2013-08)

Technical Specification

**Intelligent Transport Systems (ITS);
Users and applications requirements;
Part 1: Facility layer structure, functional requirements
and specifications**

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Foreword

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

The present document is part 1 of a multi-part deliverable covering the ITS applications and facilities layer, as identified below:

Part 1: **"Facility layer structure, functional requirements and specifications";**

Part 2: "Applications and facilities layer common data dictionary".

The present document has been prepared by considering feedback from the Car-to-Car Communication Consortium (C2C-CC). The specifications of facilities layer structure and facilities layer entities are based on experience gathered from various European Projects such as DRIVE C2X, CVIS, SCORE@F and simTD.

Introduction

The present document provides architecture and functional specifications for the facilities layer of the ITS station (ITS-S) as defined in [1]. It is based on the previous work that has been realized within ETSI TC ITS WG1 related to the Basic Set of Applications (BSA) [i.1].

ITS applications are distributed among multiple ITS-Ss in order to share information using wireless communications. ITS applications provide a large diversity of customer's services. BSA has been defined by ETSI TC as a set of ITS applications that can be deployed reasonably within a three-year time frame after its standardization completion. Furthermore, ETSI TC ITS developed and defined functional requirements for BSA [i.2].

This previous work will allow ETSI TC ITS to identify a set of facilities in the facilities layer that are required to satisfy some common functional requirements and operational requirements of BSA. The facilities specified in the present document are minimum functionalities, services and data that are needed to ensure the interoperability and basic operation of ITS applications. The architecture of the facilities layer is intended to be an open architecture, which is available for ITS application developers to incorporate advanced proprietary facilities and different kinds of access networks such as ITS G5 or cellular networks.

The following projects and organizations had been consulted during the preparation of the present document:

- Car to Car Communication Consortium (http://www.car-to-car.org)

- COMeSafety (http://www.comesafety.org)

- PREDRIVE C2X (www.pre-drive-c2x.eu)

- DRIVE C2X (http://www.drive-c2x.eu)

- CVIS (www.cvisproject.org)

- simTD (www.simtd.de)

- CoVel (www.covel-project.eu)

- SCORE@F (http://www.scoref.fr/)

1   Scope

The present document defines the functional architecture for the facilities layer of the ITS station as defined in [1] and provides functional requirements and specifications for main identified facilities.

The identified facilities are required to support BSA as defined in [i.1]. Other proprietary facilities might be required to be included in the facilities layer for BSA and other ITS applications. Such proprietary facilities are not defined in the present document.

2   References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

> NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1   Normative references

The following referenced documents are necessary for the application of the present document.

> [1]   ETSI EN 302 665 (V1.1.1): "Intelligent Transport Systems (ITS); Communications Architecture".

> [2]   ETSI EN 302 637-2: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service".

> [3]   ETSI EN 302 637-3: "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specifications of Decentralized Environmental Notification Basic Service".

2.2   Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

> [i.1]   ETSI TR 102 638 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Definitions".

> [i.2]   ETSI TS 102 637-1 (V1.1.1): "Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 1: Functional Requirements".

> [i.3]   CEN/TS 16157-1: "Intelligent transport systems - DATEX II data exchange specifications for traffic management and information - Part 1: Context and framework".

> [i.4]   ETSI TS 102 890-2: "Intelligent Transport Systems (ITS); Facilities layer function; Part 2: Services announcement specification".

> [i.5]   ETSI TR 102 893 (V1.1.2): "Intelligent Transport Systems (ITS); Security; Threat, Vulnerability and Risk Analysis (TVRA)".

> [i.6]   ETSI TS 103 084: Intelligent Transport Systems (ITS); Vehicular Communications; GeoMessaging Enabler".

[i.7]   ETSI EN 302 636-4-1: "Intelligent Transport System (ITS); Vehicular communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality".

3   Definitions and abbreviations

3.1   Definitions

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

application support: sub set of facilities, providing support elements for ITS applications

backend systems: system that includes middleware in the generic domain, providing back end support and functions for BSA ITS use case

basic set of applications: group of applications, supported by vehicular communication system

NOTE: BSA definition is provided in [i.1]

CA basic service: facility at the facilities layer to support ITS applications, CAM management and CAM dissemination

communication support: sub set of facilities, providing support for communications

cooperative awareness message: ITS facilities layer PDU providing ITS-S information

decentralized environmental notification message: ITS facilities layer PDU providing event information

DEN basic service: facility at the facilities layer to support ITS applications, DENM management and DENM dissemination

facility: functionalities, services or data provided by the facilities layer

information support: sub set of facilities, providing support for data management

ITS application: component of ITS applications layer

ITS use cases: procedure of executing an ITS application

LDM: local georeferenced database

message: facilities layer or application layer PDU

NOTE: Examples are cooperative awareness message and decentralized environmental notification message.

3.2   Abbreviations

For the purposes of the present document, the following abbreviations apply:

AID	Application identifier
ALERT-C	Advice and problem Location for European Road Traffic
API	Application Programming Interface
ASN.1	Abstract Syntax Notation One
BSA	Basic Set of Application
C2C-CC	Car to Car Communication Consortium
CA	Cooperative Awareness
CAM	Cooperative Awareness Message
CF	Common Facility
DCC	Decentralized Congestion Control
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DF	Domain Facility

DGPS   Differential Global Positioning System
DIASER   DIAlogue Standard for traffic Regulation Equipment
E2E   End to end
EFCD   Extended vehicle floating car data
EGNOS   European Geostationary Navigation Overlay Service
FA-SAP   Facilities Application SAP
GNSS   Global Navigation Satellite System
HMI   Human Machine Interface
HTTP   Hypertext Transfer Protocol
ISO   International Organization for Standardization
ITS   Intelligent Transport System
ITS-S   ITS station
IVS   In vehicle signage
LDM   Local Dynamic Map
MF-SAP   Management Facilities SAP
N&T   Networking and transport layer
NF-SAP   Networking and transport Facilities SAP
OSI   Open Systems Interconnection
PDU   Protocol Data Unit
PER   Packed Encoding Rules
QoS   Quality of Service
RSU   Road side unit
SAM   Service Announcement message
SAP   Service Access Point
SF-SAP   Security Facilities SAP
SOAP   Simple Object Access Protocol
SPAT   Signal Phase And Timing
TAI   International Atomic Time
TMC   Traffic Message Channel
TMC-LOC   TMC Location Referencing
TOPO   Road topology message
TPEG   Transport Protocol Experts Group
TPEG-LOC   TPEG Location Referencing
TVRA   Vulnerability and Risk Analysis
VMS   Variable Message Sign
XER   XML encoding rules
XML   Extensible Markup Language

4   ITS application overview

The overall ITS environment comprises ITS stations (ITS-S) that may communicate directly as follows:

- From Vehicle to Vehicle, via ad-hoc (or cellular) communication or based on Infrastructure involvement;

- From Vehicle to Infrastructure; and

- From Infrastructure to Vehicle.

ITS-Ss may communicate with each other through a local wireless access point (e.g. ITS G5 based) or a wireless wide area network (e.g. a cellular network).

This is shown in simplified form in figure 4.1. The dotted lines represent the logical connections between ITS-Ss.
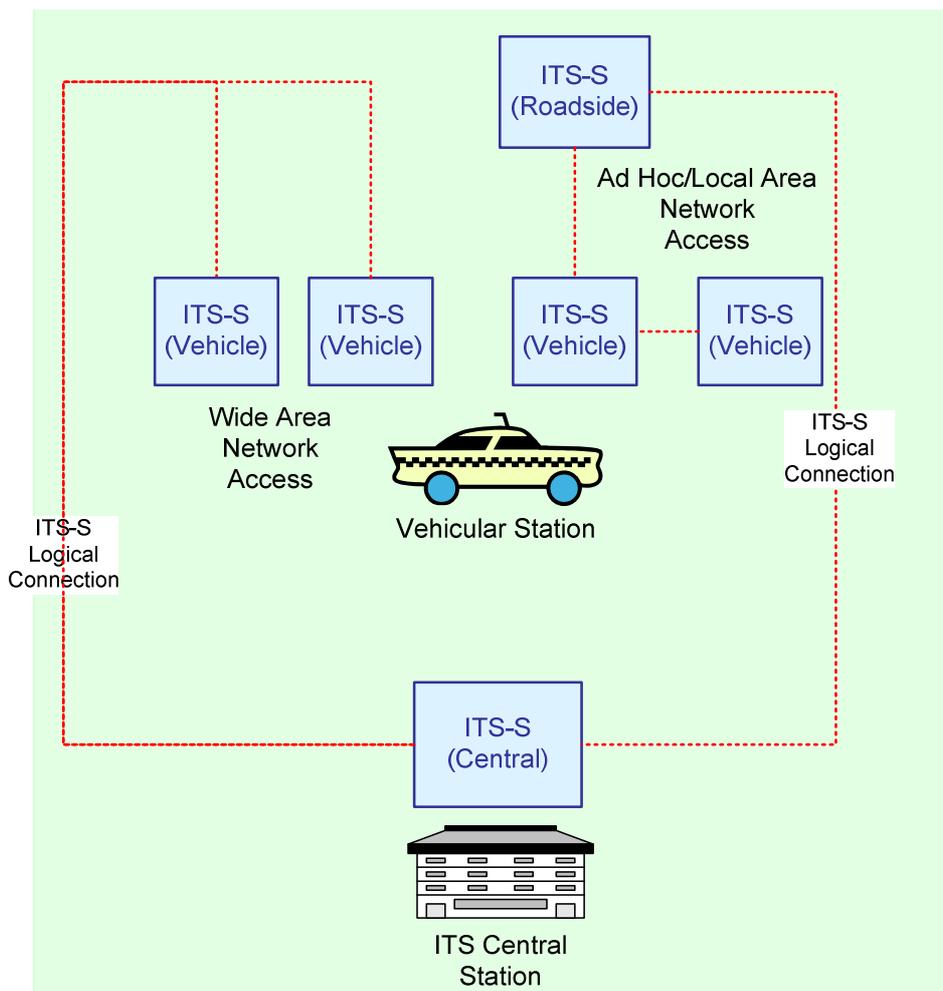
Figure 4.1: Simplified view of ITS environment

4.1 ITS architecture and ITS stations

Four ITS-S types are defined in [1], namely:

- **Central ITS-S:** A central ITS-S provides centralized ITS applications. A central ITS-S may play the role of traffic operator, road operator, services provider or content provider. Furthermore, a central ITS-S may require further connection with backend systems via e.g. Internet. For deployment and performances needs, specific instances of central ITS-S may contain grouping of Applications or Facilities.

- **Road side ITS-S:** A road side ITS-S provides ITS applications from the road side. A road side ITS-S may provide ITS applications independently or cooperatively with central ITS-S or other road side ITS-Ss. For deployment and performances needs, specific instances of road side ITS-S may contain grouping of Applications or Facilities.

- **Vehicle ITS-S:** A vehicle ITS-S provides ITS applications to vehicle drivers and/or passengers. It may require an interface for accessing in-vehicle data from the in-vehicle network or in vehicle system. For deployment and performances needs, specific instances of vehicle ITS-S may contain grouping of Applications or Facilities.

- **Personal ITS-S:** A personal ITS-S provides ITS applications to personal and nomadic devices. For deployment and performances needs, specific instances of personal ITS-S may contain grouping of Applications or Facilities.

A common reference communication architecture for all ITS stations is defined in [1] and as illustrated in figure 4.2. This architecture is an extension of the ISO 7-layer OSI model.

The present document defines the functional architecture of the facilities layer.
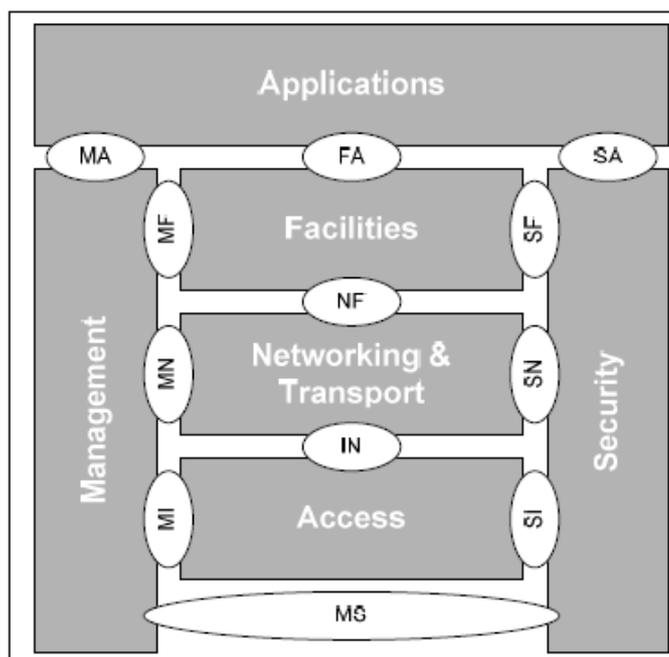
Figure 4.2: ITS station reference architecture

4.2 Application layer overview

ITS applications are defined within the application layer. An ITS application makes use of the underlying facilities and communication capacities provided by the ITS-S.

The applications layer provides ITS services. Three classes of applications have been defined in [i.1]: road safety, traffic efficiency and other applications. Each application can be assigned to one of the three identified application classes.

The Basic Set of Applications (BSA) are applications that are considered as deployable with reasonable efforts within 3 years' time scale after the complete standardization of the system. Each application regroups a set of use cases to realize some user benefits, including societal benefits, mobility benefits or customer benefits. The complete list of the BSA use cases and assigned applications are provided in [i.1].

The facilities layer is a middleware composed of multiple facilities. A facility is a component that provides functions, information or services to ITS applications. It exchanges data with lower layers and with management and security entities of the ITS-S as defined in [1].

The present document provides specifications of the facilities layer entities in support of the BSA. Further use cases are expected to be added in the future.

5 Facilities layer functional architecture

5.1 ITS-S external gateways

In order to connect with external systems, an ITS-S may provide gateway functions for these external systems to exchange information with the facilities layer of the ITS-S. For BSA, one or multiple gateway functions may need to be developed in order to satisfy the application requirements.

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5.1.1   Vehicle ITS-S gateway to in vehicle network

For a vehicle ITS-S, the facilities layer is connected to the in-vehicle network via an in-vehicle data gateway as illustrated in figure 5.1. The facilities and applications of a vehicle ITS-S receive from this gateway the required in-vehicle data in order to construct messages (e.g. CAM and DENM) and for the application usage.

The implementation of the in vehicle data gateway needs to adapt to the specifications of the in vehicle network which may be proprietary to the industry. Therefore, the specifications of this gateway are out of the scope of the present document.
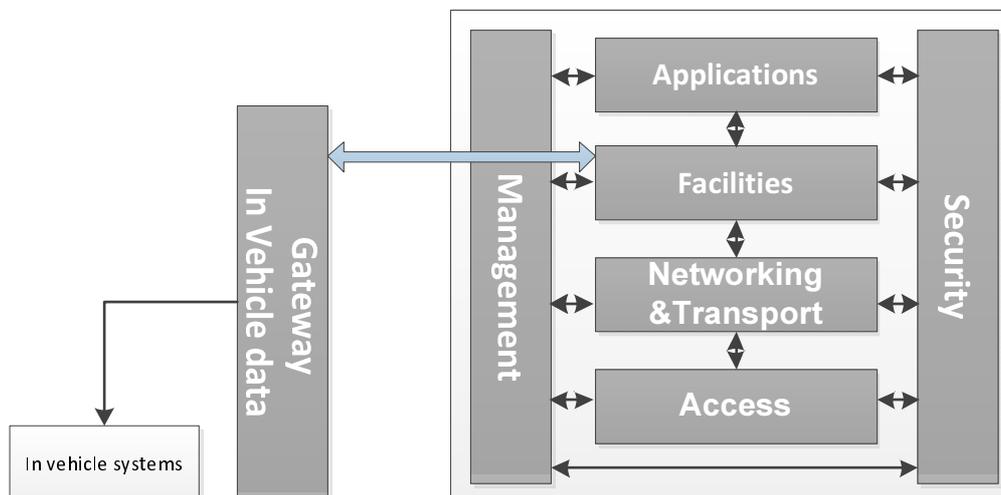
Figure 5.1: Vehicle ITS-S in-vehicle data gateway

5.1.2   Road side ITS-S gateway to central ITS-Ss

A roadside ITS-S is in general connected to a central ITS-S e.g. traffic management centre or road operator centre. In a possible road side ITS-S deployment scenario, road side ITS-Ss are managed by a private road infrastructure management network. Specific protocols for the traffic management, for the roadside equipment management and operational management are applied within such road infrastructure network. A gateway function may be equipped at the road side ITS-S in order to provide connections between message exchanges protocols (e.g. CAM, DENM) and these infrastructure protocols. In Europe, DATEX II protocol [i.3] is a standardized protocol deployed for exchanges of the traffic management information between traffic management centres and between traffic management centre and road side equipment (e.g. Variable Message Sign System). In a possible implementation, a roadside ITS-S is connected to road infrastructure network by a DATEX II gateway as illustrated in figure 5.2. A road side ITS-S may either receive information from central ITS-S or send information to central ITS-S via this gateway.

The DATEX II gateway of a road side ITS-S may include several functions:

- Aggregation of the received messages from vehicle ITS-Ss (such as CAM and DENM) and transmit to traffic management centre in DATEX II messages.

- Receive and filter traffic management information from traffic management center in DATEX II protocol, then transmit to vehicle ITS-S in messages such as CAM or DENM.

