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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Next Generation Networks – Service aspects: Interoperability of services and networks in NGN

Framework of networked vehicle services and applications using NGN

Recommendation ITU-T Y.2281

ITU International Telecommunication Union

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Recommendation ITU-T Y.2281

Framework of networked vehicle services and applications using NGN

Summary

Recommendation ITU-T Y.2281 describes the framework of networked vehicle services and applications in the context of next generation networks (NGN). This Recommendation identifies the relationship between NGN and a networked vehicle as well as requirements taking into consideration the necessity of supporting networked vehicle services and applications using NGN. In addition, a framework architecture of NGN-capable networked vehicle and intelligent transport systems (ITS) infrastructure is described to support the communication features of an NGN harmonized with the networked vehicle.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T Y.2281	2011-01-28	13

Keywords

ITS, networked vehicle, NGN, vehicle communication.

FOREWORD

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Introduction

A vehicle is one of the important components utilizing network capabilities in terms of vehicle to infrastructure (V2I), vehicle to vehicle (V2V) and vehicle to home (V2H) communications. In that context, a networked vehicle can cooperate with next generation networks (NGNs) to support more advanced services and applications such as road safety applications, road traffic related applications, multimedia services and location-based implementation of these services.

Recommendation ITU-T Y.2281

Framework of networked vehicle services and applications using NGN

1 Scope

This Recommendation describes a framework for networked vehicle services and applications assuming operation in an area where telecommunication services are provided by NGN. This Recommendation identifies features and requirements for the provision of networked vehicle services and applications using NGN. This Recommendation also provides a framework architecture to support these features and requirements.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

[ITU-T Y.2201] Recommendation ITU-T Y.2201 (2009), *Requirements and capabilities for ITU-T NGN*.

[ITU-T Y.2291] Recommendation ITU-T Y.2291 (2011), *Architectural overview of next generation home networks*.

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[ITU-T Y.2702] Recommendation ITU-T Y.2702 (2008), *Authentication and authorization requirements for NGN release 1*.

[ITU-R M.1453-2] Recommendation ITU-R M.1453-2 (2005), *Intelligent transport systems – Dedicated short range communications at 5.8 GHz*.

[ITU-R M.1457-9] Recommendation ITU-R M.1457-9 (2010), *Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2000 (IMT-2000)*.

[ETSI EN 302 665] ETSI EN 302 665 V1.1.1 (2010), *Intelligent Transport Systems (ITS); Communications Architecture*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 functional entity [ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.2 intelligent transport systems (ITS) [b-ITU-R Handbook]: ITS is defined as systems utilizing the combination of computers, communications, positioning and automation technologies to improve the safety, management and efficiency of terrestrial transport systems.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 infrastructure: The basic facilities and systems comprised of network nodes (i.e., switches and/or routers) and the means to connect them (i.e., wired (cable or fibre) or wireless) for the purpose of communication between two end-points.

3.2.2 networked vehicle: A vehicle capable of providing communication between entities within the vehicle as well as between entities within the vehicle and ITS infrastructure or other communication networks such as NGN using various access technologies.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ABS Automatic Break System

AM Amplitude Modulation

ANI Application to Network Interface

API Application Programming Interface

CALM Communication Access to Land Mobile

DMB Digital Multimedia Broadcasting

DRM Digital Rights Management

DSRC Dedicated Short Range Communications

DVB-T Digital Video Broadcasting – Terrestrial

DVD Digital Versatile Disc

ECM Engine Control Module

ECU Electronic Control Unit

FM Frequency Modulation

FMC Fixed Mobile Convergence

GNSS Global Navigation Satellite System

GPS Global Positioning System

H2V Home to Vehicle

ICT Information and Communication Technologies

IMT International Mobile Telecommunications

ISDN Integrated Services Digital Network

ITS Intelligent Transport Systems

IVN In-Vehicle Network

MAC Media Access Control

MM Multifunction Mobile

MP3	Moving Picture 3 (digital audio format)
NAPT	Network Address Port Translation
NAT	Network Address Translation
NGN	Next Generation Networks
NNI	Network to Network Interface
OBD	On Board Diagnostics
OBU	On Board Unit
OEM	Original Equipment Manufacturer
PDA	Personal Digital Assistant
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
QoS	Quality of Service
RFID	Radio Frequency Identification
RTK	Real-Time Kinematic
SMS	Short Message Service
SNI	Server to Network Interface
SNMP	Simple Network Management Protocol
SP	Service Platform
SPI	Service Programming Interface
SRC	Seamless Radio Connectivity
TCM	Transmission Control Module
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
UNI	User to Network Interface
USB	Universal Serial Bus
UWB	Ultra-Wideband
V2G	Vehicle to Grid
V2H	Vehicle to Home
V2I	Vehicle to Infrastructure
V2I2V	Vehicle to Infrastructure to Vehicle
V2V	Vehicle to Vehicle
VGP	Vehicle Gateway Platform
VoD	Video on Demand
VPN	Virtual Private Network
WLAN	Wireless Local Area Network

5 Conventions

In this Recommendation, the "I" in the keywords "V2I" and "V2I2V" stands for ITS infrastructure.

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is prohibited from" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this Recommendation can still be claimed even if this requirement is present.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 High-level view of a networked vehicle

Intelligent transport systems (ITS) provide capabilities, using information and communication technologies (ICT), to support safe and efficient use of transport infrastructure and transport means (e.g., car, train, plane or ship) for transportation of goods and humans.