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Detailed specifications of this gateway is out of the scope of the present document.
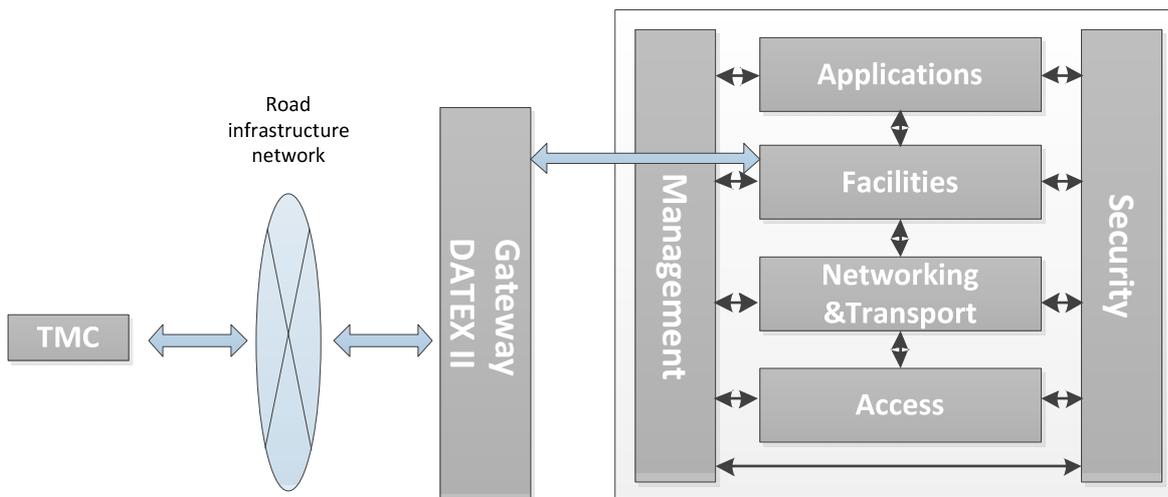
Figure 5.2: Roadside ITS-S gateway to road infrastructure network

5.1.3   Road side ITS-S or central ITS-S gateway to road equipment

An ITS applications may require data related to the traffic regulation (e.g. rail-road intersection, traffic light status, speed limit), or require support from the road side detection capacities (e.g. road side sensors). This requires that road side equipment exchanges information with central or roadside ITS-S. For example, as specified in [i.2] in the third part intersection collision risk warning, a road side ITS-S equipped at the intersection may detect the traffic light violation of a vehicle by dedicated road side sensors (e.g. intersection radar, camera), then this road side ITS-S triggers a DENM and disseminates to other oncoming vehicles in order to reduce the risk of intersection collision.

A central or roadside ITS-S may obtain traffic regulation and road side sensor data via a specific gateway to the road side equipment as presented in figure 5.3. National or international standards may already exist, e.g. DIASER a French standard for information exchanges between traffic light controllers and traffic light equipment. These standards are to be taken into account when developing this gateway interface, detailed specifications of this gateway is out of the scope of the present document.
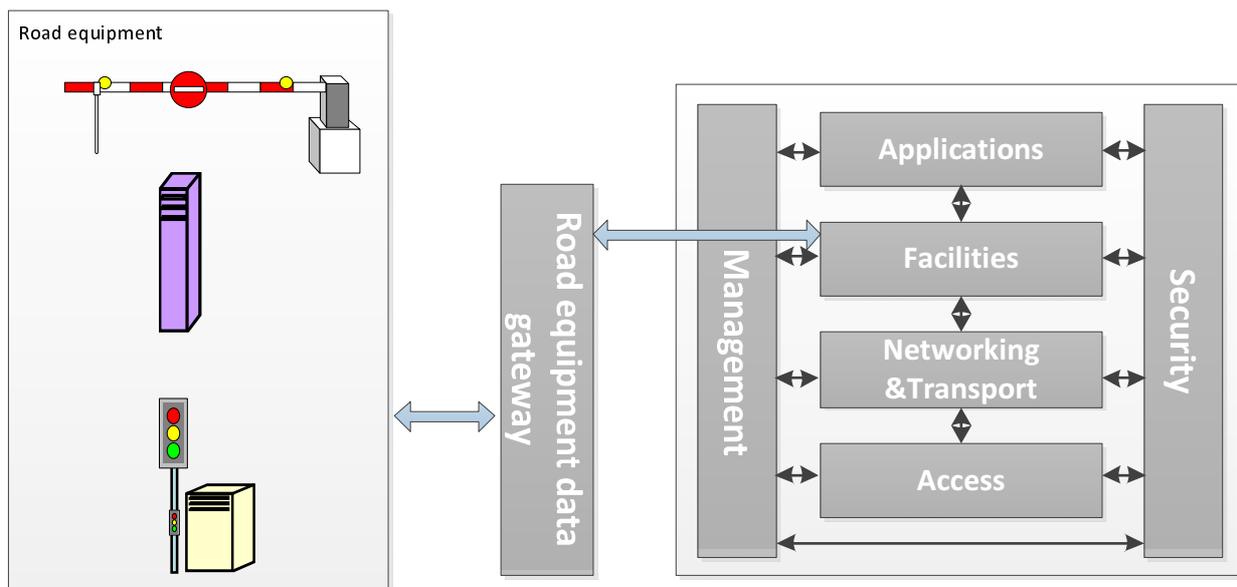
Figure 5.3: Roadside ITS-S gateway to road equipment

5.1.4   ITS-S gateway to back end systems

An ITS-S (e.g. road side ITS-S or central ITS-S) may need to connect to a back end system via a generic networks such as Internet. The back end systems provide required services, service support or service content to the ITS-S in order to satisfy the requirements of the ITS applications. In a possible implementation, an ITS-S is connected to the back end system by a gateway as illustrated in figure 5.4. Detailed specifications of this gateway are out of the scope of the present document.
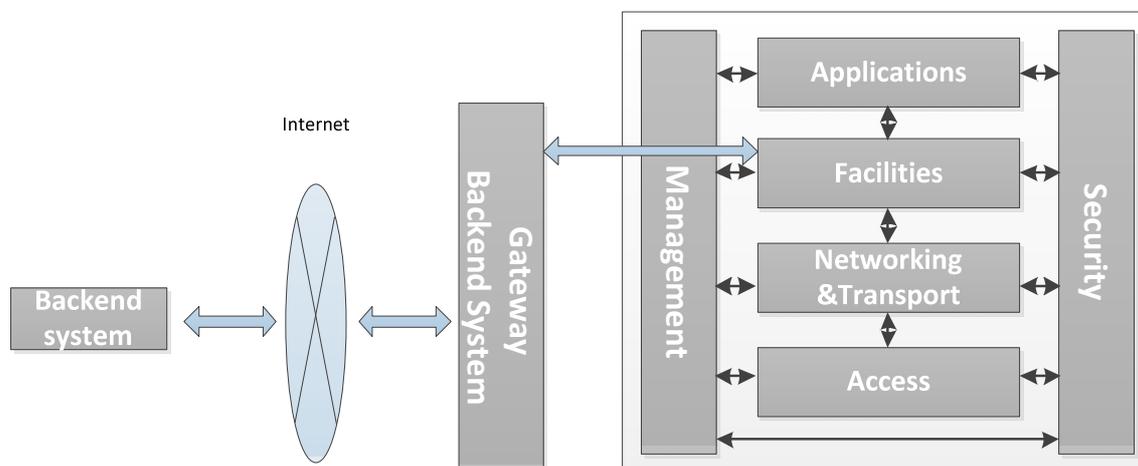
Figure 5.4: ITS-S gateway to back end system

5.1.5   Personal ITS-S gateway to vehicle ITS station

When a personal ITS-S is located in a vehicle, this personal ITS-S may be considered as a vehicle ITS-S under the condition that the personal ITS-S satisfies some predefined requirements. In particular for a personal ITS-S to support the road safety applications, a connection to the vehicle electronics may be required. The personal ITS-S is connected securely with vehicle ITS-S via a gateway to the in vehicle network or with the vehicle ITS-S to receive the in vehicle data.

Detailed specifications of this gateway are out of the scope of the present document.

5.2   Facilities layer functional architecture

The general functional architecture of the facilities layer is illustrated in figure 5.5. A set of facilities are identified in order to support the BSA, these facilities can be classified into two categories as below:

- **Common facilities:** Common facilities provide basic core services to support the reliable operation of an ITS-S and the interoperability of the BSA applications. Common facilities are common for all ITS-Ss and all BSA applications. Examples of the common facilities are time service, positioning service.

  Detailed specifications of the common facilities are provided in clause 6 of the present document.

- **Domain facilities:** Domain facilities provide services and functions for one or several specific BSA applications such as DEN basic service for cooperative road hazard warning applications. Domain facilities are common for one or several applications. One domain facility may become optional or not used for other applications.

  Detailed specifications of the domain facilities are provided in clause 7 of the present document.

Furthermore, according to the functionalities that a facility provides, a facility as identified in the present document can be of one of the following types:

- **Application support facility:** A facility that provides common services and/or functionalities for BSA execution. Examples of the application support facilities are CA basic service and DEN basic service.

- **Information support facility:** A facility that provides common data and database management functionalities for BSA execution. Examples of the information support facilities are Local Dynamic Map (LDM) and map data base.

- **Communication support facility:** A facility that provides services for communications and session management. Examples of the communication support facilities are addressing mode, geocasting support and session support.

- **Management facility:** A facility that is interconnected with management or with security entity of the ITS-S.
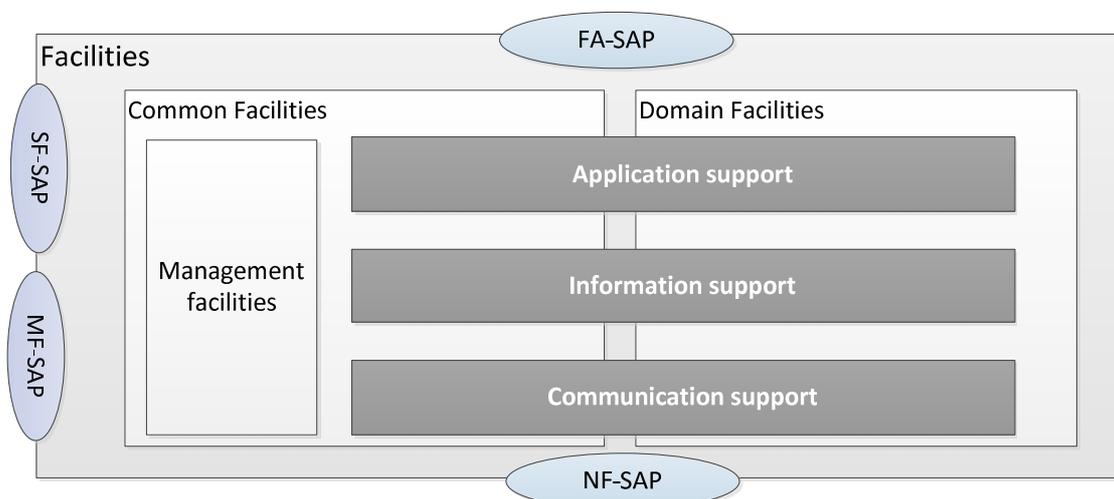
Figure 5.5: Facilities layer functional architecture

As represented in figure 5.5: four Service Access Points (SAP) are connected to the facilities layer:

- The FA-SAP (Facilities/Applications - Service Access Point): A SAP that enables the full duplex exchange of data between the applications layer and the facilities layer.

- The SF-SAP (Security/Facilities - Service Access Point): A SAP that enables the full duplex exchange of data between the facilities layer and the security. For example, the facility layer may request the security layer for certification of transmitted messages and the authentication of received messages.

- The MF-SAP (Management/Facilities - Service Access Point): A SAP that enables the full duplex exchange of data between the facilities layer and the management layer. For example, the management layer will communicate to the facilities layer the applicable management policies to optimize the global system operation of the ITS-S and a consistent cross layer operation.

- The NF-SAP (Network - Transport/Facilities - Service Access Point): A SAP that enables the full duplex exchange of data between the facilities layer and the network - transport layer.

NOTE: The detailed specifications of the SAPs are out of the scope of the present document.

5.3   List of facilities

Based on BSA functional requirements as provided in [i.2], a set of facilities are identified. The common facilities are listed in table 5.1, the domain facilities are listed in table 5.2. The present document provides functional descriptions for each of the facilities listed in table 5.1 and table 5.2, as well as the interactions with other facilities or with other layers of the ITS-S as defined in [1].

NOTE 1: The present document does not make judgement whether a facility needs to be standardized. Some facilities may be proprietary and implemented depending to the development strategies of industries.

NOTE 2: The present document does not specify any implementation architecture of the ITS-S facilities layer. In one possible implementation, a facility may be grouped with other facilities into one component, or may be implemented into multiple components.

The list of the common facilities is given in table 5.1. Detailed functional specifications of each common facility are provided in clause 6 of the present document.

Table 5.1: List of common facilities

Classification	Identifier	Facility name	Short description
Management	CF001	Traffic class management	Manage assignment of traffic class value for the higher layer messages.
	CF002	ITS-S ID management	Manage ITS-S identifiers used by the application and the facilities layer.
	CF003	AID management	Manage the application ID used by the application and the facilities layer.
	CF004	Security access	Deal with the data exchanged between the application and facilities layer with the security entity.
Application support	CF005	HMI support	Support the data exchanges between the applications and HMI devices.
	CF006	Time service	Provide time information and time synchronization service within the ITS-S.
	CF007	Application/facilities status management	Manage and monitor the functioning of active applications and facilities within the ITS-S and the configuration.
	CF008	SAM processing	Support the service management of the management layer for the transmission and receiving of the service announcement message (SAM).
Information support	CF009	Station type/capabilities	Manage the ITS-S type and capabilities information.
	CF010	ITS-S positioning service	Calculate the real time ITS-S position and provides the information to the facilities and applications layers.
	CF011	Location referencing	Calculate the location referencing information and provide the location referencing data to the applications/facilities layer.
	CF012	Common data dictionary	Data dictionary for messages.
	CF013	Data presentation	Message encoding/decoding support.
Communication support	CF014	Addressing mode	Select addressing mode for messages transmission
	CF015	Congestion control	Facilities layer decentralized congestion control functionalities.

The list of the domain facilities is given in table 5.2. Detailed functional specifications of each common facility are provided in clause 7 of the present document.

Table 5.2: List of domain facilities

Classification	Identifier	Facility name	Short description
Application support	DF001	DEN basic service	Support the protocol processing of the Decentralized Environmental Notification Message.
	DF002	CA basic service	Support the protocol processing of the Cooperative Awareness Message.
	DF003	EFCD	Aggregation of CAM/DENM data at the road side ITS-S and provide to the central ITS-S.
	DF004	Billing and payment	Provide service access to billing and payment service provider.
	DF005	SPAT basic service	Support the protocol processing of the Signal Phase and Timing Message.
	DF006	TOPO basic service	Support the protocol processing of the Road Topology Message.
	DF007	IVS basic service	Support the protocol processing of the In Vehicle Signage Message.
	DF008	Community service user management	Manage the user information of a service community.
Information support	DF009	Local dynamic map	Local Dynamic Map database and management of the database.
	DF010	RSU management and communication	Manage the RSUs from the central ITS-S and communication between the central ITS-S and road side ITS.
	DF011	Map service	Provide map matching functionality.
Communication support	DF012	Session support	Support session establishment, maintenance and closure.
	DF013	Web service support	High layer protocol for web connection, SOA application protocol support.
	DF014	Messaging support	Manage ITS services messages based on message priority and client services/use case requirements.
	DF015	E2E Geocasting	Deal with the disseminating of information to ITS vehicular and personal ITS stations based on their presence in a specified Geographical area.

6   Common facilities functional requirements

Common facilities are facilities that are required by the operation of the ITS-S and/or provide support for communication interoperability. Moreover, certain common facilities provide cross layer information to the management and the security entities as defined in [1], therefore, these common facilities are management facilities.

For the usage in the present document, each common facility is assigned with a unique number CF#, as illustrated in table 5.1. For each facility, a set of sub function and interfaces are defined. Each function is denoted by an identifier [CF#_F#] where CF# indicates the ID of the common facility; F# indicates the number of the function. Each interface is also denoted by an identifier [CF#_IN#] where CF# indicates the ID of the common facility, IN# indicates the number of the interface.

For illustration purpose, a block diagram is defined for each common facility. This block diagram summarizes the main functionalities of the facility and logical connections with other facilities of the facilities layer and/or with other layers of the ITS-S, illustrated as external components in the block diagram. For simplicity reason, any external component if not referred as one of the facilities defined in the present document, the following external components are defined for illustration:

- N&T: it corresponds to the ITS networking and transport layer as defined in [1].

- Management: it corresponds to the ITS management entity as defined in [1].

- Security: it corresponds to the ITS security entity as defined in [1].

- ITS application: it corresponds to the ITS application layer as defined in [1].

- Messages: it corresponds to any facility that manages the facilities layer or ITS application layer PDU, such as CA basic service, DEN basic service, etc.

- Other external components as defined in corresponding facility.

6.1 Management facilities functional requirements

6.1.1 CF001: Traffic class management

This facility deals with assignment of a traffic class value to each message transmitted by the applications and facilities layer of an ITS-S. The traffic class level is used by the management layer to select the appropriate communication protocol and access technologies to be used for the message transmission. Furthermore, the traffic class may also be used by the ITS networking and transport layer for the packet routing.

The assignment of the traffic class is based on predefined rules and conditions. The parameters being taken into account for the assignment may be the message type, communication requirements, QoS requirements and the priority level of the application. The traffic class management facility implements conditions and policies to assign traffic class level to messages.

The definition of traffic class and the assignment policies may be updated if required. If updates are required, the update information should be provided by an authorized entity of the application management, which may be implemented in an external system or in another ITS-S.

The functional block diagram of the traffic class management common facility is illustrated in figure 6.1.

Figure 6.1: Block diagram: Traffic Class Management

The functional requirements of this common facility are presented in table 6.1:

Table 6.1: Functional requirements: Traffic Class Management

Functions	Requirement
[CF001_F1]:	This function shall assign traffic class level to messages by implementing conditions and policies.
[CF001_F2]:	This function shall update the definition of the traffic class and the assignment policies if required by the application management authorities. This function is optional.

The interfaces of this common facility are presented in table 6.2:

Table 6.2: Interfaces: Traffic Class Management

Interface	Related component	Direction	Information exchanged over the interface
[CF001_IN1]	Application	IN	Data required for the traffic class assignment: e.g. communication requirements.
[CF001_IN2]	Message	IN	Data required for the traffic class assignment: e.g. communication requirements, message type, QoS requirements etc.
[CF001_IN3]	Networking and transport layer	OUT	Traffic class set for the message.
[CF001_IN4]	Management entity	OUT	Traffic class set for the message.
[CF001_IN5]	Application management Authority (may be implemented in an external ITS-S)	IN	Update information for the traffic class definition or the traffic class assignment policies. This interface may be an external interface.

6.1.2 CF002: ITS-S ID management

This facility manages the identifier of an ITS-S being used within the application and facilities layer of the ITS-S.

The identifier of an ITS-S shall allow unambiguous identification of an ITS-S from other ITS-Ss in the network. Given the security and privacy protection requirements as identified in [i.5], this ITS-S ID may be a temporary pseudonym. The ITS-S ID management shall include functionality to update the ITS-S ID. It may be updated periodically by the security entity of the ITS-S. For this purpose, the ITS-S should be able to connect to the security infrastructure in order to update the ITS-S ID.

Different ITS applications may have different requirements to identify an ITS-S from other ITS-Ss, an ITS-S ID is defined to satisfy these requirements. The ITS-S ID management facility interfaces with the security entity in order to ensure that the application requirements are provided to the security entity of the ITS-S. The ITS-S ID may be included in a message if required.

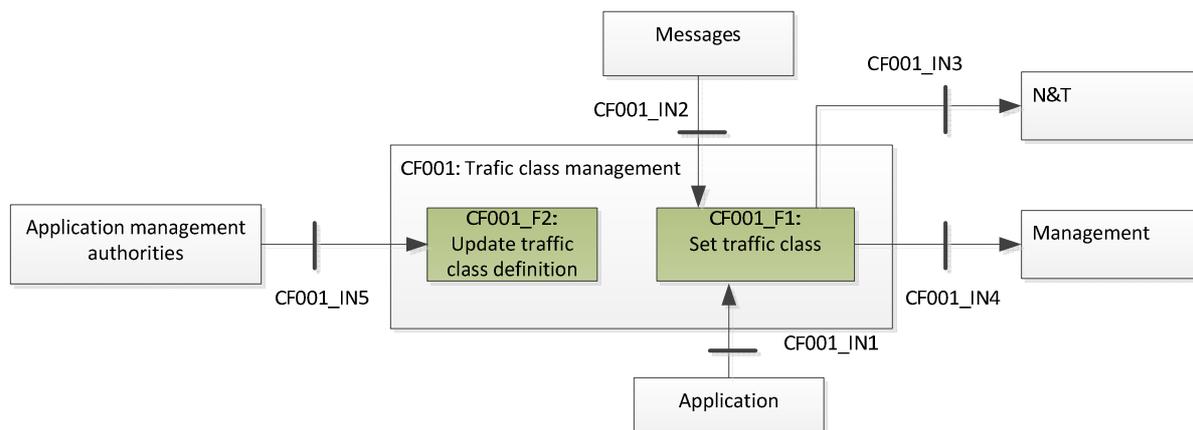The functional block diagram of the ITS-S ID management facility is given in figure 6.2.

Figure 6.2: Block diagram: ITS-S ID management

The functional requirements of this common facility are presented in table 6.3:

Table 6.3: Functional requirements: Traffic Class Management

Functions	Requirement
[CF002_F1]:	This function shall update the ITS-S ID for the usage of ITS applications and facilities layer, in connection with the security entity.
[CF002_F2]:	This function shall discard the outdated ITS-S ID.

The interfaces of this common facility are presented in table 6.4:

Table 6.4: Interfaces: ITS-S ID Management

Interface	Related component	Direction	Information exchanged over the interface
[CF002_IN1]	Security entity	IN/OUT	OUT: Requirements for the ITS-S ID assignment. IN: Updated ITS-S ID to be used by the ITS applications and the facilities layer.
[CF002_IN2]	Message or Applications	IN/OUT	OUT: Updated ITS-S ID to be used by the ITS applications and the facilities layer. IN: Requirements for the ITS-S ID assignment.

6.1.3   CF003: AID Management

This common facility manages the Application Identifier (AID) being used within the application and facilities layer. An AID is the identifier of a message or the identifier of an ITS application. An AID can be updated and new AIDs can be added if the ITS-S is informed by an authorized application management entity which may be implemented in another ITS-S. An AID shall allow unambiguous identification of one ITS application or messages from other ITS applications and from other message. The assignment of an AID is based on regulatory and management rules that are defined by the authorized ITS application management entity.

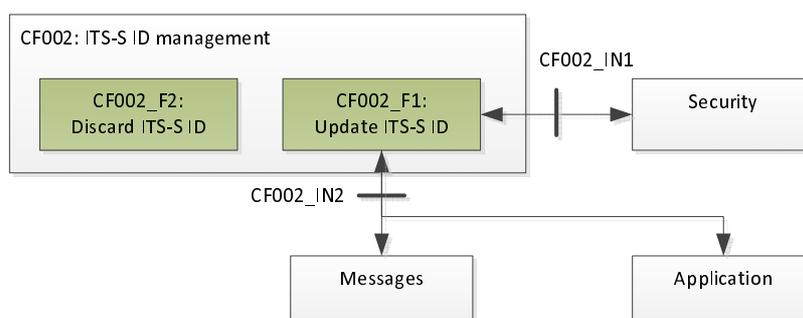The functional block diagram of the AID management common facility is illustrated in figure 6.3.

Figure 6.3: Block diagram: AID management

The functional requirements of this common facility are presented in table 6.5.

Table 6.5: Functional requirements: AID management

Functions	Requirement
[CF003_F1]:	This function shall set an AID to an applications and/or a message that allows the unambiguous identification of an ITS application or a message from other ITS applications and from other message.
[CF003_F2]:	This function shall update the AID when necessary, as informed by the application management entity. This sub function is optional.
[CF003_F3]:	This function shall discard the invalid AIDs.

The interfaces of this common facility are presented in table 6.6.

Table 6.6:Interfaces: AID Management

Interface	Related component	Direction	Information exchanged over the interface
[CF003_IN1]	Applications or messages.	IN/OUT	IN: Requirements for the AID assignment. OUT: The AID of the application.
[CF003_IN2]	Management layer	OUT	The AID that may be useful in the management layer.
[CF003_IN3]	Application management authorities (may be implemented in another ITS-S)	IN	The update information of the AID. This interface may be an external interface.

6.1.4   CF004: Security access

This common facility enables the data exchanges between the applications, the facilities layer and the security entity of the ITS-S. It provides the transmitted and received message or the application data to the appropriate security mechanism in the security entity that will process the message or data accordingly. Depending to the application requirements and the potential risks, different security mechanisms can be used to protect the messages and the data of the applications and the facilities layer. The decision on which security and protection actions to be used may be taken by the security entity or alternatively by the security access facility.

Furthermore, the application and the facilities layer may require certain security reports from the security entity, in order to be informed of the malfunctioning or the security events of the ITS-S.

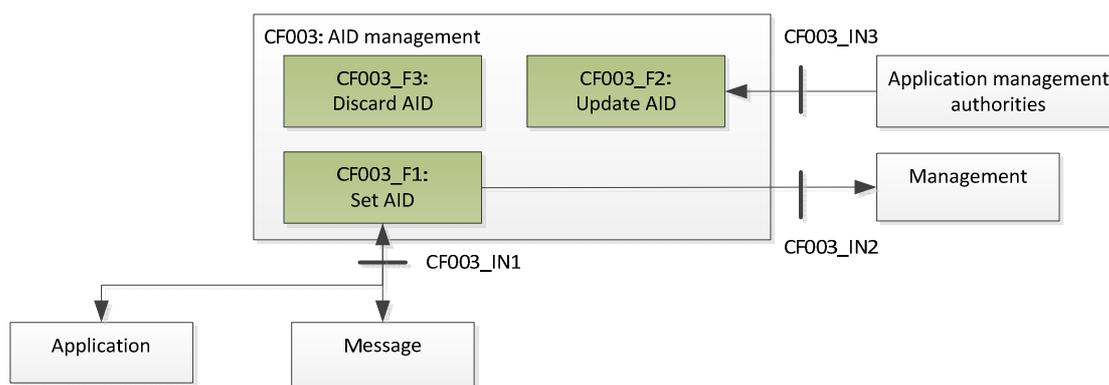The functional block diagram of the common facility is illustrated in figure 6.4.

Figure 6.4: Block diagram: Security access

The functional requirements of this common facility are presented in table 6.7.

Table 6.7: Functional requirements: Security access

Functions	Description
[CF004_F1]:	This function shall forward the message to the security for security processing, if applicable. Furthermore, this function may select the appropriate security and privacy protection mechanism for the transmitted and received message.
[CF004_F2]:	This function exchanges with the security in order to receive security events notifications as required by the applications. It shall be able to receive the information from the security entity and provide them to the applications or the facilities requesting such information.

The interfaces of this common facility are presented in table 6.8.

Table 6.8: Interfaces: Security access

Interface	Related component	Direction	Information exchanged over the interface
[CF004_IN1]	Application or Messages	IN/OUT	IN: Message and security related primitives. OUT: Secured message.
[CF004_IN2]	Security	IN/OUT	OUT: Message and security related primitives, requests of security events notifications. IN: Secured message, security events notifications.

6.2 Application support facilities functional requirements

6.2.1 CF005: HMI support

This common facility provides gateway function between the ITS applications and the Human Machine Interface (HMI) devices equipped by an ITS-S. It enables the dispatching of the application information to the HMI devices. One or more ITS applications active in the ITS-S send application processing results to the HMI devices through this common facility. According to the ITS application needs and the properties of the HMI device, one directional or duplex information exchange may be required.

The HMI support common facility may statically or dynamically manage the information in the order of priority e.g. the emergency level of the information (e.g. collision risk warning, information on the traffic status) and/or the validity time of the information.

In order to manage the communication between the ITS-S and HMI devices, the HMI support maintains a list of available HMI devices equipped by the ITS-S. Information included in this list may include the type of HMI device, the type of interface being used by the HMI device, and/or the availability of the HMI device, etc.

The functional block diagram of the AID management is illustrated in figure 6.5.
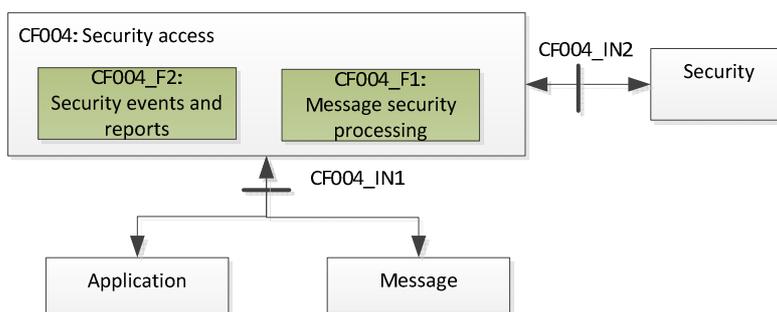

Figure 6.5: Block diagram: HMI support

The functional requirements of this common facility are presented in table 6.9.

Table 6.9: Functional requirements: HMI support

Functions	Requirement
[CF005_F1]:	This function shall receive data from ITS application or by the HMI device (HMI related data).
[CF005_F2]:	This function shall manage the HMI related data with a predefined policy e.g. priority levels.
[CF005_F3]:	This function shall send information to the ITS application or to the HMI device, when necessary.
[CF005_F4]:	This function may keep the information of the HMI devices equipped by the ITS-S.

The interfaces of this common facility are presented in table 6.10.

Table 6.10: Interfaces: HMI support

Interface	Related component	Direction	Information exchanged over the interface
[CF005_IN1]	Application layer.	OUT/IN	Application processing results or the information sent from the HMI device.
[CF005_IN2]	HMI device	OUT/IN	Application processing results or the information sent from the HMI device.

6.2.3   CF006: Time service

This common facility provides support for dealing with time and time synchronization for all available time stamped data being used within message and ITS applications. A common unified and standardized time reference is defined and used for all ITS-Ss. Referring to this common ITS time definition, different time stamps may be defined in different message, depending on the validity time and time granularity requirement of that message. For the messages being defined for the BSA, the International Atomic Time (TAI) is used as the common time reference. The time stamp definition of each message is specified specifically by each message standard.

The time service shall include a functionality to synchronize the time to the standardized TAI time. Different time augmentation data sources can be used for such synchronization, e.g. satellite based time augmentation, ground based time augmentation, etc. In case of non-synchronization, a time correction shall be applied.

The functional block diagram of the time service common facility is illustrated in figure 6.6.
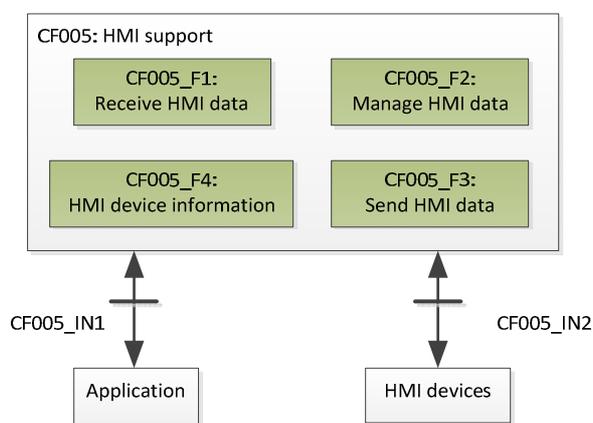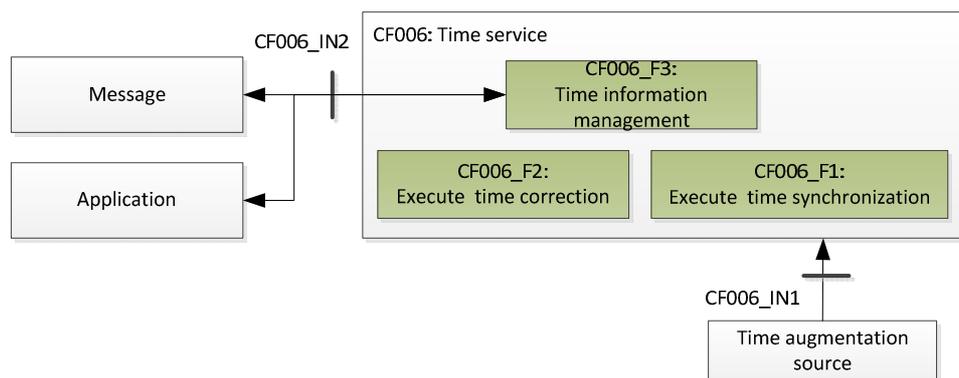

Figure 6.6: Block diagram: Time service

The functional requirements of this common facility are presented in table 6.11.

Table 6.11: Functional requirements: Time service

Functions	Requirement
[CF006_F1]:	This function shall execute the time synchronization to the TAI time with the time augmentation source when necessary.
[CF006_F2]:	This function shall execute the time correction in case of non-synchronization.
[CF006_F3]:	This function shall provide the time information to the required messages and applications.

The interfaces of this common facility are presented in table 6.12.

Table 6.12: Interfaces: Time service

Interface	Related component	Direction	Information exchanged over the interface
[CF006_IN1]	Time augmentation data e.g. satellite based time correction (may be implemented in an external system).	IN	Time augmentation data provided by the time augmentation source, this interface may be an external interface.
[CF006_IN2]	message facilities and/or applications.	OUT/IN	OUT: Time information. IN: Request of time information if necessary.

6.2.4 CF007: Application/facilities status management

This common facility manages a list of available applications and facilities in the ITS-S. It also keeps the corresponding configuration information for each ITS application and facility. This common facility also monitors the functioning status of the applications and facilities of the ITS-S. In case of the malfunction of an application or a facility, this common facility may notify the related applications/facilities or to the user of the malfunctioning.

Optionally, this common facility manages the ITS-S applications life cycle through downloading of new customer applications, up-grading or removing of existing applications. If the update of one application can be done remotely, services provisioning servers advertise the availability of new services which can be contracted/downloaded by ITS-S via the service announcement message (SAM). In a receiving ITS-S, the service management component of the management layer analyses the received SAM. The application layer, after a local dialogue with the user if necessary or based on pre-defined strategies, identifies the applications to be installed or updated. Then, the downloading of selected application software and associated data are achieved by the ITS-S which initiates a communication session with the service provisioning servers. Such downloading operation will lead to an updating of the information managed by the application management common facility.

The functional block diagram of the Application/facilities status management common facility is illustrated in figure 6.7.
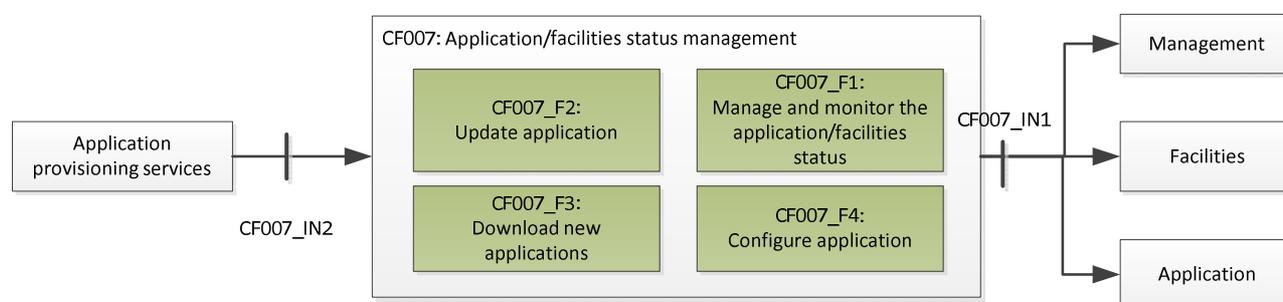
Figure 6.7: Block diagram: Application/facilities status management

The functional requirements of this common facility are presented in table 6.13.

Table 6.13: Functional requirements: Application/facilities status management

Functions	Requirement
[CF007_F1]:	This function shall maintain a list of available applications and facilities being activated in an ITS-S. It shall also monitor the functioning status of the application and facilities. The list of available applications and facilities may be extended and updated.
[CF007_F2]:	This function shall updates an application/facilities and their corresponding configuration provided by the application provisioning services, either from a local connection or remotely. This function is optional.
[CF007_F3]:	This function shall download new applications and facilities provided by the application provisioning services, either from a local connection or remotely. This function is optional.
[CF007_F4]:	This function shall configure the application, its related facilities and interfaces at the start up or updates of the applications and facilities.

The interfaces of this common facility are presented in table 6.14.

Table 6.14: Interfaces: Application/facilities status management

Interface	Related component	Direction	Information exchanged over the interface
[CF007_IN1]	Application/facilities/management	IN/OUT	Configuration data updates information.
[CF007_IN2]	Application provisioning service	IN	Data for the updates of an application and/or facilities, or data for the downloading of new application and/or new facilities. This interface may be an external interface.

6.2.5 CF008: Service announcement message (SAM) processing

This common facility supports the service management function of the management layer as specified in [i.4], it constructs and transmits the service announcement message (SAM) at the request of the ITS-S management layer, in order to announce the available user services as well as the communication access technology being used to access to the service. The SAM includes information of the provided service, the communication access technologies and other information that enables the access to the services. When the service management component in the management layer needs to send a SAM, it provides the SAM content data to the SAM processing facility which constructs a corresponding SAM and transmits it to the ITS networking and transport layer.

For a received SAM the SAM processing facility decodes the received SAM and provides the data to the management layer, which communicates with the corresponding applications in order to decide whether the service is interested by the ITS-S and/or users.