A vehicle (i.e., bus, car, lorry (truck) or van), which is one of the most dominant means of transportation, is either moving or stationary.

A moving vehicle requires various capabilities including the support of networked vehicle services and applications such as road safety, traffic status, automatic toll road billing and emergency information. The support of such networked vehicle services and applications normally requires the use of communication capabilities supported by telecommunication infrastructures such as NGN, dedicated short range communication (DSRC) [ITU-R M.1453-2] or IMT-2000 [ITU-R M.1457-9]. Considering the importance of such communications to/from a networked vehicle, QoS/QoE, security and mobility, together with other factors, should be supported by the above-mentioned networking infrastructures.

A stationary vehicle requires, from time-to-time, static operation such as maintenance and/or upgrade of devices. While in a stationary mode, networked vehicle communication generally needs support from residential home networks (e.g., that of the vehicle owner) and/or other networks (e.g., that of a repair workshop).

Thus, key features of NGN such as fixed mobile convergence (FMC) support providing QoS and security play an important role. Figure 6-1 shows a high-level conceptual view of the relationship between a networked vehicle and external networks using NGN capabilities. In this figure, a networked vehicle is composed of personal devices and on-board equipments, etc. Roadside station and central station (e.g., traffic information centre) are examples of elements within ITS infrastructure.

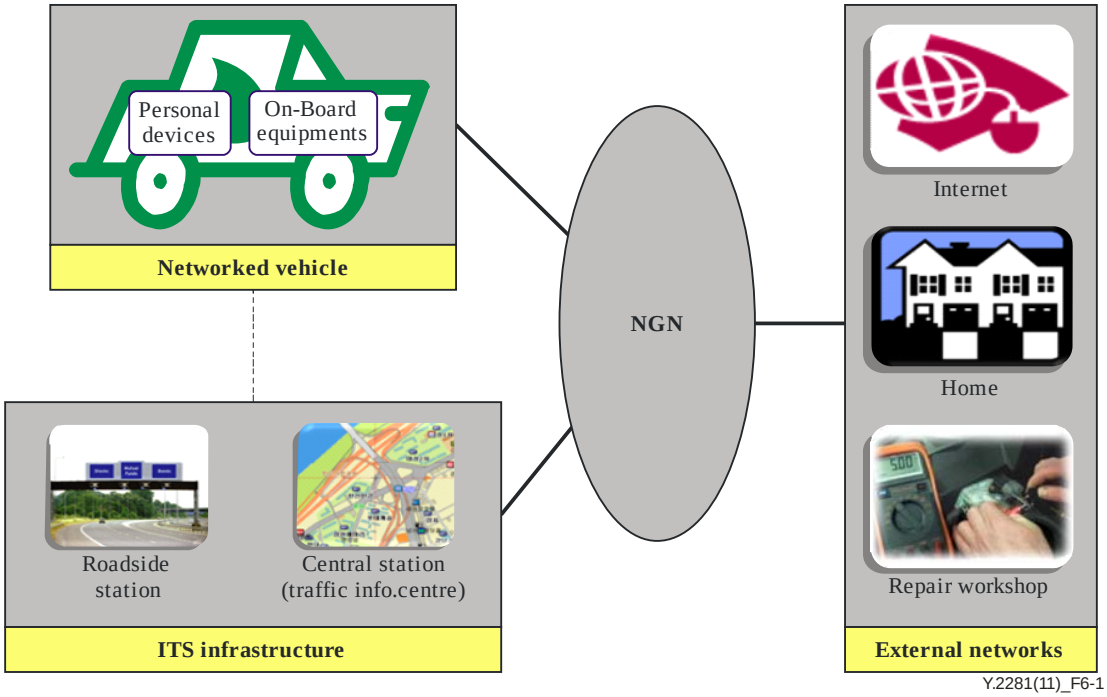

Figure 6-1 – High-level view of a networked vehicle using NGN capabilities

7 Services and communication features of networked vehicles

7.1 Networked vehicle services and applications

From the service and application aspects related to a networked vehicle, the following perspective can be considered:

1) **Vehicle maintenance-oriented services/applications (SA-1)**: The primary objective of these services/applications is the management of the vehicle itself. Possible vehicle management-oriented services/applications include:
   - Remote vehicle diagnosis: This service/application supports the remote monitoring of the vehicle status based on the status of the relevant vehicle devices and management of internally controlled and monitored diagnostics. Security and privacy protection of remotely monitored vehicle information is recommended to be ensured.
   - Vehicle data/software provisioning and update

2) **Road safety services/applications (SA-2)**: The primary objective of these services/applications is the improvement of road safety. However, it is recognized that in improving road safety these services/applications may offer secondary benefits which are not directly associated with road safety. These services/applications are built upon the reporting of road-related situations such as vehicle accidents or vehicle malfunctioning. Possible co-operative road safety services/applications include:
   - "Driving assistance – Co-operative awareness" covers use cases such as 'Emergency vehicle warning', 'Slow car warning', 'Intersection collision warning' [b-ETSI TR 102 638];
   - "Driving assistance – Road Hazard Warning" covers use cases such as 'Collision risk warning', 'Wrong way driving warning', 'Vehicle accident', 'Traffic condition warning', 'Road adhesion', 'Road visibility', etc. [b-ETSI TR 102 638] .

3) **Passenger-oriented services/applications (SA-3)**: The primary objective of these services/applications is to provide passengers in the vehicle with telecommunication-oriented services/applications such as interpersonal conversational services, audiovisual services (e.g., IPTV services), informational services (e.g., about the presence of locally based services or/and points of interest), access to Internet.