The functional block diagram of this common facility is illustrated in figure 6.8.
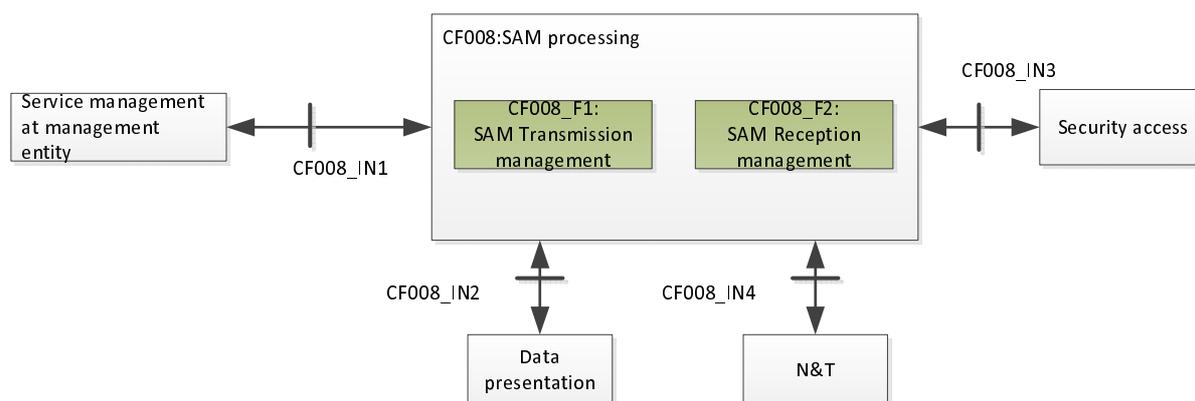
Figure 6.8: Block diagram: SAM processing

The functional requirements of this common facility are presented in table 6.15.

Table 6.15: Functional requirements: SAM processing

Functions	Requirement
[CF008_F1]:	This function shall execute the SAM transmission protocol under the request from management entity.
[CF008_F2]:	This function shall execute the SAM reception protocol and provide the content of the received SAM to the management layer.

The interfaces of this common facility are presented in table 6.16.

Table 6.16: Interfaces: SAM processing

Interface	Related component	Direction	Information exchanged over the interface
[CF008_IN1]	Service management of the management entity	IN/OUT	IN: Request to construct a SAM and the content of the message. OUT (to service management): content of the received SAM.
[CF008_IN2]	Data presentation	IN/OUT	Import the data presentation from the common data dictionary and message encoding/decoding support.
[CF008_IN3]	Security access	IN/OUT	SAM (sent and received) for security processing.
[CF008_IN4]	N&T	IN/OUT	OUT: SAM delivered to the ITS networking and transport layer for transmission. IN: SAM received from the ITS networking and transport layer.

6.3 Information support facilities functional requirements

6.3.1 CF009: Station type/capabilities

This common facility provides information to describe a profile of an ITS-S to be used in the applications and the facilities layer, in particular:

- The ITS-S type: vehicle ITS-S, road side ITS-S, personal ITS-S or central ITS-S.

- The role that is currently played by the ITS-S: operation status of an emergency vehicle and other prioritized vehicle, status of a dangerous goods transporting vehicle, etc.

- Detection capabilities and status e.g. positioning capability, sensing capabilities, etc. of the ITS-S. For the vehicle ITS-S, this common facility collects the in vehicle data from the in vehicle data gateway including the highly dynamic vehicle mobility information and the status of the in vehicle electronic systems; For the road side ITS-S, this common facility may receive from the road side equipment data gateway the real time road side sensor information and the equipment status information; For the central ITS-S, the capabilities information may refer to the controls means of an central ITS-S in order to control the road side equipment remotely e.g. centralized traffic light controllers, Variable Message sign, road side sensors, etc.

Each application may have its own specific requirements on the ITS-S station type, roles and capabilities in order to enable the application running. The same ITS-S may play different roles in different applications. For example, a moving road construction vehicle may be considered as a road side ITS-S in roadwork warning application, while in a forward collision warning application, it may be considered as a vehicle ITS-S. Furthermore, different applications may have different requirements to the capabilities, in order to ensure the required data quality. For example, the positioning accuracy is one of most important requirement for road safety applications.

It should be noted that station type/capabilities information may be dynamic and vary over space and over time. An example of such dynamism is that when personal ITS-S is located within a vehicle, it may be considered as a vehicle ITS-S under some conditions and participates to certain ITS applications as the vehicle ITS-S. Another example is that when a vehicle enters a tunnel, the position accuracy level may be reduced due to the loss of the satellite signal. Therefore, this common facility shall include functionality to monitor the status of the ITS-S and connected sensors.

An ITS-S should satisfy the specific requirements in order to be used as that station type in that specific application. These requirements can be security requirements, detection capacities, performance requirements, operational requirements or other requirements.

Furthermore, this common facility may also include a functionality to monitor the station status and detects abnormal station failures. It provides station state of the ITS-S and if available the status information of equipped sensors. For example, the sensor status information may be used to define the reliability level of the detected road hazard by an ITS-S application.

The functional block diagram of the common facility is illustrated in figure 6.9.
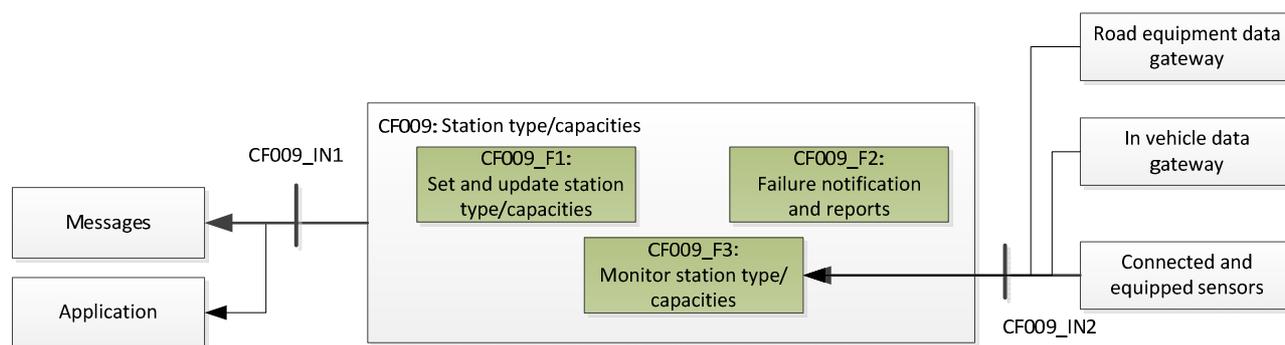

Figure 6.9: Block diagram: Station type/capabilities

The functional requirements of this common facility are presented in table 6.17.

Table 6.17: Functional requirements: Station type/capabilities

Functions	Requirement
[CF009_F1]:	This function shall update the station type/capacities information when necessary. It shall provide the relevant information of the station type/capacities to the applications and the facilities.
[CF009_F2]:	This function shall notify the failure and malfunctioning of the sensors or station type information to the applications and the facilities, either automatically when the failure is detected or under the request of the applications/facilities.
[CF009_F3]:	This function shall monitor the status and changes of the station type/capacities.

The interfaces of this common facility are presented in table 6.18.

Table 6.18: Interfaces: Station type/capabilities

Interface	Related component	Direction	Information exchanged over the interface
[CF009_IN1]	Application, message, other facilities	OUT	Station type/capacities information as needed for the facilities and applications.
[CF009_IN2]	Connected and equipped sensors of the ITS-S; in vehicle data gateway; road equipment data gateway.	IN	Sensors status information.

6.3.2 CF010: ITS-S positioning service

This common facility provides and updates the geographical positioning of an ITS-S in real time. Different technologies can be used to determine in real time the geographic position, with variable accuracy level. The Global Navigation Satellite System (GNSS) may be used as primary positioning means in the ITS co-operative system, in particular for the mobile ITS-Ss. The position accuracy and freshness is one of the key requirement for the road safety ITS applications. For example, the CA basic service requires that the positioning information of a vehicle ITS-S is able to be updated at high frequency e.g. 10 Hz. When the GNSS signal is not available or when GNSS position accuracy is not sufficient for the applications, some positioning augmentation technologies can be used to provide other information and data for the position augmentation, such as satellite based positioning augmentation (e.g. EGNOS) and ground based positioning augmentation (e.g. DGPS). For vehicle ITS-S, in vehicle sensor data may also be used to further improve the positioning accuracy information, e.g. the vehicle speed, vehicle heading, etc. A data fusion function can be used to fuse the data from different augmentation sources and obtain an increased accuracy and integrity information of the position. The ITS-S positioning facility also provides speed and heading information of the ITS-S in mobility. All above information is provided together with an accuracy level. Optionally, the ITS-S position may also be provided with integrity information, when required by an ITS application.

The functional block diagram of the common facility is illustrated in figure 6.10.

Figure 6.10: Block diagram: ITS-S positioning service

The functional requirements of this common facility are presented in table 6.19.

Table 6.19: Functional requirements: ITS-S positioning service

Functions	Description
[CF010_F1]:	This function shall calculate the ITS-S positioning in real time from the GNSS receiver or from a positioning system. When applicable, this functionality shall also calculate the speed and direction information of the ITS-S.
[CF010_F2]:	This function shall augment the position and velocity information based on the received ground based augmentation data. This function is optional.
[CF010_F3]:	This function shall augment the position and velocity information with the in-vehicle data or other sensors data connected to the ITS-S. This function is optional.
[CF010_F4]:	This function shall augment the position and velocity information based on the received satellite based augmentation data. This function is optional.
[CF010_F5]:	This function shall fuse the data of multiple augmentations and calculate a final position and related accuracy of the ITS-S.
[CF010_F6]:	This function shall check the integrity of the position and velocity information when required. This function is optional.

The interfaces of this common facility are presented in table 6.20.

Table 6.20: Interfaces: ITS-S positioning service

Interface	Related component	Direction	Information exchanged over the interface
[CF010_IN1]	GNSS receiver or other positioning means	IN	Positioning information as received from the GNSS receiver or other positioning means.
[CF010_IN2]	Station type/capabilities	IN	In vehicle data or other sensor information for the position augmentation.
[CF010_IN3]	Ground based augmentation data	IN	Data for the position augmentation sent from the ground based positioning augmentation service provider. This interface may be an external interface.
[CF010_IN4]	Satellite based augmentation data	IN	Data for the position augmentation sent from the satellite based positioning augmentation service provider. This interface may be an external interface.
[CF010_IN5]	Message; Application or other facilities	OUT	Position, speed, heading information, the accuracy and/or the integrity information.

6.3.3   CF011: Location referencing

This common facility provides location referencing information of a geographic location that allows the association of a geographical location with regards to road network and surrounding environment. Depending on the application requirement(s), the information needed for location referencing may vary in different levels of detail and levels of geographical extensions.

Multiple location referencing methodologies are available in ITS, e.g. TMC-LOC, ALERT-C, TPEG-LOC, etc. For interoperability purpose, a common location referencing definition and coding rule should be used by all ITS-Ss implementing the same sets of message protocols. For example for the DENM protocol as specified in [3], the "trace" location referencing is used. This location referencing provides a list of waypoint coordinates, along which the receiver ITS-S may encounter the event as informed by DENM. This location referencing allows different ITS-Ss receiving the DENM to reference the event position regardless of different map formats being used in the ITS-S and verify the relevance of the information to the receiving ITS-S.

This common facility generates the location referencing data as required by the application, according to the application requirements. Optionally, this common facility may be implemented at the applications layer.

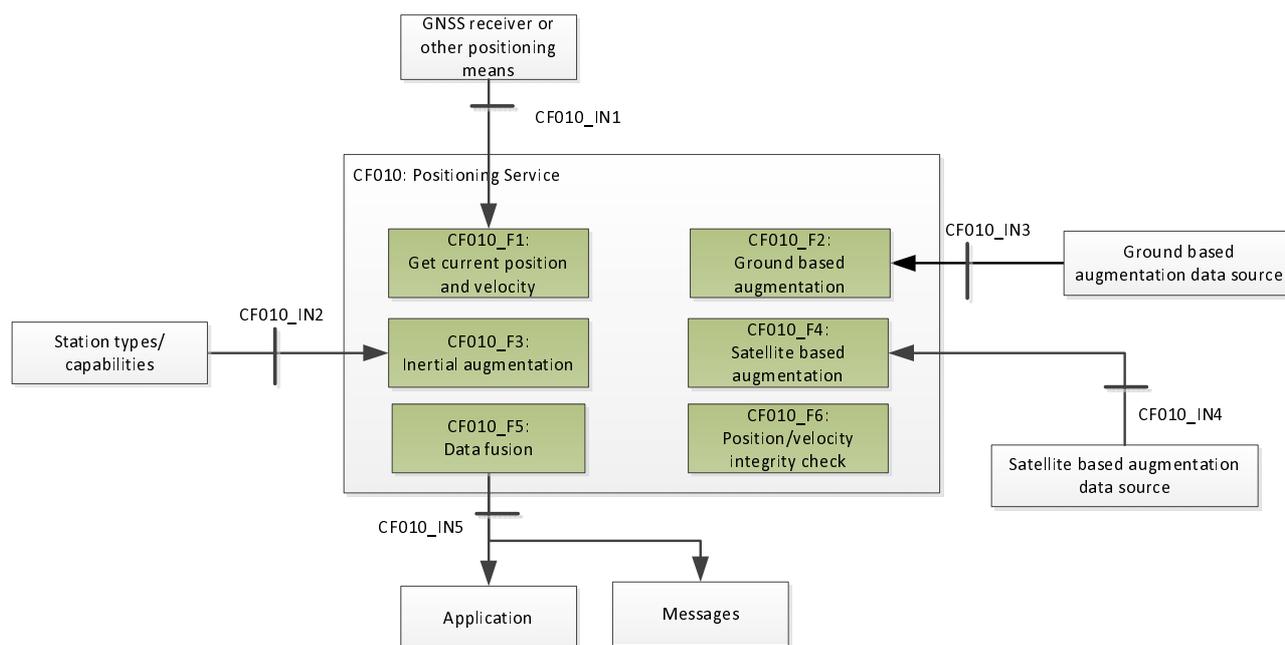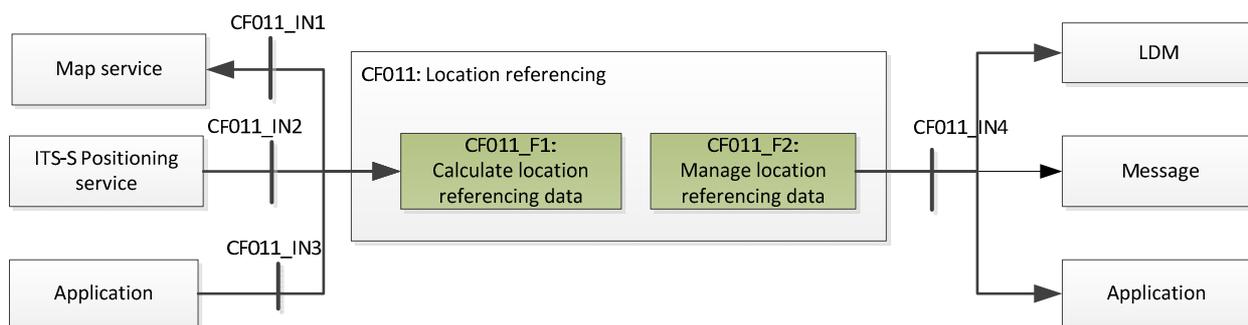The functional block diagram of the common facility is illustrated in figure 6.11.

Figure 6.11: Block diagram: Location Referencing

The functional requirements of this common facility are presented in table 6.21.

Table 6.21: Functional requirements: Location Referencing

Functions	Requirement
[CF011_F1]:	This function shall collect required data from other facilities and/or from applications for the calculation of the location referencing information. In particular, this function may receive request and requirements from the applications for the calculation of the location referencing. It may further interact with the station positioning management in order to obtain the current position of ITS-S if needed. This function may need to consult the map data base in order to calculate the location referencing data.
[CF011_F2]:	This function elaborates the location referencing data and provides them for the applications and facilities usage. In particular, it shall provide the information to the message, if the location referencing information is required to be included within the message e.g. DENM.

The interfaces of this common facility are presented in table 6.22.

Table 6.22: Interfaces: Location Referencing

Interface	Related component	Direction	Information exchanged over the interface
[CF011_IN1]	Map service	IN/OUT	Map database information used for the location referencing if the digital map is needed for the location referencing calculation.
[CF011_IN2]	Station positioning management	IN	ITS-S current position and velocity information.
[CF011_IN3]	Application	IN	Request of application and application requirements for the details and extensions of location referencing.
[CF011_IN4]	Message, applications, LDM or other facilities	OUT	Location referencing data as included in the message or needed by the applications and/or other facilities.

6.3.4   CF012: Common data dictionary

This common facility manages a common data dictionary for data elements being commonly used in the messages and/or by the ITS applications and facilities e.g. vehicle data, position data, time, location referencing data, road topology data, traffic regulation data, etc. The data dictionary may be organized in multiple classes depending to the type and source of the data. When new applications and messages are included in the ITS-S including new data, this data dictionary may be extended.

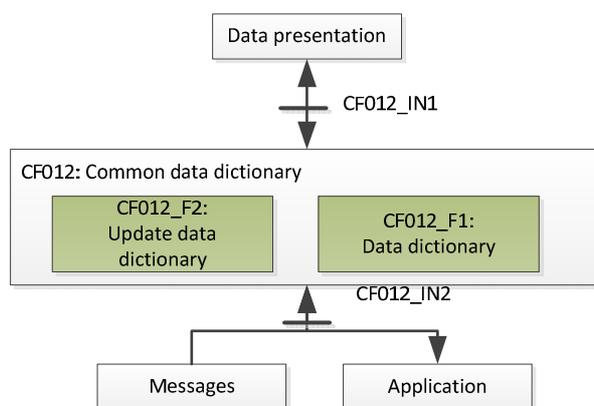The functional block diagram of the basic facility is illustrated in figure 6.12.

Figure 6.12: Block diagram: Data dictionary

The functional requirements of this common facility are presented in table 6.23.

Table 6.23: Functional requirements: Data dictionary

Functions	Requirement
[CF012_F1]:	This function shall maintain the list of data elements and data frames definition in the data dictionary.
[CF012_F2]:	This function shall update the data dictionary to include modification of exiting data elements/data frames or new data elements/data frames.

The interfaces of this common facility are presented in table 6.24.

Table 6.24: Interfaces: Data dictionary

Interface	Related component	Direction	Information exchanged over the interface
[CF012_IN1]	Applications, Messages, facilities	IN/OUT	IN: Update information. OUT: Data definition being used in the applications and/or in the facilities layer.
[CF012_IN2]	Data presentation	IN/OUT	Data elements syntax for data presentation.

6.3.5 CF013: Data presentation

This common facility provides encoding/decoding support for messages being exchanged between ITS-Ss and data exchanged within an ITS-S. The data presentation is based on the common data dictionary contained in the ITS-S. It formats or encrypts a messages with standardized syntax and semantics representations before transmitting the message payload to the ITS networking and transport layer. At the receiving side, this common facility provides supports to the corresponding facilities during the decoding of the message payload.

For messages CAM and DENM as specified in [2] and [3], ASN.1 unaligned PER encoding rules shall be used. For other applications, other formats such as XER may be used, for example for messages exchanged between road side ITS-S and central ITS-S and between two central ITS-Ss (e.g. DATEX II). If required for the data exchanged within the ITS-S, this common facility may also provide the encoding/decoding support.

The data presentation facility is interacting with data dictionary for the encoding and decoding of messages.

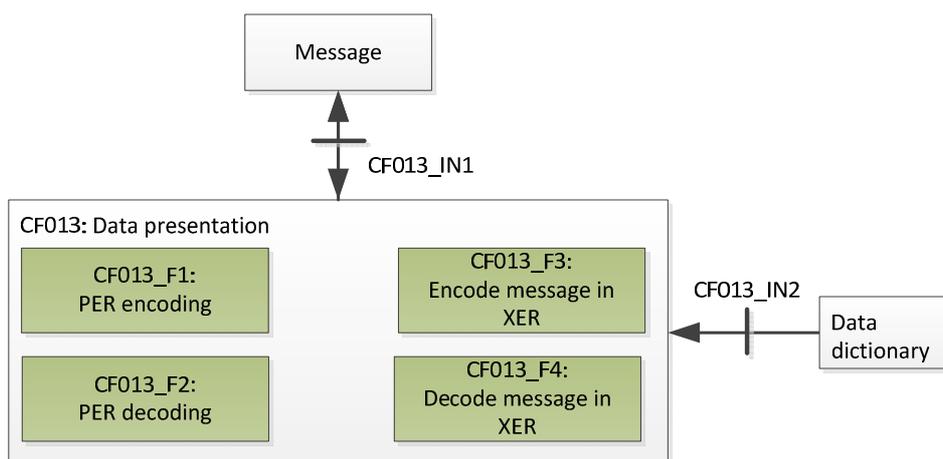The functional block diagram of the common facility is illustrated in figure 6.13.

Figure 6.13: Block diagram: Data presentation

The functional requirements of this common facility are presented in table 6.25.

Table 6.25: Functional requirements: Data presentation

Functions	Requirement
[CF013_F1]:	This function shall provide compiling functions for the encoding of message based on PER rules.
[CF013_F2]:	This function shall provide compiling functions for the decoding of message based on PER rules.
[CF013_F3]:	This function shall provide compiling functions for the encoding of message based on XER rules.
[CF013_F4]:	This function shall provide compiling functions for the decoding of message based on XER rules.

The interfaces of this common facility are presented in table 6.26.

Table 6.26: Interfaces: Data presentation

Interface	Related component	Direction	Information exchanged over the interface
[CF013_IN1]	Message	IN/OUT	Data for the encoding and decoding of the messages.
[CF013_IN2]	Data dictionary	IN	Data definition required for the encoding and decoding.

6.4 Communication support facilities functional requirements

6.4.1 CF014: Addressing mode

This common facility determines the addressing mode for messages that need to be transmitted from the ITS-S according to the dissemination destination as required by the messages. Depending on the use case requirements as defined in the BSA [i.1], dissemination destination of a message may be:

- a geographic area;

- ITS-Ss with specific network address;

- ITS-Ss with specific IDs;

- ITS-Ss bearing specific user profiles; or

- ITS-Ss with combinations of some of above descriptions.

For each of the destination type, information provided from the addressing mode facility to the ITS networking and transport layer shall allow receivers to reconstruct the destination area for relevance checks. Standardized description method needs to be defined in order to ensure the interoperability. The addressing mode facility shall provide the destination information to the ITS networking and transport layer as compliant to the information being used by the ITS networking and transport layer protocol. In case that the destination information provided by the application is not compliant to the ITS networking and transport layer destination area description, the addressing mode facility shall include a functionality to convert to the data as required by the ITS networking and transport layer.

Furthermore, addressing mode shall determine the dissemination mode being used by the ITS networking and transport layer protocol, such as point to point, point to multi point.

All above addressing mode information shall be provided to the ITS networking and transport layer via the NF-SAP. If required, it shall provide other data required by the ITS networking and transport layer, e.g. the traffic class of the message, the transmission interval, etc.

The above mentioned data may be provided to the management layer, which selects the appropriate communication protocol stack for the communication.

The functional block diagram of the common facility is illustrated in figure 6.14.
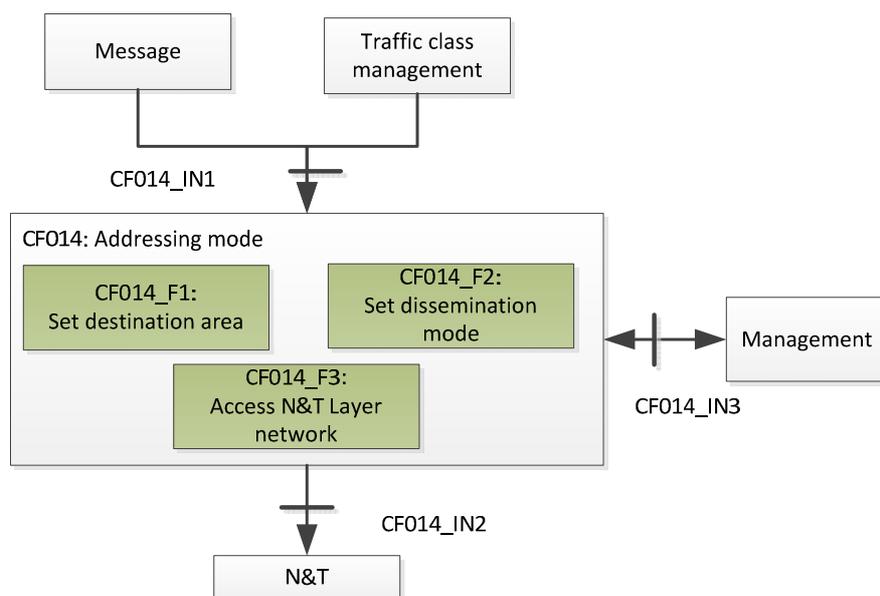
Figure 6.14: Block diagram: Addressing mode

The functional requirements of this common facility are presented in table 6.27.

Table 6.27: Functional requirements: Addressing mode

Functions	Description
[CF014_F1]:	This function shall determine the destination information for a message.
[CF014_F2]:	This function shall determine the dissemination mode for a message.
[CF014_F3]:	This function shall provide access to the Networking and Transport layer and provide the data of the destination, the dissemination mode as well as related data.

The interfaces of this common facility are presented in table 6.28.

Table 6.28: Interfaces: Addressing mode

Interface	Related component	Direction	Information exchanged over the interface
[CF014_IN1]	Message; traffic class management	IN	Destination and dissemination mode of the message, traffic class of the message.
[CF014_IN2]	N&T	OUT	Data required by the ITS N&T layer for the message dissemination.
[CF014_IN3]	Management	IN/OUT	Data required by the management entity and data provided by the management entity.

6.4.2 CF015: Congestion control

The common facility includes the decentralized congestion control (DCC) functionalities of the facilities layer. It interacts with the management entity and contributes to the overall ITS-S congestion control functionalities. Various methods may be used at the facilities and applications layer for reducing at the number of generated messages based on the congestion level. Among them following methods may be used:

- To adjust the message transmission interval in order to reduce the number of messages sent to the network. An ITS application may have specific requirements of the message transmission frequency. The DCC of the facilities layer should take into account the application requirements.

- To control the re-forwarding of the messages within the congestion situation. As specified in DEN basic service [3], a facilities layer keep-alive function may be used to forward a received DENM within an area and within a validity time, in order to maintain the DENM dissemination in case that the originator transmitting ITS-S has lost the capacity of transmission in an unexpected manner. According to the congestion level, the DCC of the facilities layer may deactivate this facilities layer forwarding functionality.

- To aggregates the received messages during the forwarding. If multiple messages generated by different ITS-Ss are duplicating with other others, the ITS applications or facilities may aggregate the duplicate message and keep the most updated or reliable messages for the forwarding. This function (referred as Information Centric Forwarding) may reduce the number of messages transmitted and forwarded within the ITS network.

The DCC at the facilities layer may interact with the DCC functionalities of other layers in order to take appropriate actions according to the congestion level and to satisfy the application requirements. The DCC common facilities shall receive from the management entity the congestion status information of the ITS networks, and accordingly select an appropriate DCC mechanism for the message transmission and forwarding.

The functional block diagram of the common facility is illustrated in figure 6.15.

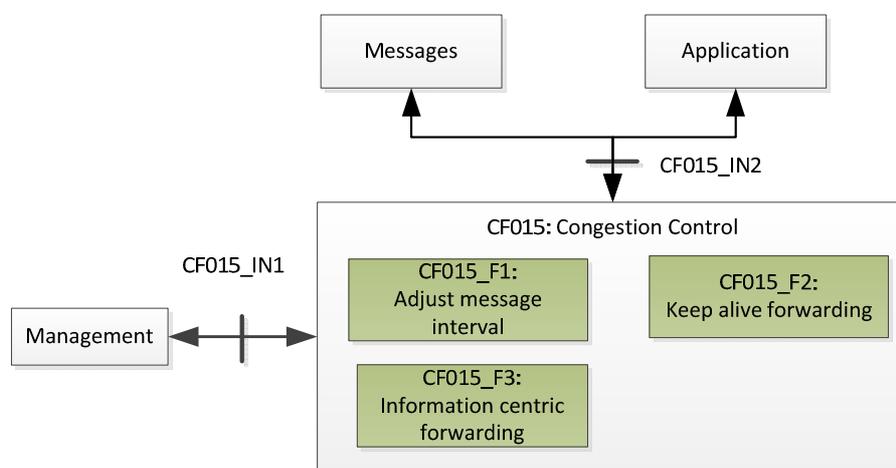NOTE: The indicated functions are provided as example.

Figure 6.15: Block diagram: Congestion control

The functional requirements of this common facility are presented in table 6.29.

Table 6.29: Functional requirements: Congestion control

Functions	Requirement
[CF015_F1]:	This function shall adjust the message transmission frequency for the applications and facilities layer messages. It may apply to a specific message transmission under predefined rules of the DCC.
[CF015_F2]:	This function shall execute the keep alive functionality of messages. It may apply to a specific message transmission under predefined rules of the DCC.
[CF015_F3]:	This function shall execute the information centric forwarding function for messages. It may apply to a specific message transmission under predefined rules of the DCC.

The interfaces of this common facility are presented in table 6.30.

Table 6.30: Interfaces: Congestion control

Interface	Related component	Direction	Information exchanged over the interface
[CF016_IN1]	Message and applications	IN/OUT	IN: Data required by the DCC functionalities from the messages e.g. requirements, traffic class, etc. OUT: Data related to the messages transmissions according to the applied DCC mechanism.
[CF016_IN2]	Management	IN/OUT	IN: Network congestion status and other cross layer data needed by the congestion control mechanism; OUT: Data required by the management layer.

7   Domain facilities functional requirements

Domain facilities provide services and functionalities for one or several BSA applications or for one or several ITS-S types. A domain facilities may become optional for other ITS applications and other ITS-S types.

For the usage in the present document, each domain facility is assigned with a unique number DF#, also illustrated in table 5.2. For each facility, a set of sub function and interfaces are defined. Each function is denoted by an identifier [DF#_F#] where DF# indicates the ID of the domain facility, F# indicates a sequence number of the function. Each interface is also denoted by an identifier [DF#_IN#] where DF# indicates the ID of the domain facility, IN# indicates a sequence number of the interface.

For illustration purpose, a block diagram is defined for each domain facility. This block diagram summarizes the main functionalities of the facility and logical connections with other facilities of the facilities layer and/or with other layers of the ITS-S, illustrated as external components in the block diagram. For simplicity reason, any external component if not referred as one of the facilities defined in the present document, the following external components are defined for illustration:

- N&T: it corresponds to the ITS networking and transport layer as defined in [1].

- Management: it corresponds to the ITS management entity as defined in [1].

- Security: it corresponds to the ITS security entity as defined in [1].

- ITS application: it corresponds to the ITS application layer as defined in [1].

- Messages: it corresponds to any facility that manages the facilities layer or ITS application layer PDU, such as CA basic service, DEN basic service, etc.

- Other external components as defined in corresponding facility.

7.1   Application support facilities functional requirements

7.1.1   DF001: DEN basic service

This domain facility executes the Decentralized Environmental Notification Message (DENM) protocol and provides management support of DENMs. The DENM protocol is used mainly by the Cooperative Road Hazard Warning applications as defined in BSA [i.1] in order to inform a detected event on the roads to approaching vehicles and to road users. A DENM is originated by an ITS-S upon detection of an event. The application provides data about attributes of the detected event, e.g. event type, event duration, destination area of the DENM dissemination, etc. to the DEN basic service domain facility via an application request. The DEN basic service shall constructs a DENM as specified in [3] and sends the message as payload to the ITS networking and transport layer via the NF-SAP.

Typically, a detected event is characterized by its position, an event type, and duration. An event may be evolving over space and over time. Therefore, the applications of the ITS-S may request to send updated DENMs in order to indicate the evolution and the termination of the event. Consequently, the DENM protocol shall include functions to construct updated DENMs as specified in [3].

At receiving side, the DENM protocol includes the discarding of outdated DENMs and optionally the keep alive function as mentioned in clause 6.4.2. The received event information is provided to ITS applications, either directly via an application programming interface (API) or via a common database (Local Dynamic Map). Due to the high mobility and the dynamics of the vehicle ITS-Ss, the originated ITS-S may either leave the originated position or lose the capacity to transmit DENM related to the events. An ITS-S may forward a DENM within the destination area as long as the DENM is still valid. For some applications, an ITS-S that triggers a DENM may be different from the ITS-S that informs the termination of the event, in case the ITS-S that triggered the DENM has left or have lost the capability itself. The DENM protocol shall support the above mentioned situations.

DENM protocol shall be as specified in [3].

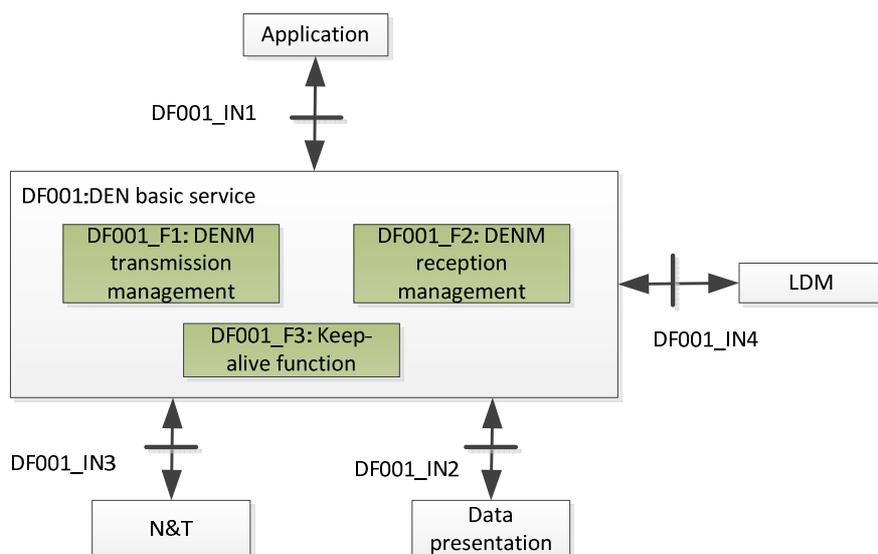The functional block diagram of the basic facility is illustrated in figure 7.1.

Figure 7.1: Block diagram: DEN basic service

The functional requirements of this domain facility are presented in table 7.1.

Table 7.1: Functional requirements: DEN basic service

Functions	Requirement
[DF001_F1]:	This function shall execute the DENM transmission protocol. It constructs a DENM when receiving a request from application, and initiates the DENM transmission. The construction of the DENM shall be supported by the data presentation facility as specified in clause 6.2.5. The DENM format shall be as specified in [3]. The DENM transmission protocol shall include functionalities to enable the DENM initiation, DENM updates and DENM termination from originator ITS-S.
[DF001_F2]:	This function shall execute the DENM reception protocol. It decodes a received DENM, manages its life time according to a validity time and provides the DENM content to the applications and/or to the LDM when requested. The DENM reception protocol shall include functionalities to discard the outdated DENM and to provide the update DENM content to the ITS applications.
[DF001_F3]:	This function shall execute a "keep-alive function" as defined in clause 6.4.2 in order to maintain forwarding of a DENM which is still valid within a specific area and specific duration. This function is optional.

The interfaces of this domain facility are presented in table 7.2.

Table 7.2: Interfaces: Congestion control

Interface	Related component	Direction	Information exchanged over the interface
[DF001_IN1]	Application; LDM or other facilities	IN/OUT	IN: Request from application for the transmission of new DENM, updated DENM or DENM termination, together with the data related to the detected event and the DENM dissemination requirements. OUT: Content of the received DENM.
[DF001_IN2]	Data presentation	IN/OUT	Data required for the DENM encoding/decoding, as supported by the data presentation common facility.
[DF001_IN3]	ITS networking and transport layer	IN/OUT	IN: Received DENM payload delivered from the N&T layer to the DEN basic service. OUT: DENM payload delivered from the DEN basic service to the N&T layer for DENM transmission.
[DF001_IN4]	LDM or other facilities	OUT	Content of the received DENM.

7.1.2   DF002: CA basic service

The Cooperative Awareness (CA) basic service is a facilities layer entity that provides functions for the management of the facilities layer heartbeat messages i.e. cooperative awareness messages (CAM). It operates the CAM protocol. In BSA, this common facility is relevant to vehicle ITS-S and road side ITS-S. It is expected that other ITS-S may transmit the CAM in the future.

The CA basic service is in charge of constructing and transmitting CAM at a variable interval. For this purpose, the CA basic service interfaces with other facilities in order to collect required data for the CAM construction. For the received CAM, the CA basic service decodes the received CAMs and provides the received information to a facilities layer database Local Dynamic Map (LDM) and/or to the ITS application. The CAM is a heartbeat message of the facilities layer with a transmission interval varying between several hundred milliseconds to one second. This frequency may be adjusted according to the application requirements and/or the network congestion level. For this purpose, interfaces with the application and the management layer may be needed.

The CA basic service shall be as specified in [2].

The functional block diagram of the CA basic service common facility is illustrated in figure 7.2.

Figure 7.2: Block diagram: CA basic service

The functional requirements of this common facility are presented in table 7.3.