   – These services/applications are provided using devices either already built in the vehicle and/or temporarily operated within a vehicle through communication inside the vehicle or to/from outside the vehicle. The vehicle owner can download or upload multimedia data through a head unit (i.e., built-in on-board unit (OBU)) with networking capability or personal stations such as a smart phone.

4) **Traffic efficiency services/applications (SA-4)**: The primary objective of these services/applications is the improvement of traffic flow. However, it is recognized that improving traffic flow may offer secondary benefits not directly associated with traffic management. These services/applications provide for collecting and delivering of real-time traffic information by exchanging vehicle probe data periodically among vehicles and traffic information centres. The time stamp, the vehicle speed and location are some of the core elements of vehicle probe data, and should be transmitted to the centre in predetermined time periods. Possible applications include:

   – "Speed management" covering use cases such as 'Regulatory/contextual speed limits' and 'Traffic light optimal speed advisory' [b-ETSI TR 102 638];

   – "Co-operative navigation" covering use cases such as 'Traffic information and recommended itinerary', 'Enhanced route guidance and navigation' and 'Limited access warning and detour notification' [b-ETSI TR 102 638].

5) **Vehicle-oriented services/applications (SA-5)**: The primary objective of these services/applications is the support of vehicle logistics and freight-oriented applications. These applications include applications such as fleet management and vehicle parking management applications.

7.2 Communications features

Two types of communications are considered, within a networked vehicle and to/from outside a networked vehicle:

1) **Communication inside a networked vehicle**: This is a case in which communications are made inside a networked vehicle. The following types of communication can be distinguished:

   • **Communication among objects which are equipped components of a networked vehicle**: This is the case where objects of a networked vehicle (such as engine control module (ECM), transmission control module (TCM), automatic break system (ABS)) communicate among themselves and/or communicate with a central vehicle control/monitoring platform.

   • **Communication with devices temporarily operating within a networked vehicle**: This is the case of any devices temporarily operating in a networked vehicle (typically devices belonging to passengers such as a smart phone, an MP3 player or a personal digital assistant (PDA)). These devices may communicate among themselves and/or with equipment of the networked vehicle (such as a car radio, or a TV set).

2) **Communication from/to outside of a networked vehicle**: This is the case where communication is established between a given networked vehicle and other objects located outside of the networked vehicle. The following types of communication can be distinguished:

- **Vehicle-to-vehicle (V2V) communication**: This is relevant both to ad hoc communication and communication through various mobile access networks. This communication occurs between a networked vehicle and another networked vehicle to propagate safety critical information within a short period of time while the networked vehicle is moving. V2V communication is classified into two categories. One is direct communication between moving networked vehicles by using point-to-point, point-to-multipoint, or multi-hop routing. The other is vehicle to infrastructure to vehicle (V2I2V) multi-hop communication having more than two-hops by way of either a roadside station or a mobile network infrastructure. V2V direct communication mode is out of scope of this Recommendation.
- **Vehicle-to-infrastructure (V2I) communications**: This relates to communication between a networked vehicle and an ITS infrastructure through networks such as NGN, international mobile telecommunications (IMT)-2000, wireless local area network (WLAN), or dedicated short range communications (DSRC).
- **Vehicle-to-home (V2H) communications**: This relates to communications between a networked vehicle and a residential home network through networks such as NGN. When the networked vehicle is parked in a home, the networked vehicle could be treated as an element of the home network. There are two cases: one is for handling it as the owner's home device (i.e., belonging to the same owner as the home), and the other is to treat it as a visiting device (i.e., the one that does not belong to the owner of the home, but which is allowed as a visitor).
- **Vehicle-to-grid (V2G) communications**: This relates to communications between a networked vehicle and utility grids for smart charging. Ethernet over power-line adapter or IMT-2000/DSRC can be used for this type of communication.

7.3 Relationship between networked vehicle services and applications with communication features

A key aspect of a networked vehicle is its ability to communicate while transporting persons or goods. Therefore, at a given time, a networked vehicle can be considered as a moving equipment and/or device. In addition, a networked vehicle may also stay in a specific place such as in a car park or garage for a certain period of time. In this situation, a networked vehicle can also be considered as a fixed equipment and/or device.

Based on whether the network vehicle is a moving vehicle or a stationary vehicle (as described in clause 6), Table 7-1 provides the summary of the relationship between networked vehicle services and the applications described in clause 7.1 with communication features identified in clause 7.2.

Table 7-1 – Relationship between networked vehicle services and applications with communication features

Situation of networked vehicle	Communication aspects				
	Inside vehicle		Outside vehicle		
	Between on-board equipments	Between a vehicle and temporary devices	V2V	V2I	V2H/V2G
Moving vehicle	SA-1, SA-2	SA-1, SA-3	SA-2	SA-1, SA-2, SA-3, SA-4, SA-5	SA-1, SA-3
Stationary vehicle	SA-1, SA-3	SA-3	N/A	SA-1, SA-3, SA-5	SA-1, SA-3
N/A = Not Applicable					

From these key communication aspects, a networked vehicle can be considered as follows:

- a fast moving 'terminal and/or residential home network' interacting with several end devices;
- a service platform which monitors/controls the networked vehicle operation (including remote operation) and also supports multimedia services and applications by passengers such as video on demand (VoD), music within a networked vehicle;
- a communication platform for V2V, V2I and V2H communications.

Those features are the basic input for the requirements identified in clause 8.

8 Requirements for networked vehicle services and applications using NGN

A networked vehicle is a vehicle with various devices, including those belonging to the vehicle occupants. It should be possible to connect to a networked vehicle through various networks, including NGN. This clause identifies requirements of networked vehicle services and applications using NGN.

8.1 Requirements for a networked vehicle communicating with ITS infrastructure

8.1.1 General requirements

This clause identifies requirements for a networked vehicle in terms of general aspects of telecommunication.

- **Maintenance of positioning information**

  A networked vehicle is required to maintain positioning information obtained from the global navigation satellite system (GNSS) or other sources. Requirements include:

  i) collection and management of the networked vehicle's positioning information calculated from various sources such as a GNSS receiver (i.e., real-time kinematic (RTK)), a wireless network (e.g., WLAN, ZigBee, ultra-wideband (UWB)) and sensors (e.g., Gyro, radio frequency identification (RFID), accelerometer);

  ii) periodic reception of positioning information, and transmission of information either periodically, based on position triggers or as a response to a server application request.

- **Ad hoc network connectivity**

  Networked vehicle occupant devices connect smoothly to the networked vehicle.

  i) a networked vehicle is required to support ad hoc network connectivity with networked vehicle occupant devices such as an MP3 player, a PDA, a mobile phone, etc., for various value-added services (e.g., user's operation via the mobile phone, multimedia sharing, the user's phone address book);

  ii) a networked vehicle is recommended to support multiple communication interfaces such as Bluetooth, ZigBee, and WLAN.

- **IPv6 support**

  i) A networked vehicle is required to support IPv4 and is recommended to support IPv6 packet delivery over ITS communication.

- **Network management**

  i) A networked vehicle is required to have network management functionality in order to differentiate services according to the networked vehicle's priority in terms of services.

- **Operational requirements**

  i) A networked vehicle is required to handle multiple clients for the on-board diagnostics (OBD) system, to minimize the risk of collisions (i.e., send multiple requests at the same time).

8.1.2 Service and application aspects requirements

- **Use of networked vehicle data and ITS infrastructure**

  Devices can receive the input from in-vehicle controls and restrict access to vehicle/nomadic devices, depending on authorization.

  i) A networked vehicle is required to collect in-vehicle electronic control unit (ECU) and sensor data as well as to translate it into a standardized format for the purposes of networked vehicle services and applications.

8.1.3 Communication aspects requirements

- **Seamless access to networks**

  Since a communication link is continuously changing due to the mobility of a networked vehicle, enabling seamless access to networks requires autonomous switching between the "best" available communication systems at the current time and location. Therefore, the following measures are required to support seamless access:

  i) a networked vehicle is required to have interfaces to one or more wide area networks such as NGN, and one or more ad hoc networks for networked vehicles including short range radio communication;

  ii) since NGN supports multiple access technologies and mobility as basic functionality, a networked vehicle is required to provide the capability for initiating end-user functions to access the NGN services and the management of IP connectivity.

- **Security**

  Security is an issue because of complex technologies and sharing of sensitive information of a networked vehicle. Information of a networked vehicle should be protected from any malicious use such as invoking of malfunction, abuse of private information, etc. Therefore, the following steps are identified as requirements to support security:

  i) A networked vehicle is required to keep security through protocols and cryptographic mechanisms deployed in the components of the vehicle.

- **Latency**

  Vehicle safety applications allow a degree of latency depending on safety services requirements and on the network characteristics. Safety applications as 'pre-crash warning' or 'lane changing assistance' require real-time communication processing with accompanying vehicles. To exchange the emergency information and invoke safety critical controls for the networked vehicle or alert the driver, low latency communication should be supported. On the contrary, safety services as a moving road work and an approaching emergency networked vehicle can tolerate seconds of latency.

  i) A networked vehicle supporting stringent safety applications is required to support low latency communication to exchange emergency warning information within a certain period of time (e.g., end-to-end latency ≤ 100 ms) to assure the reliability of communication with nearby moving vehicles.

- **Beaconing of vehicle information**

  A networked vehicle providing safety applications could gather its own vehicle information and transmit the information to its neighbouring networked vehicles through beacons. Vehicle information includes globally unique networked vehicle's identifier (e.g., MAC address), location, speed, etc. The beacon protocol is applied between networked vehicles and also between a networked vehicle and a roadside station to exchange positions of nearby moving vehicles.

  i) a networked vehicle is required to transmit vehicle information periodically to its neighbouring networked vehicles;

  ii) a networked vehicle is required to be able to receive vehicle information periodically from its neighbouring networked vehicles. It is also required to maintain its neighbouring networked vehicles' information. The roadside station is recommended to be able to receive/transmit networked vehicles' beacon information.

- **Multi-hop communication**

  In case of beaconing of vehicle information, it is necessary to extend the original emergency messages' propagation range. To do so, it is recommended to devise a multi-hop communication technique. By means of the multi-hop communication, a networked vehicle can communicate with another networked vehicle which is outside of its propagation range.

  i) a networked vehicle and a roadside station exchange probe data collected from each networked vehicle and roadside sensors. The traffic and road status information is propagated to networked vehicles by using multi-hop communication;

  ii) a networked vehicle is required to support multi-hop communication with hop count parameters depending on the distance from an "event" or "time" since the event may be just as relevant.