Table 7.3: Functional requirements: CA basic service

Functions	Requirement
[DF002_F1]:	This function shall collect data required to construct a CAM. The CAM format shall be as specified in [2].
[DF002_F2]:	This function shall manage the CAM transmission frequency according to the congestion level.
[DF002_F3]:	This function shall operate the CAM originator protocol and transmit the CAM to the networking and transport layer.
[DF002_F4]:	This function shall operate the CAM receiver protocol and process the received CAMs.

The interfaces of this common facility are presented in table 7.4.

Table 7.4: Interfaces: CAM basic service

Interface	Related component	Direction	Information exchanged over the interface
[DF002_IN1]	Station type/capacities; AID management; Position and time management; ITS-S ID management;	IN	Data required for the construction of CAM: • Station type; • In vehicle data (for vehicle CAM); • AID information of CAM; • Current position and time information of the ITS-S; • ITS-S ID information; • Other information included in CAM as specified in [2].
[DF002_IN2]	Data presentation	IN/OUT	Data presentation and message encoding/decoding support.
[DF002_IN3]	N&T	IN/OUT	OUT: CAM delivered to Networking and Transport layer for transmission. IN: Received CAM delivered by the Networking and Transport layer.
[DF002_IN4]	LDM	OUT	Content of the received CAMs to the LDM.
[DF002_IN5]	Application	IN/OUT	IN: Application requirements, if applicable. OUT: Content of the received CAMs to the LDM and/or to the application.
[DF002_IN6]	Management	IN/OUT	Data required by the management layer and/or information of the congestion level.

7.1.3   DF003: Extended vehicle floating car data (EFCD)

This domain facility enables road side ITS-S, vehicle ITS-S or personal ITS-S to assist the road traffic management applications. Vehicle ITS-S or personal ITS-S transmits CAM periodically and DENM when a specific event is detected. These two messages contain information that may be useful for the traffic management. CAM and DENM may be transmitted to road operator, either directly from vehicle or via a road side ITS-S. CAM, DENM data provided by vehicle ITS-S can be considered as an extension of the Floating car data (FCD). Due to the large amount of the data being transmitted (e.g. CAM and DENM are transmitted at a high frequency varying from 0,5 Hz to 10 Hz), this domain facility may collect, aggregate the data before transmitting to road operator. As example, the road side ITS-S may calculate the average travel time based on the position and time data in received CAMs from vehicle ITS-S. Then the road side ITS-S transmit the aggregated travel time data to TMC using a specific message format such as DATEX II message [i.3].

This domain facility includes functionalities to collect the received messages, process the data into aggregated information and transmission of the aggregated information according to the needs of the traffic management. These needs (e.g. data to be provided, transmission interval of the data report) may be set by a central ITS-S.

The functional block diagram of the basic facility is illustrated in figure 7.3.

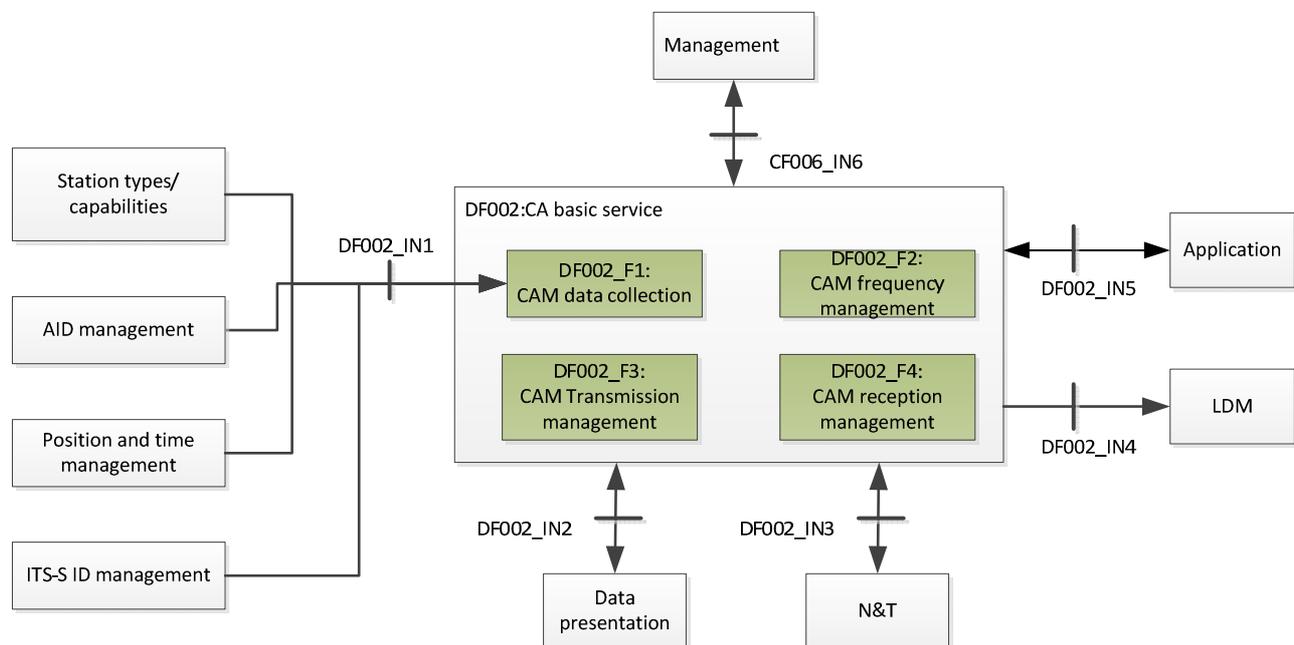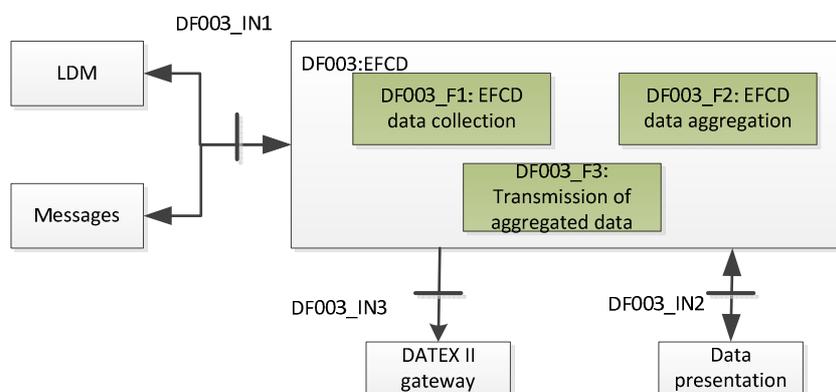**Figure 7.3: Block diagram: EFCD**

The functional requirements of this domain facility are presented in table 7.5.

Table 7.5: Functional requirements: EFCD

Functions	Description
[DF003_F1]:	This function shall collect the CAM, DENM or other messages from mobile ITS-Ss. It may collect these data from the LDM which stores the received CAM, DENM information or directly from the messages.
[DF003_F2]:	This function shall process and aggregate the collected data, as required by the traffic management operator.
[DF003_F3]:	This function shall transmit the aggregated data to the central ITS-S via e.g. the DATEX II gateway, with a required frequency or upon request from the central ITS-S.

The interfaces of this domain facility are presented in table 7.6.

Table 7.6: Interfaces: Congestion control

Interface	Related component	Direction	Information exchanged over the interface
[DF003_IN1]	LDM; messages	IN	Data received from mobile ITS-Ss via the messages.
[DF003_IN2]	Data presentation	IN/OUT	Data required for encoding of messages sent to the central ITS-S.
[DF003_IN3]	DATEX II gateway	IN/OUT	IN: Rules and requirements for data aggregation. OUT: Transmission of aggregated data in the format of e.g. DATEX II.

7.1.4 DF004: Billing and payment

This domain facility is relevant for applications requiring billing and payment. It provides billing and payment functionality for services that require payment. This facility establishes connections with back end actors that operate, handle and confirm billing as required by the applications. In a possible implementation of ITS-S, the billing and payment services can be provided by a specific billing/payment application (probably already implemented in an existing system external to the ITS-S. This domain facility should provide an interface to this billing/payment application. If an interaction with client is required by the billing process, such as confirmation of the payment information, confirmation of the user identifier, etc. this domain facility may sends and receives data to the HMI support common facility, as defined in clause 6.2.1.

Billing and payment requires high security and privacy protection, therefore, this domain facility shall have an interface to the security entity via the security access facility as defined in clause 6.1.4.

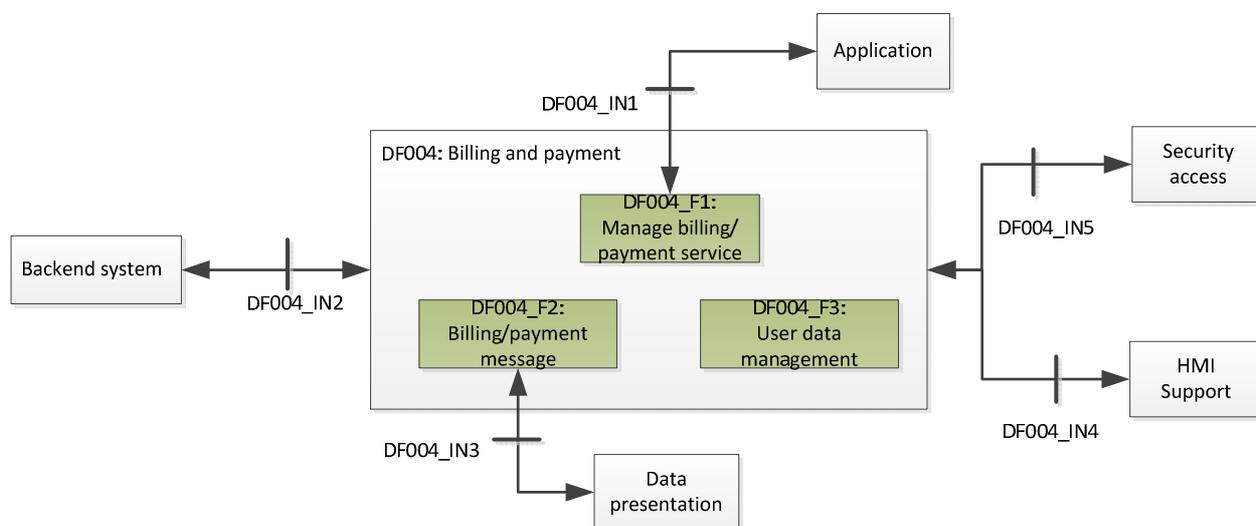The functional block diagram of this domain facility is illustrated in figure 7.4.

Figure 7.4: Block diagram: Billing and payment

The functional requirements of this domain facility are presented in table 7.7.

Table 7.7: Functional requirements: Billing and payment

Functions	Requirement
[DF004_F1]:	This function shall interact with application in order to initiate, and to terminate the process of the billing and payment.
[DF004_F2]:	This function shall generate and transmit billing/payment messages as required by the ITS application. It shall manage the received messages regarding the billing/payment messages and provide the information to the application.
[DF004_F3]:	This function manages the user data required for the billing/payment.

The interfaces of this domain facility are presented in table 7.8.

Table 7.8: Interfaces: Billing and payment

Interface	Related component	Direction	Information exchanged over the interface
[DF004_IN1]	Application	IN/OUT	Data exchanged with application for the initiation, management and termination of the billing/payment.
[DF004_IN2]	Back end system	IN/OUT	Communication with back end system for the billing/payment process. This interface is an external interface.
[DF004_IN3]	Data presentation	IN/OUT	Data required for the encoding/decoding of messages.
[DF004_IN4]	HMI support	IN/OUT	Data required to interact with end user for the billing/payment process if necessary.
[DF004_IN5]	Security access	IN/OUT	Data exchanged for the security processing of billing/payment data.

7.1.5 DF005: Traffic light phase and timing basic service (SPAT basic service)

This domain facility is relevant to the ITS applications that need information about the traffic light phase and timing information at the intersections equipped with a traffic light. A road side ITS-S may transmit the current and planned traffic phase and timing information to the approaching vehicle ITS-Ss via a standardized Signal Phase and Timing Message (SPAT). At vehicle ITS-S that receives the SPAT message, this domain facility decodes the SPAT messages and provides the information to the applications, in order to support vehicle ITS-S in certain intersection safety applications or green light speed advisory applications as specified in [i.6]. Therefore, this domain facility may be implemented at road side ITS-S and at vehicle ITS-S. It shall including functionalities to construct, transmit and receive the SPAT message.

In order to receive traffic light phase and timing information, the road side ITS-S shall be connected with the traffic light controller system. This connection may be realized by the road side equipment gateway implemented at the road side ITS-S as defined in clause 5.1.3. Specific national or international standards may needs to be considered to develop this gateway.

At receiving ITS-S, the received SPAT information should be matched to the intersection topology in order to correctly understand to which road section or lane section that the traffic light phase and timing is relevant. The intersection topology information may either be transmitted by the road side ITS-S in a road topology message (TOPO message).

In a potential deployment scenario, a road side ITS-S may first announce the availability of the SPAT information via a service announcement message (SAM) as defined in clause 6.2.5. At receiving side, the receiving ITS-S needs to interact with the management layer, in order to set the receiving ITS-S to the proper conditions for the SPAT reception (e.g. the communication protocol and access technology being used by the road side ITS-S to transmit the SPAT message).

NOTE: The TOPO domain facility is defined in clause 7.1.6.

The functional block diagram of this domain facility is illustrated in figure 7.5.
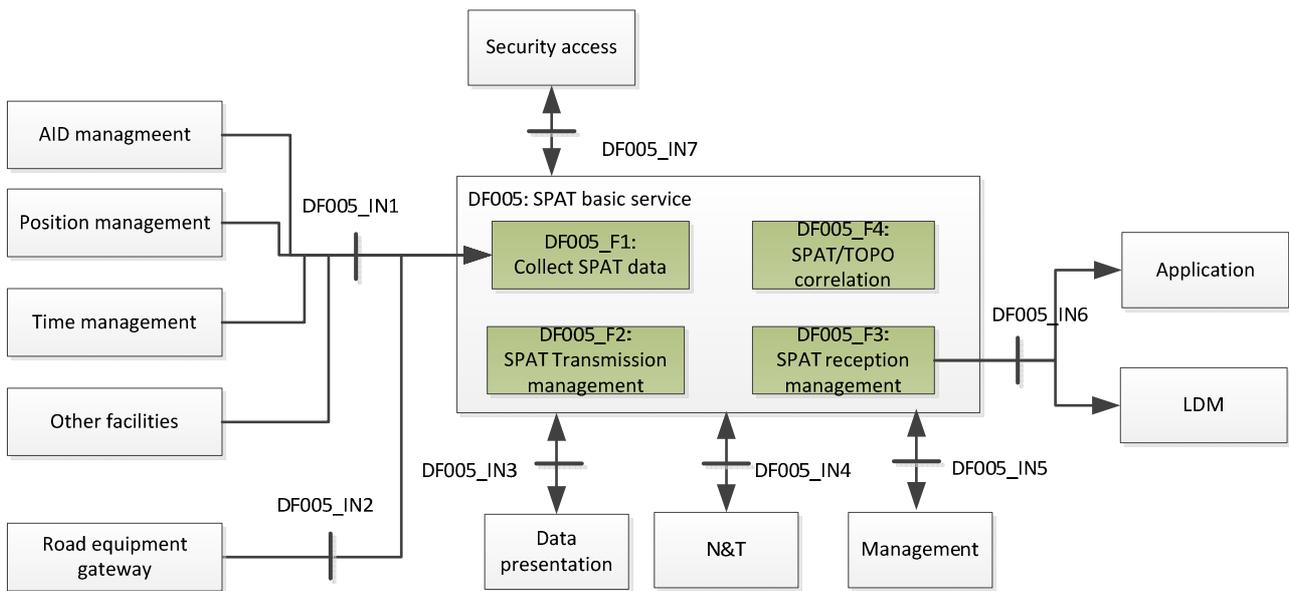

Figure 7.5: Block diagram: SPAT basic service

The functional requirements of this domain facility are presented in table 7.9.

Table 7.9: Functional requirements: SPAT basic service

Functions	Requirement
[DF005_F1]:	This function shall collect traffic light phase and timing data from the traffic light controller via the road equipment gateway, and other data needed for the construction of SPAT messages from corresponding facilities. This function applies to the road side ITS-S.
[DF005_F2]:	This function shall execute the SPAT transmission protocol. It constructs a SPAT message and transmits the constructed SPAT as scheduled by the SPAT transmission protocol. This function applies to the road side ITS-S.
[DF005_F3]:	This function shall execute the SPAT reception protocol. It receives a SPAT message and provides the content of the SPAT message to the ITS applications. This function applies to the vehicle ITS-S.
[DF005_F4]:	This function shall correlate the received signal phase and timing information to the intersection topology. This function applies to the vehicle ITS-S.

The interfaces of this domain facility are presented in table 7.10.

Table 7.10: Interfaces: SPAT basic service

Interface	Related component	Direction	Information exchanged over the interface
[DF005_IN1]	ITS-S ID management; AID management; position management; time management and/or other facilities	IN	Data required for the construction of the SPAT message.
[DF005_IN2]	road equipment gateway	IN	Real time signal phase and timing information provided by the traffic light controller system.
[DF005_IN3]	Data presentation	IN/OUT	Data required for the encoding/decoding of the SPAT message.
[DF005_IN4]	N&T	IN/OUT	SPAT for transmission or received SPAT.
[DF005_IN5]	Service Management	IN/OUT	IN: Indication of the availability of SPAT service. OUT: Data required by the service management.
[DF005_IN6]	Application; LDM	OUT	Received SPAT data.
[DF005_IN7]	Security access	IN/OUT	Data required for the SPAT security processing.

7.1.6   DF006: Road topology basic service (TOPO basic service)

This domain facility is relevant to the ITS applications that rely on a service provided from road side to inform the local road topology. As example, when the road side ITS-S transmits the SPAT message to the approaching vehicle ITS-S. It may furthermore transmit the TOPO message as well, in order to ensure that the receiving ITS-S is able to correlate the SPAT data corresponding to the road topology.

However, the TOPO message may be used in other ITS-S applications not only in the traffic light equipped intersection area. For example, a road side ITS-S may transmit a TOPO message in order to inform the road users of a dangerous curve. This domain facility may be implemented at road side ITS-S and at vehicle ITS-S. It shall including functionalities to construct, transmit and receive the TOPO message.

In other to overcome the issue of different map format being used in different ITS-Ss, a TOPO message may be defined with a format that is independent to a specific map or to a specific map provider (e.g. using the geographic coordinates to describe the road topology).

In a potential deployment scenario, a road side ITS-S may first announce the availability of the TOPO information via a service announcement message (SAM) as defined in clause 6.2.5. At receiving side, the receiving ITS-S needs to interact with the management entity, in order to set the receiving ITS-S to the proper conditions for the TOPO message reception (e.g. the communication stack and access technology being used by the road side ITS-S to transmit the TOPO message).

The functional block diagram of this domain facility is illustrated in figure 7.6.
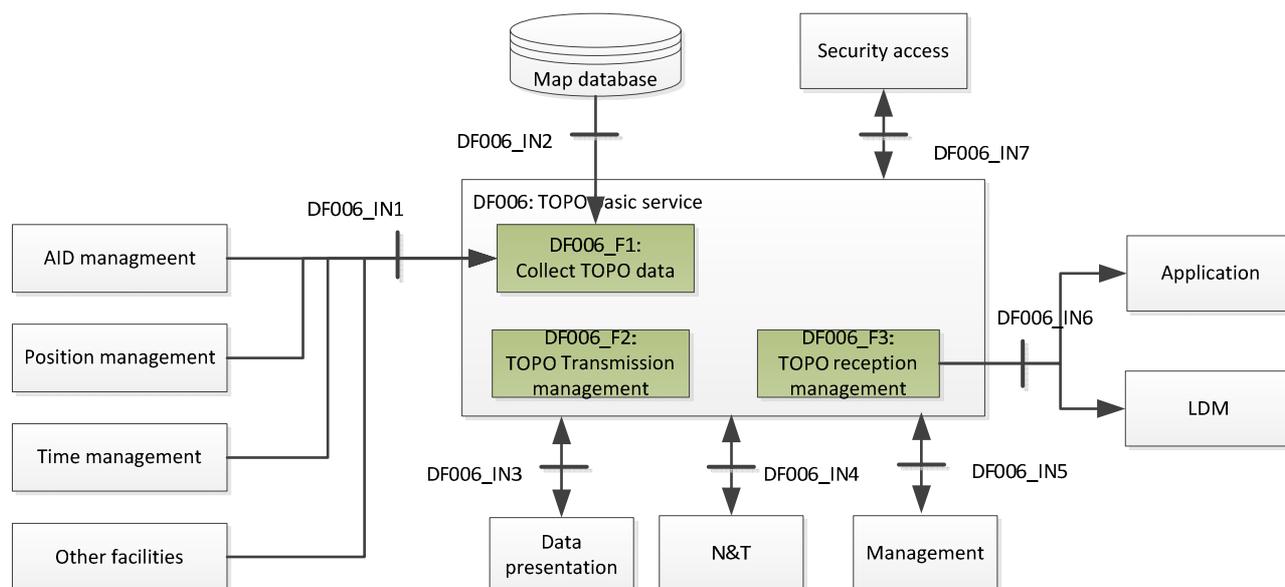

Figure 7.6: Block diagram: TOPO basic service

The functional requirements of this domain facility are presented in table 7.11.

Table 7.11: Functional requirements: TOPO basic service

Functions	Description
[DF006_F1]:	This function shall collect data needed for the construction of TOPO messages from the map data base and from the corresponding facilities. This function applies to the road side ITS-S.
[DF006_F2]:	This function shall execute the TOPO transmission protocol. It constructs a TOPO message and transmits the constructed TOPO as scheduled by the transmission protocol. This function applies to the road side ITS-S.
[DF006_F3]:	This function shall execute the TOPO reception protocol. It receives a TOPO message and provides the content to the ITS applications and facilities that requesting the data. This function applies to the vehicle ITS-S.

The interfaces of this domain facility are presented in table 7.12.

Table 7.12: Interfaces: TOPO basic service

Interface	Related component	Direction	Information exchanged over the interface
[DF006_IN1]	ITS-S ID management; AID management; position management; time management and/or other facilities	IN	Data required for the construction of the TOPO message.
[DF006_IN2]	Map database	IN	IN: Road topology information.
[DF006_IN3]	Data presentation	IN/OUT	Data required for the encoding/decoding of the TOPO message.
[DF006_IN4]	N&T	IN/OUT	IN: Received TOPO from ITS networking and transport layer. OUT: TOPO for transmission by ITS networking and transport layer.
[DF006_IN5]	Management	IN/OUT	IN: Indication of the availability of TOPO service. OUT: Data required by the management.
[DF006_IN6]	Application; LDM	OUT	Received TOPO data.
[DF006_IN7]	Security access	IN/OUT	Data required for the TOPO security processing.

7.1.7   DF007: In vehicle signage basic service (IVS basic service)

This domain facility is relevant to the ITS applications that rely on a service provided from road side ITS-S or central ITS-S, to inform the road side signage information to the road users via the wireless communications. The road side signage information may include the static road signage information such as speed limit, school zone, crossing priority, etc. and the dynamic information such as information provided by the Variable Message Sign.

Road side ITS-S obtains the road signage information via the road equipment gateway or from a static configuration of the application (for static road signage). In case that the road signage information is provided by a central ITS, for example a traffic management operator manages the VMS information in real time. The central ITS-S may provide directly the information to the road side ITS-S via DATEX II gateway. Alternatively, the IVS information may be provided directly from the central ITS-S to vehicle ITS-S.

This domain facility constructs an IVS message with the obtained road signage information and transmits the IVS message to the approaching mobile ITS-Ss (vehicle ITS-S or personal ITS-S). The IVS basic service of the receiving ITS-S side receives the message and provide the content to an ITS applications. This application may check the relevance of the information and present the information to the user when necessary. This information may be used to assist the navigation service provided to the road user.

In a potential deployment scenario, a road side ITS-S may first announce the availability of the IVS information via a service announcement message (SAM) as defined in clause 6.2.5. At receiving side, the receiving ITS-S needs to interact with the management layer, in order to set the receiving ITS-S to the proper conditions for the IVS message reception (e.g. the correct communication stack and access technology being used by the road side ITS-S to transmit the IVS message).

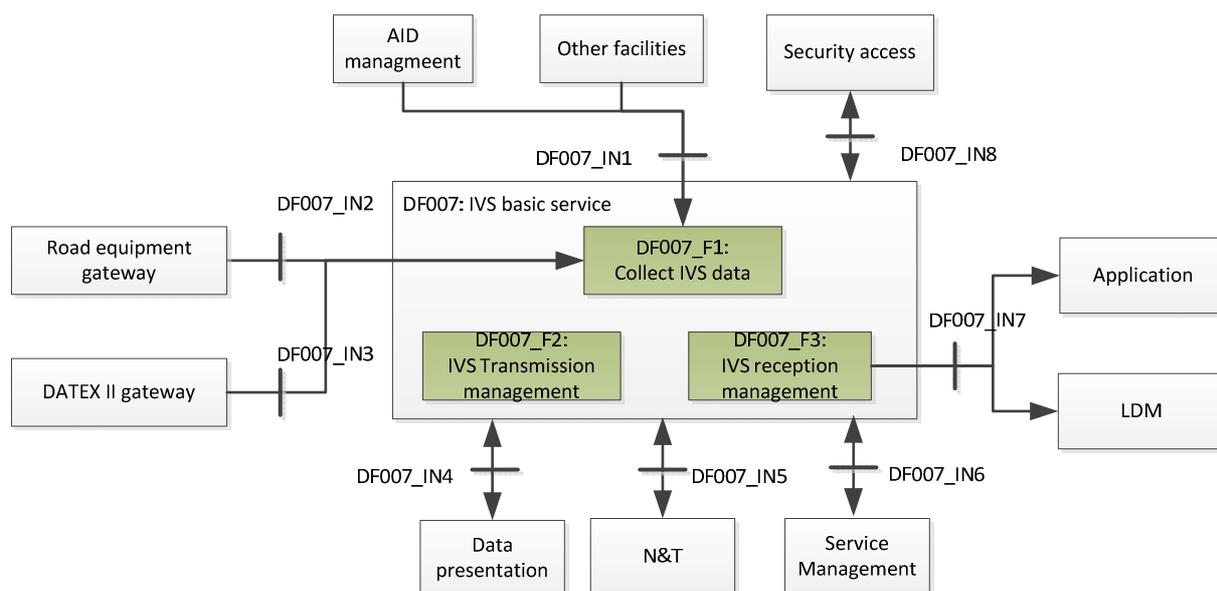The functional block diagram of this domain facility is illustrated in figure 7.7.

Figure 7.7: Block diagram: IVS basic service

The functional requirements of this domain facility are presented in table 7.13.

Table 7.13: Functional requirements: IVS basic service

Functions	Description
[DF007_F1]:	This function shall collect data needed for the construction of IVS messages from gateways and from the corresponding facilities. This function applies to the road side ITS-S or to the central ITS-S.
[DF007_F2]:	This function shall execute the IVS transmission protocol. It constructs an IVS message and transmits the constructed IVS as scheduled by the transmission protocol. This function applies to the road side ITS-S or to the central ITS-S.
[DF007_F3]:	This function shall execute the IVS reception protocol. It receives an IVS message and provides the content to the ITS applications. This function applies to the vehicle ITS-S.

The interfaces of this domain facility are presented in table 7.14.

Table 7.14: Interfaces: IVS basic service

Interface	Related component	Direction	Information exchanged over the interface
[DF007_IN1]	ITS-S ID management; AID management; position management; time management and/or other facilities	IN	Data required for the construction of the IVS message.
[DF007_IN2]	Road equipment gateway	IN	Road side signage data provided by the road equipment connected with the road side ITS-S.
[DF007_IN3]	DATEX II gateway	IN	Road side signage data provided by the central ITS-S connected with the road side ITS-S.
[DF007_IN4]	Data presentation	IN/OUT	Data required for the encoding/decoding of the IVS message.
[DF007_IN5]	N&T	IN/OUT	IN: TOPO message received from networking and transport layer. OUT: TOPO message delivered to networking and transport layer for transmission.
[DF007_IN6]	Management	IN/OUT	IN: Indication of the availability of IVS service. OUT: Data required by the management.
[DF007_IN7]	Application; LDM	OUT	Received IVS data.
[DF007_IN8]	Security access	IN/OUT	Data required for the IVS security processing.

7.1.8   DF008: Community services user management

This domain facility is relevant to a central ITS-S that provides ITS community services. The community services are services that are provided to a specific groups or categories of users belonging to specific communities, typically under contract or agreements. The user of a community may be end users that are connected to the service provision server using the ITS-S via HMI. The user of the community services is assigned with a client ID, this client ID is linked to a specific user profile, e.g. ITS-S ID, end user identification, etc.

First of all, this domain facility shall include a client ID and user profile management function, allowing the identification of a user belonging to the community. This functionality is in charge of updating, adding or discarding user identifiers of the community members. For this purpose, this facility shall include a database of user repository, including community user client ID and user profiles information. For example, the database may include the vehicle static data such as vehicle type, vehicle description information corresponding to each user identifier for a service that is provided to vehicles owners (e.g. insurance service). A user profile allows unambiguous identification of each user or ITS-S of the community.

Furthermore, this domain facility may provide a functionality to discover ITS-Ss (in particular the mobile ITS-Ss) and community users belong to a service community when these ITS-Ss enters a certain communication networks. It may require an access point to detect e.g. from periodical sent service announcement messages, or other means e.g. on demand from mobile ITS-S, and judge whether such ITS-S and user is belonging to the community. Depending to the requirement of use case, this facility may send request to vehicles to retrieve more detailed data for unambiguous identification.

Finally, this facility may include another functionality to monitor user data and/or dynamic data of ITS-Ss needed for service processing such as the position of the ITS-S, the request type from the user.

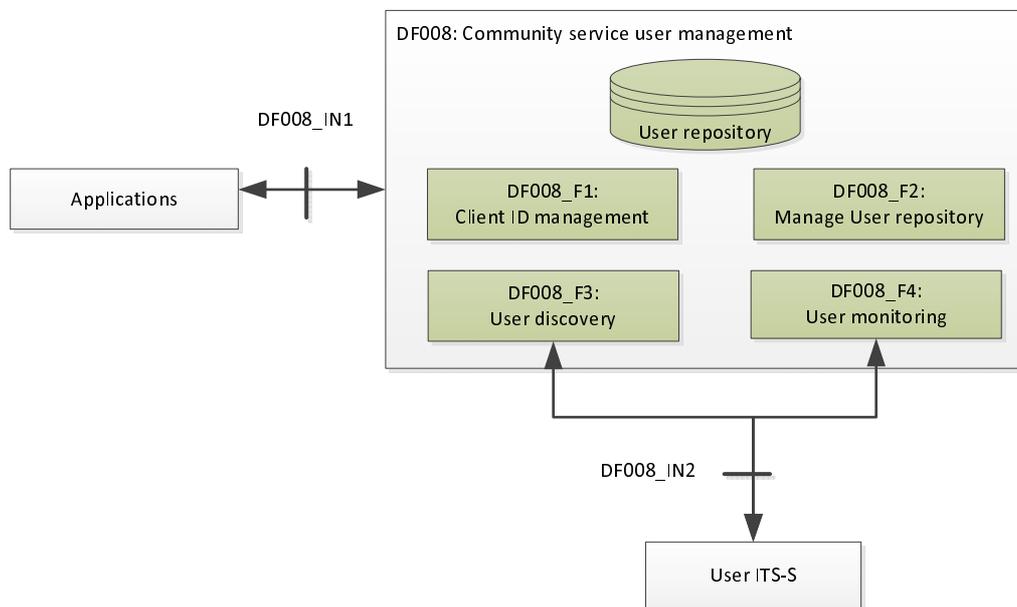The functional block diagram of this domain facility is illustrated in figure 7.8.

Figure 7.8: Block diagram: Community services user management

The functional requirements of this domain facility are presented in table 7.15.

Table 7.15: Functional requirements: Community services user management

Functions	Requirement
[DF008_F1]:	This function shall manage the community user IDs and user profiles information. It may interface with community services applications for the client ID management.
[DF008_F2]:	This function shall manage the data base of the user repository. It includes functionalities to generate, to update user repository of the community service users and to delete the invalid information.
[DF008_F3]:	This function shall interact with user ITS-S in order to discover a community user being susceptible to the service, when required by the community service application. This functionality is optional, it allows the service provider ITS-S to propose or initiate the community services.
[DF008_F4]:	This function shall monitor the user connectivity and user status e.g. provision, when required by the community service application. This functionality is optional, it allows the service provider ITS-S to propose or initiate the community services.

The interfaces of this domain facility are presented in table 7.16.

Table 7.16: Interfaces: Community services user management

Interface	Related component	Direction	Information exchanged over the interface
[DF008_IN1]	Application	IN/OUT	IN: Data and requirements for the community user management. OUT: Discovered users that are susceptible to receive the proposed community services or user monitoring information.
[DF008_IN2]	User ITS-S	IN/OUT	Data exchanged between central ITS-S and end user ITS-Ss for user discovery and/or user monitoring. This interface is an external interface.

7.2 Information support facilities functional requirements

7.2.1 DF009: Local dynamic map (LDM)

As defined in [i.1], the LDM is relevant to vehicle, personal ITS-S and road side ITS-S. The LDM is a database that provides a representation of the surrounding situation of the ITS-S based on the received messages such as CAM, DENM. Furthermore, the LDM may include the static map data, road traffic data (e.g. SPAT, TOPO, and IVS message), driving context information (e.g. weather condition) and/or highly dynamic data (e.g. sensor data, other vehicles data from received CAM and DENM). The content of the LDM may vary from one implementation to another. However, the LDM content may be organized and defined based on a standardized common data dictionary as defined in clause 6.3.4. Different ITS applications consult the LDM database for the application execution.

The LDM shall have a functionality to manage the LDM data, for example to update the LDM database based upon the reception of new messages and updated dynamic information. In a possible implementation of the LDM, the LDM may include functionalities to further process the data included in the LDM for example to aggregate and correlate the data coming from multiple ITS-Ss or multiple data sources. Finally, the LDM shall provide an API to the ITS applications, for it to obtain information for the application execution.

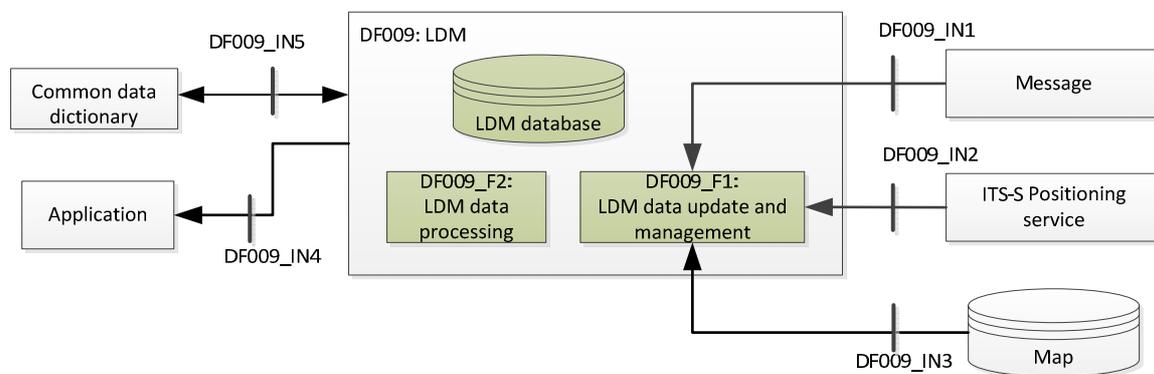The functional block diagram of this domain facility is illustrated in figure 7.9.

Figure 7.9: Block diagram: LDM

The functional requirements of this domain facility are presented in table 7.17.

Table 7.17: Functional requirements: LDM

Functions	Requirement
[DF009_F1]:	This function shall provide the management functionalities for the LDM database, including updating LDM data and discarding invalid LDM data.
[DF009_F2]:	This function shall provide LDM data processing functions in order to assist the application running and to improve the efficiency (e.g. reduce the amount of data) information exchanges with applications. This function is optional. Detailed processing rules and functionalities are depending on the system design of the ITS-S.

The interfaces of this domain facility are presented in table 7.18.

Table 7.18: Interfaces: LDM

Interface	Related component	Direction	Information exchanged over the interface
[DF009_IN1]	Messages	IN	Information for LDM update based on received messages.
[DF009_IN2]	ITS-S positioning service	IN	Current position and velocity of the ITS-S if the LDM includes such information.
[DF009_IN3]	Map	IN	Local or global map data if the LDM includes such data.
[DF009_IN4]	Applications	IN/OUT	Applications may send requests to LDM for obtaining LDM data based on certain rules (e.g. updates frequency). LDM provides data required by the applications via this interface.
[DF009_IN5]	Common data dictionary	IN/OUT	Data element definition.