- **Vehicle ad hoc routing**

  To support multi-hop communication, a message should be forwarded from a networked vehicle to other networked vehicles based on the routing schemes. A number of ad hoc routing algorithms can be applied application by application.

  i) A networked vehicle is required to support ad hoc routing for the following purposes:

     - to exchange the networked vehicle's positioning information with the neighbouring networked vehicles;
     - to deliver advanced traffic information to the networked vehicles that follow;
     - to receive traffic/roadside information from the infrastructure.

- **Network address translation**

  NGN is required not to preclude solutions for access of a networked vehicle to an NGN with network address translation (NAT)/network address port translation (NAPT) and firewalls in the user environment where the assignment of IP addresses to networked vehicle can optionally be done by the user network. These addresses need not be routable in the NGN.

  A networked vehicle's access to the NGN is required to support the following configurations:

  i) direct connectivity and interaction between the networked vehicle and the NGN;

  ii) indirect connectivity and interaction between individual devices in a networked vehicle and the NGN.

- **Vehicle-to-home (V2H) communication**

  The requirements for a networked vehicle's access to the home network are as follows:

  i) A networked vehicle's access to the home network is recommended to be enabled by access services provided within the home network (locally and/or through interconnected NGN).

  ii) A networked vehicle's access to the home network is recommended to support:

  - security, management and QoS for interoperability with home networks;
  - device provisioning and service configuration including remote access.

8.1.4 Accessibility requirements

Accessibility is required to ensure that the specified services and features are also usable as much as possible by people with disabilities. This clause describes accessibility requirements for networked vehicle services and features by applying the checklist defined in [b-ITU-T Technical Paper].

- Control of devices through a user interface

  i) A networked vehicle is recommended to have a multi-modal interface controlling the ITS infrastructure for driving assistance.

- Control of services

  i) A networked vehicle is recommended to have alternative ways to control networked vehicle services and applications. For example, real-time traffic information obtained from a roadside station can change the driving route guided from ITS infrastructure under a co-operative system.

- Media transport

  i) a networked vehicle is recommended to support text transport properties to present various safety/infotainment messages and alarms to drivers;

  ii) a networked vehicle is recommended to support audio transport properties to present various safety messages and alarms to drivers;

  iii) a networked vehicle is recommended to support video transport properties to present multimedia traffic information and record the scene of accidents.

- Media entry by the user

  i) Video entry properties are recommended to be selected so that it is possible to present video with network supported quality for multimedia traffic information. This property is recommended to be selected so that it is possible to record video pre/post scene of accidents and incidents automatically.

- Media presentation to the user

  i) a networked vehicle is recommended to support various ways of presenting information according to the user (or passenger) situation such as text and graphic (including multimedia) presentations for a person with hearing difficulties, and sound and vocal presentation of information for a person with visual difficulties;

  ii) a networked vehicle, when provided with the above media presentation requirement, is required to support emergency information following the above media presentation to the user (or passenger) in the networked vehicle.

- User and device profile management

  i) A networked vehicle is recommended to support the user and device profile management. The profiles should themselves be configurable, or be configured through exterior sources such as NGN or personal devices to assist disabled people.

- Video resolution for sign language and lip reading

  i) A networked vehicle is recommended to support a high quality video resolution for sign language and lip reading good visual reproduction of movements [b-ITU-T H-Sup.1].

8.2 NGN requirements for networked vehicle services and applications

NGN is recommended to allow the simultaneous use of multiple types of access technologies by a single networked vehicle. Therefore, the coordination of the multiple connections is required for networked vehicle services and applications from the network point of view.

It should be noted that it is not intended to preclude the attachment of terminal equipment which could enable interface adaptation to varying user requirements, including the needs of people with disabilities, using commonly provided user interface devices.

- **Maintenance of positioning information**

  Since positioning information is essential for networked vehicle services and applications, the networked vehicle is recommended to maintain the positioning information obtained from GNSS or other sources.

  i) NGN is recommended to support network-based positioning when a networked vehicle requests its own positioning information to a location server in the core network.

- **IPv6 support**

  i) NGN is recommended to support IPv6 network access for the roadside station and the OBU in a networked vehicle.

  NOTE 1 – NGN domains may support user equipment using IPv4 only, IPv6 only, or both at the user-network interface.

  NOTE 2 – In NGN, it is assumed that IPv6-based user equipment can also support IPv4 at the user-network interface.

- **Network management**

  i) NGN is recommended to support network management (e.g., simple network management protocol (SNMP)) with roadside station for exchange of network-attached devices conditions that need administrative attention.

- **Use of networked vehicle data and ITS infrastructure**

  The OBU located within a networked vehicle can receive input from in-vehicle controls and restrict access to personal station, depending on authorization.

  i) NGN is required to support secure transmission of networked vehicle data by using advanced security mechanisms such as confidentiality, anonymity, and traceability.

- **Priority**

  A networked vehicle is required to support a priority scheme by the type of service and also the type of client for the networked vehicle.

  For this purpose, the following steps are identified as NGN requirements:

  i) NGN is required to support "Prioritization" of networked vehicle transmission requests in two different levels: 'Concurrent channel access requests' within a single device' and 'Concurrent medium access requests among different devices';
     - Concurrent channel access: Prioritization among networked vehicle applications which request channel access concurrently;
     - Concurrent medium access: Prioritization among networked vehicle stations which try to access the physical communication channel simultaneously.

  ii) NGN is required to provide negotiation mechanisms between the networked vehicle and NGN to ensure the end-to-end networked vehicle service/application with different priorities.