7.2.2   DF010: RSU management and communication

This domain facility is relevant at the central ITS-S that manages the road side ITS-Ss (road side units RSU) in its network. The central ITS-S maintains a database of the road side ITS-Ss managed or deployed by the central ITS-S. This database includes information of the road side ITS-Ss required by the management, maintenance, control and the communication. Typically for one road side ITS-S, the following information is kept by the database:

- Road side ITS-S identifier

- Road side ITS-S network identifier

- Road side ITS-S geographical position and its location referencing

- Road side ITS-S supported applications/services

- Road side ITS-S communication capacities

- Road side ITS-S communication coverage

- Road side ITS-S detection capacities

- Road side ITS-S functioning status

Based on this database, different types of data can be exchanged between central ITS-S and road side ITS-S:

- Command and control data: a central ITS-S sends specific commands to control the behaviour or to upgrade the capacities of the road side ITS-S. On the other hand, road side ITS-S may send its operation status information to the central ITS-S.

- Traffic management information: a central ITS-S may send information related to the traffic management or travelling information to the road side ITS-S and request the dissemination of the information to road users.

- Traffic probe data and/or event information detected at road side: a road side ITS-S may process the received CAM and DENM from vehicle ITS-S and provides the information to the central ITS-S, supplementary to other road side detection information via other road side detection sensors e.g. induction loops, cameras.

The communication may be initiated by the central ITS-S to the road side ITS-S, or by the road side ITS-S towards the central ITS-S.

The functional block diagram of this domain facility is illustrated in figure 7.10.
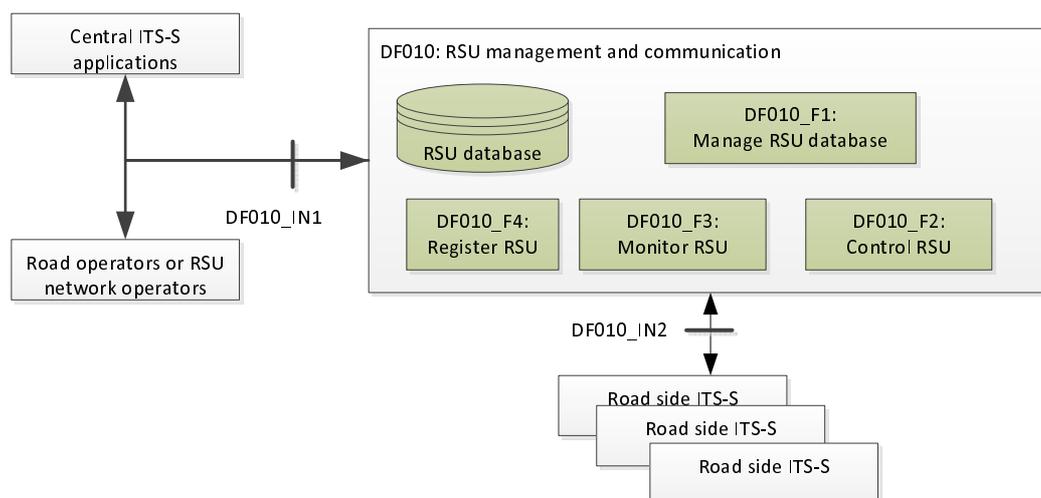

Figure 7.10: Block diagram: RSU management and communication

The functional requirements of this domain facility are presented in table 7.19.

Table 7.19: Functional requirements: RSU management and communication

Functions	Requirement
[DF010_F1]:	This function shall manage the RSU database. It enables the database update and information retrieving.
[DF010_F2]:	This function shall initiate the communication from the central ITS-S towards one or more than one road side ITS-Ss, in order to allow the central ITS-S to command and control the road side ITS-S.
[DF010_F3]:	This function shall receive information from the road side ITS-S, which enables the central ITS-S to monitor the road side ITS-S.
[DF010_F4]:	This function shall enable the central ITS-S or an external actor (e.g. road operator or RSU network operator) to registers or deregisters a RSU within the RSU database.

The interfaces of this domain facility are presented in

table 7.20.

Table 7.20: Interfaces: Community services user management

Interface	Related component	Direction	Information exchanged over the interface
[DF010_IN1]	Central ITS-S applications or external actors (road operator or RSU network operator)	IN/OUT	IN: RSU registration data. OUT: RSU data required by the central ITS-S applications or external actors.
[DF010_IN2]	Road side ITS-Ss	IN/OUT	Data exchanged for the monitoring, the control and/or the application of the RSUs.

7.2.3　DF011: Map service

This domain facility provides map information to a facility or an ITS application when necessary. For this, a map matching functionality shall be provided, in order to match a geographical position to road topology and provides the map matched data to the requested application or facility. Within an ITS-S implementation, different map format and/or map matching functionality may be used.

The functional block diagram of this domain facility is illustrated in figure 7.11.
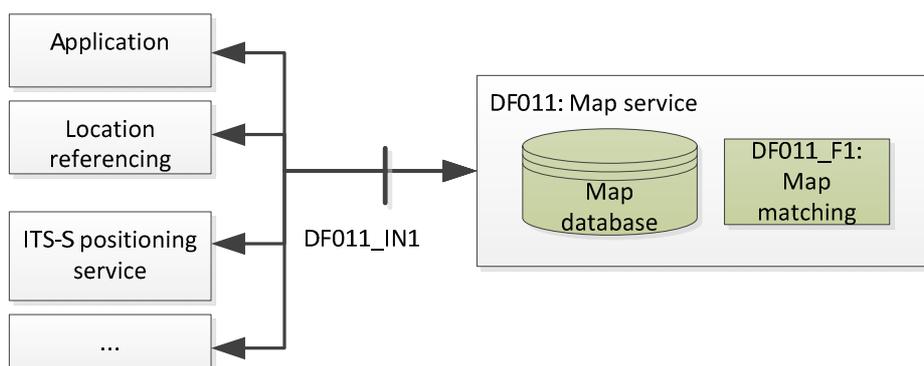

Figure 7.11: Block diagram: Map service

The functional requirements of this domain facility are presented in table 7.21.

Table 7.21: Functional requirements: Map service

Functions	Requirement
[DF011_F1]:	This function shall provide the map matching service when requested by application or other facilities.

The interfaces of this domain facility are presented in table 7.22.

Table 7.22: Interfaces: Map service

Interface	Related component	Direction	Information exchanged over the interface
[DF011_IN1]	ITS application; location referencing; station positioning management; other facilities	IN/OUT	IN: Request to map service for map matching. OUT: Map matching information.

7.3   Communication support facilities functional requirements

7.3.1   DF012: Session support

This domain facility manages the communication session between ITS-Ss. If required by an ITS application, this domain facility initiates, maintains, recovers and closes the communication session. If required by the ITS application, this domain facility may furthermore provide the report of the session status to the ITS application.

The functional block diagram of this domain facility is illustrated in figure 7.12.
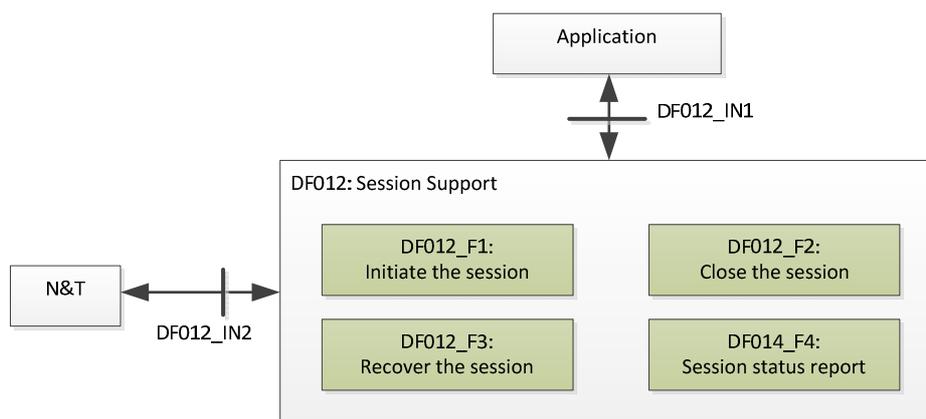

Figure 7.12: Block diagram: Session support

The functional requirements of this domain facility are presented in table 7.23.

Table 7.23: Functional requirements: Session support

Functions	Requirement
[DF012_F1]:	When required by the application, this function shall send a request to N&T to initiate a session.
[DF012_F2]:	When required by the application, this function shall send a request to N&T to close a session.
[DF012_F3]:	When required by the application, this function shall send a request to N&T to recover a session.
[DF012_F4]:	When required by the application, this function shall send a session status report to the requesting application.

The interfaces of this domain facility are presented in table 7.24.

Table 7.24: Interfaces: Session support

Interface	Related component	Direction	Information exchanged over the interface
[DF012_IN1]	Application	IN/OUT	Application request and session status.
[DF012_IN2]	N&T	IN/OUT	Request and session status.

7.3.2   DF013: Web service support

This domain facility implements the protocol of a web services e.g. SOAP application protocol, HTTP, etc. to enable the connection of an ITS-S to the Internet. Existing web service tools may be used by an application. One application (e.g. application implemented by a service provider at the central ITS-S) may select one or other web service tool.

Therefore, the functional requirements of this domain facility are not presented in the present document.

7.3.3   DF014: Messaging support

This domain facility is mainly used for non-safety applications requiring connection between user ITS-S and the backend system. The messaging support manages one or several message buffer queues dynamically. The message buffer queues can be organized with priority levels to account for different message priorities, QoS objectives, and - indirectly - for the intermittent connectivity of vehicles. Optionally for the ITS applications that are transmission delay tolerant, the messaging support provides functions to recover the message transmission and reception due to the intermittent connectivity of vehicle ITS-Ss to the service provision networks via a e.g. publish/subscribe message broker function. This function allows an asynchronous event-based communication. This supports the communication over unreliable point-to-point connections and allows for a decoupling between interacting entities.

This facility handles all events related to the client service. In this context, an event is an instance of information exchange between a back end system and any external entities, e.g. an ITS-S belonging to the service community, external service provider or external content provider. Different communication patterns may be used between a user ITS-S and the backend system. This domain facility makes decision whether to pull information that of its interests or to push information to the external entities as long as the connection is available. This component also provides buffering mechanisms for outgoing and incoming messages from web service. The event handler functionality is closely linked with applications to manage and update an event message queue when the session is broken. This function will ensure the service continuity between user ITS-Ss and service provider.

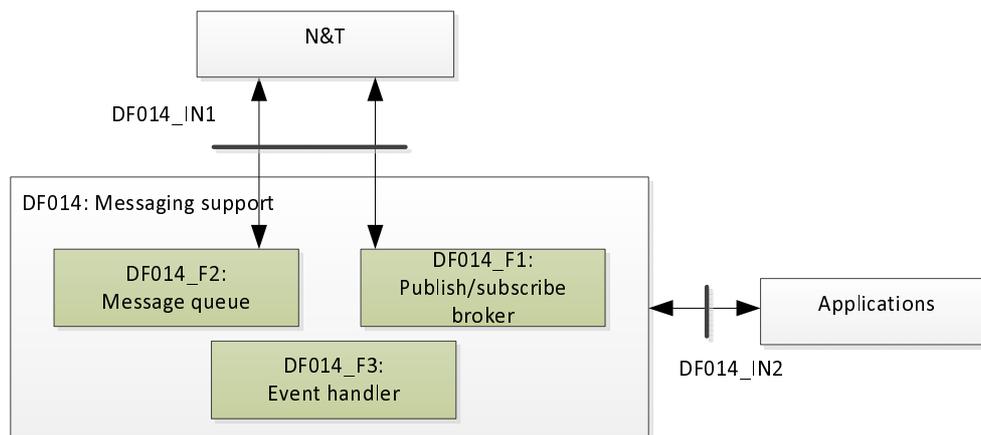The functional block diagram of this domain facility is illustrated in figure 7.13.

Figure 7.13: Block diagram: Messaging support

The functional requirements of this domain facility are presented in table 7.25.

Table 7.25: Functional requirements: Messaging support

Functions	Description
[DF014_F1]:	This function shall recover the message transmission and reception in the intermittent connectivity between user ITS-Ss and backend systems. The message transmission may be established by a push (publish) mode or a pull mode (subscribe).
[DF014_F2]:	This function shall maintain the message queues based on a defined order for example the priority level.
[DF014_F3]:	This function shall handle message queues based on event, and select the push/pull functions to be used based on application requirements.

The interfaces of this domain facility are presented in table 7.26.

Table 7.26: Interfaces: Messaging support

Interface	Related component	Direction	Information exchanged over the interface
[DF014_IN1]	N&T	IN/OUT	Messages to be sent and to be received.
[DF014_IN2]	Applications	IN/OUT	Application data and parameters to manage the message queue and the communication pattern to be used between user ITS-S and back end systems.

7.3.4   DF015: E2E (end to end) Geocasting

This domain facility specified in [i.6] is used for disseminating messages to vehicle ITS-Ss in geographical area in case a direct connection with a central ITS-S is available. This facility may be invoked both from a vehicle ITS-S in a vehicle to vehicle end to end scenario and from ITS-S in a infrastructure to vehicle scenario. From a functional point of view it provides an alternative way in respect to geonetworking protocols as specified in [i.7] for multi hop dissemination of messages. From an operational point of view this facility allows the integration of wide area and local area wireless access.

The configuration/activation of this facility depends on CF014: Addressing mode (see clause 6.4.1).

The following facilities may invoke it, as alternative to interface directly with the N&T layer:

- CF008: Service announcement message (SAM) processing;

- DF001: DEN basic service;

- DF002: CA basic service;

- DF005: Traffic light signal phase and timing message basic service (SPAT basic service);

- DF006: Road topology message basic service (TOPO basic service);

- DF007: In vehicle signage message basic service (IVS basic service).

For the purpose of message dissemination, the geographical destination area is divided into grids that correspond to a number of service areas for vehicular and personal ITS-S. The grid identifier may be used as addressing scheme.

This facility is split in two roles, i.e. as server in case of central ITS-S with a direct connection to a vehicle ITS-S, or as client in a vehicle or personal ITS-S.

The server side of the DF015 may be implemented as a specific instantiation of an ITS-S in physical equipment.

The functional block diagram of this domain facility is illustrated in figure 7.14.
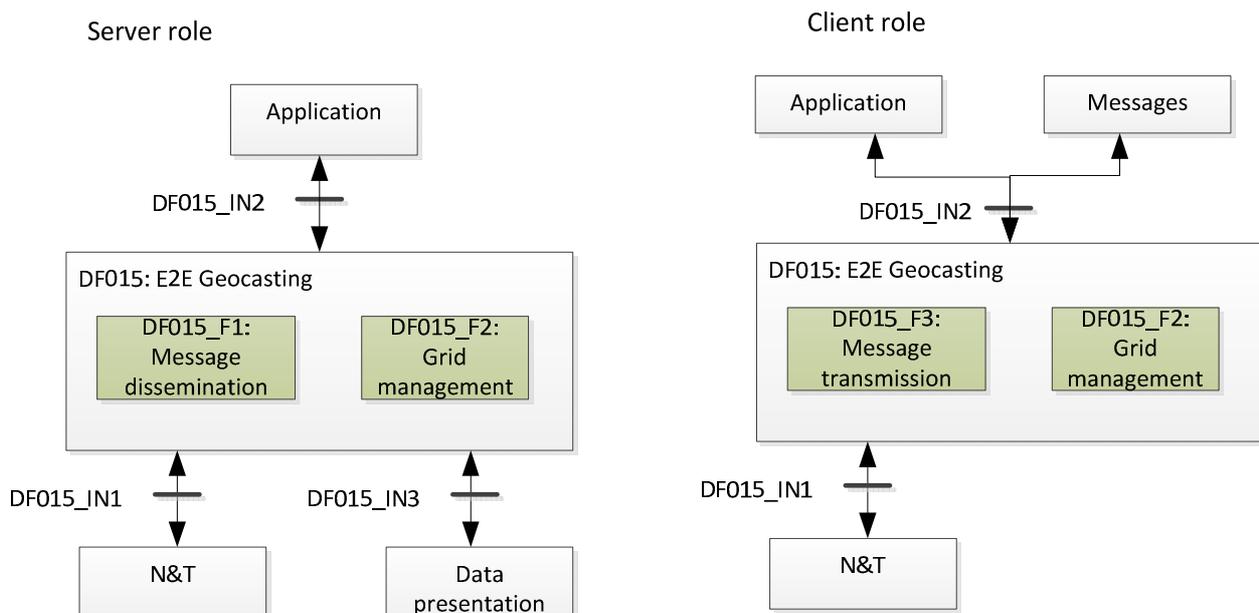

Figure 7.14: Block diagram: E2E Geocasting

The functional requirements of this domain facility are presented in table 7.27.

Table 7.27: Functional requirements: E2E Geocasting

Functions	Description
[DF015_F1]:	This server side function shall send the received geo-referenced message to all ITS-Ss in the relevant geographical area using the corresponding grid information.
[DF015_F2]:	This function shall manage grids (servers) or updates location (client) with its counterpart in the server/client architecture.
[DF015_F3]:	This client side function shall send message intended for geo-referenced distribution. It may be invoked by messages facilities such as CA and DEN basic services.

The interfaces of this domain facility are presented in table 7.28.

Table 7.28: Interfaces: E2E Geocasting

Interface	Related component	Direction	Information exchanged over the interface
[DF015_IN1]	N&T	IN/OUT	Messages to be sent and to be received, including control messages for grid updating.
[DF015_IN2]	Applications and/or messages facilities	IN	Messages from application (in the ITS Application layer or in the ITS facility layer) requesting geo-referenced broadcasting.
[DF014_IN3]	Data Presentation	IN/OUT	Import the data presentation from the common data dictionary and message encoding/decoding support in case modification of the messages is needed.

8 Conformance

The requirements specified in the present document describe the general operation of different elements in the ITS-S facilities layer. They are not intended to be tested on their own. Detailed specifications are to be defined for each specific facility for conformance test purpose. As example, specifications of facilities CA and DEN basic services can be found in [2] and [3].

Annex A (informative):
Bibliography

- CAR 2 CAR Communication Consortium Manifesto V1.1: "Overview of the C2C-CC System".

- PRE-DRIVE C2X project, Deliverable D1.4 V1.2: "Refined Architecture".

- PRE-DRIVE C2X project, Deliverable D 3.1: "Detailed selection procedure description of hardware and software components and corresponding specifications of the selected ones".

- DRIVE C2X project IR23.1: "Revised System Specification".

- CVIS project D.CVIS.3.4: " Final Architecture and System Specifications".

- simTD project Deliverable D21.4: "Spezifikation der Kommunikationsprotokolle".

- SCORE@F project L 2.2.1: "SPECIFICATION DES SYSTEMES ET DE LEURS ELEMENTS".

History

Document history		
V1.1.1	August 2013	Publication