  NOTE 3 – As an example, signalling an airbag deployment in a traffic accident should have a higher priority than downloading an entertainment video.

  NOTE 4 – Service/application priority should be identified by means of QoS and security control.

- **QoS**

  QoS can be a key criterion for choosing an available network by the user policy according to charging, network environments such as different access interfaces. Therefore, the following steps are identified as requirements:

  i) NGN is required to support per-flow, per-session, and per-service-class QoS control granularity for the networked vehicle.

  ii) NGN is required to support mechanisms prioritizing the delivery of emergency telecommunications of the networked vehicle and vehicle control information.

- **Location-based services**

  NGN is required to be able to receive location information, GNSS-based or network-based, of a networked vehicle in real time, as well as to manipulate this information dynamically in order to implement location-based services. Location information of the networked vehicle can be optionally provided upon request by an authorized service provider.

- **Network address translation**

  NGN is required not to preclude solutions for access of a networked vehicle to an NGN with NAT/NAPT and firewalls in the user environment where the assignment of IP addresses to the networked vehicle can optionally be done by the user network. These addresses need not be routable in the NGN.

- **Accessibility**

  i) Control of devices through a user interface:
     - NGN is recommended to support bidirectional connectivity to the networked vehicle to support the multi-modal commands for driving assistance. For example, the name of the driving destination can be input to the navigation system through the communication network with the help of an assistant in the service centre while driving.

  ii) Control of services:
     - NGN is recommended to support bidirectional connectivity to the networked vehicle to support the control of services for driving assistance.

iii) NGN requirements on accessibility [ITU-T Y.2201]:

Users with disabilities have a general need to be provided with means to control and use terminals and services in alternative ways and modes, suiting varied capabilities and preferences. Such requirements are best met by the inclusive design of the general provision of terminals and services.

- NGN is required to provide the means needed for the invocation of relay services. Relay services translate between various modes of telecommunication that are of interest for people with disabilities (e.g., sign language, lip reading, text, voice). Invocation of relay services can optionally be based on user preferences, address resolution or user commands.
- NGN is required to have the capability to invoke relay services by either party in an emergency telecommunication.

NOTE 5 – Other needs for users with disabilities to use emergency telecommunication services are handled in clause 20.4 of [ITU-T Y.2201].

9 Framework architecture of the networked vehicle and ITS infrastructure

This clause specifies an overall framework architecture of the networked vehicle.

Figure 9-1 shows a configuration model involving a networked vehicle including its communication types. The figure shows how networked vehicles relate to the ITS infrastructure and also to external networks such as a residential home network and an utility grid network for power distribution and transmission.

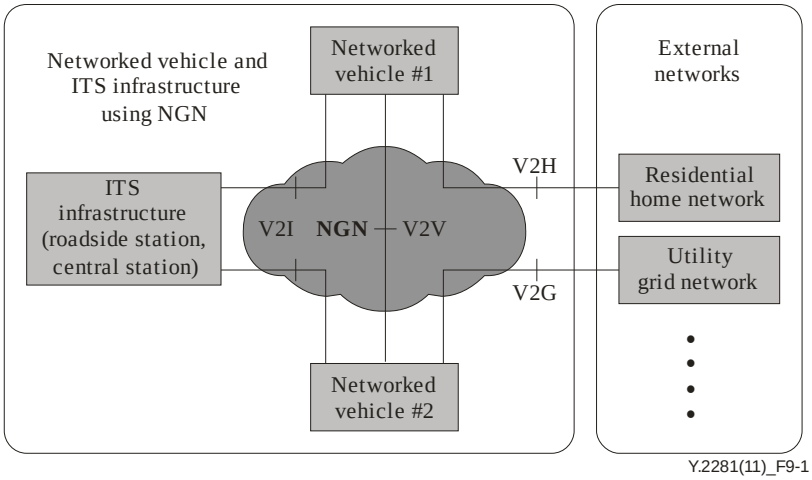

Figure 9-1 – Overall configuration model of networked vehicle and ITS infrastructure

While [ETSI EN 302 665] shows a peer-to-peer communication model using ITS-specific systems such as an ITS station router and ITS station gateways, it does not show how to use public communication networks such as NGN. Hence, this Recommendation identifies the use of NGN, thereby minimizing interoperability problems between peer-to-peer and public network scenarios. These interoperability features are especially important in the support of QoS, mobility and security with various multimedia services.

9.1 Reference architecture of the NGN-capable networked vehicle and ITS infrastructure

Based on the overall configuration model in Figure 9-1, it is possible to derive the reference architecture of the networked vehicle and ITS infrastructure. Figure 9-2 is a reference architecture model of the NGN-capable networked vehicle and ITS infrastructure based on the ITS station reference architecture model defined by [ETSI EN 302 665].

Functions for the support of networked vehicle services and applications are mapped into the ITS reference architecture which is defined in [ETSI EN 302 665]. The ITS reference architecture explains the generic functionalities that can be adopted in ITS stations. Figure II.1 shows the ITS station reference architecture defined in [ETSI EN 302 665].

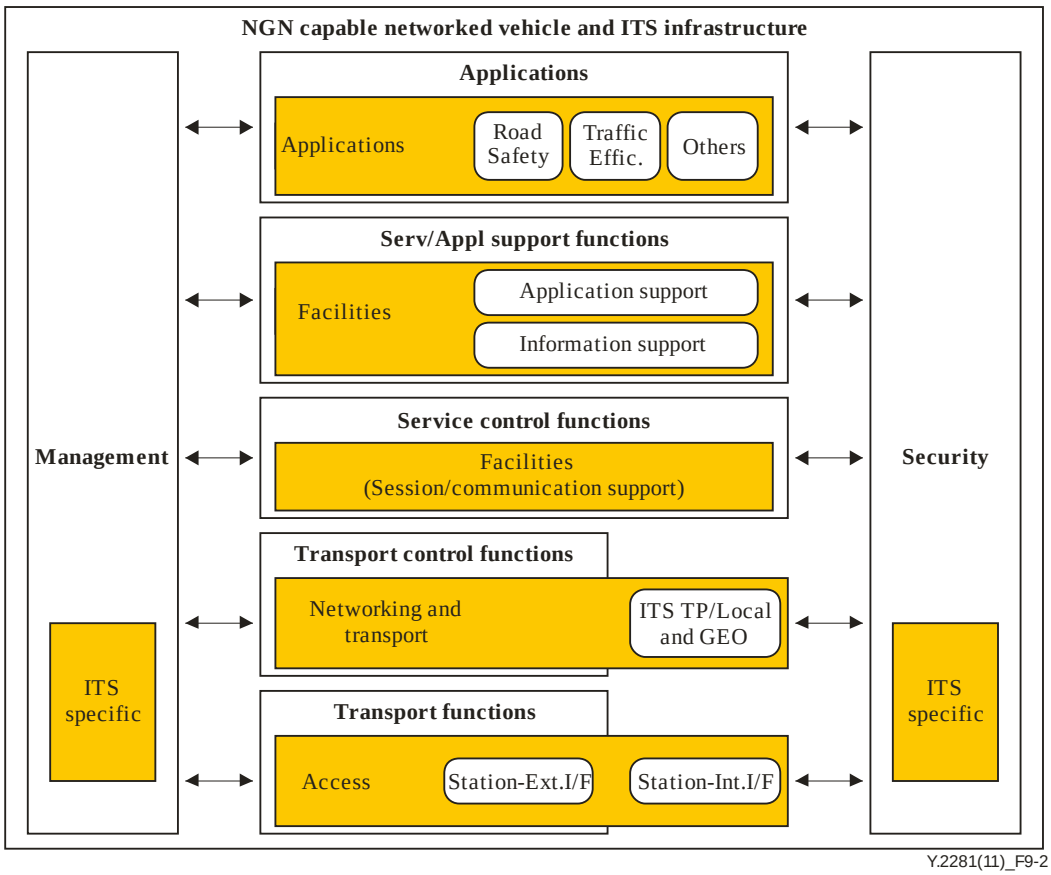

Figure 9-2 – Reference architecture of NGN-capable networked vehicle and ITS infrastructure

The key features of the functions used in Figure 9-2, based on the ITS reference architecture in [ETSI EN 302 665], are as follows:

- Applications: These functions manage networked vehicle services and applications with a function of classification, prioritization and channel assignment in the context of ITS communications.
- Facilities: These functions provide support to networked vehicle services and applications which can share generic functions and data such as session support.
- Networking and transport: These functions provide networking protocols such as GeoNetworking [b-ETSI TS 102 636], IPv6 networking and communication access to land mobile financial information exchange adapted for streaming (CALM FAST) and also provide TCP/UDP and dedicated ITS communication protocols.
- Access: These functions define the various access technologies which can be supported by the networked vehicle and ITS infrastructure.
- Management: These functions support management functions for congestion control, cross-interface, networking and application/service support.
- Security: These functions provide security functions for ITS communication protocol and applications.

9.2 Overview architecture of the NGN-capable networked vehicle and ITS infrastructure

[ITU-T Y.2012] specifies the NGN functional architecture and related functional entities. From the NGN's aspects, the NGN overview architecture consists of "End user functions", "Service stratum", "Transport stratum", "Management functions" and "NGN-based applications". The functions of the NGN-capable networked vehicle and ITS infrastructure, which is defined in clause 9.1, is located in the overview architecture, as shown in Figure 9-3.

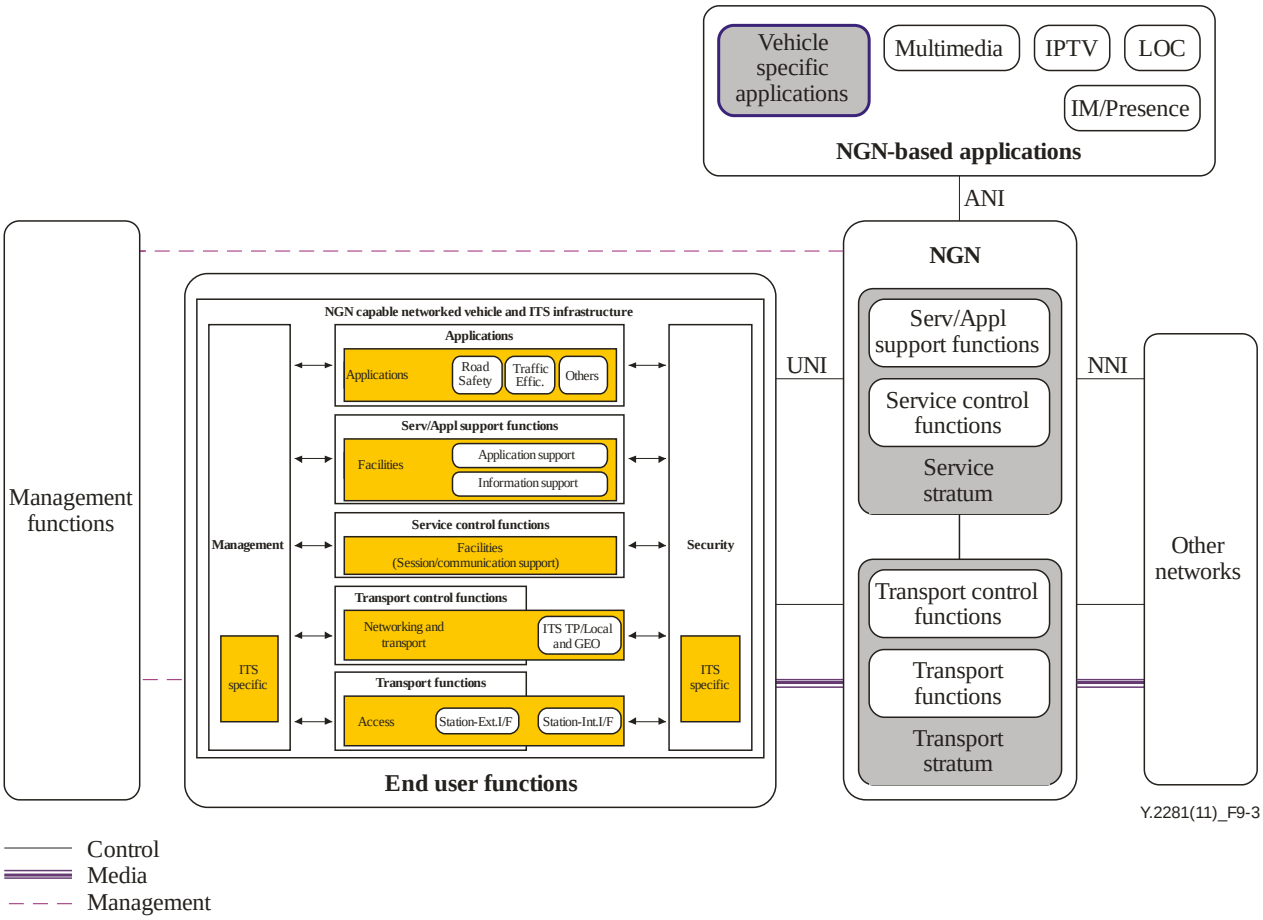

Figure 9-3 – Overview architecture of NGN-capable networked vehicle and ITS infrastructure in coorporation with NGN

In Figure 9-3, the networked vehicle related to the support of NGN capabilities is located in the end user functions. Vehicle-specific applications in the NGN-based applications are supported through the NGN for situations such as an emergency call or a public telecommunication.

NOTE – The NGN-capable networked vehicle and ITS infrastructure are the end user function in the NGN perspective [b-ITU-T Y.2291], the residential home network is located in the 'Other networks' box in Figure 9-3.

10 Security considerations

Security is an important issue for a networked vehicle. Different levels of security requirements need to be applied according to the environment where the networked vehicle is located, for example, when it is moving or stationary in a home network environment. Security requirements identified in [ITU-T Y.2201], [ITU-T Y.2701] and [ITU-T Y.2702] are applicable whenever the networked vehicle operates in NGN environments. Other cases of security requirements are out of scope of this Recommendation.

Appendix I

Use cases of networked vehicle services and applications using NGN

(This appendix does not form an integral part of this Recommendation.)

For the development of NGN capabilities and functional model to support networked vehicle services and applications, it is useful to look at usage flows of networked vehicle services and applications as well as to identify relevant mechanisms. In this regard, this appendix introduces "Use cases of the networked vehicle" using the service configuration model, as shown in Figure I.1.

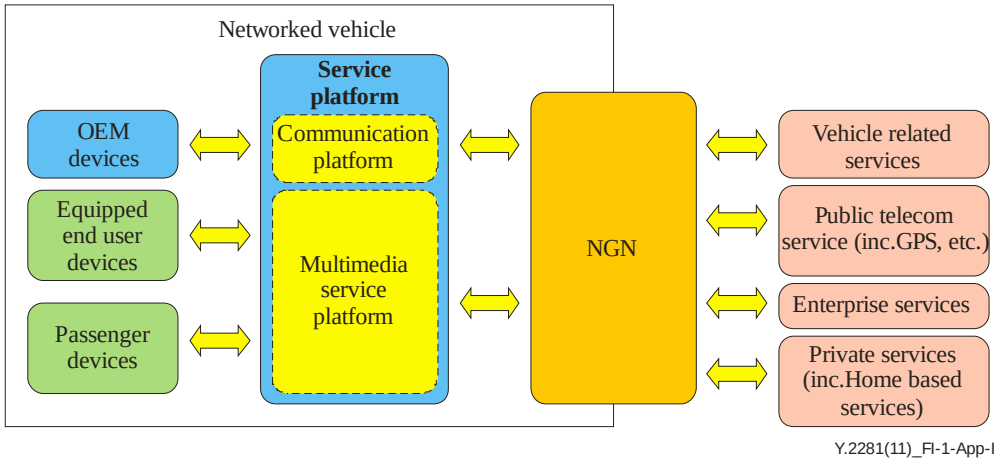

Figure I.1 – Service configuration model of a networked vehicle

Taking into account the communication features and above service configuration model, following classification of use cases can be derived as shown in Figure I.2.

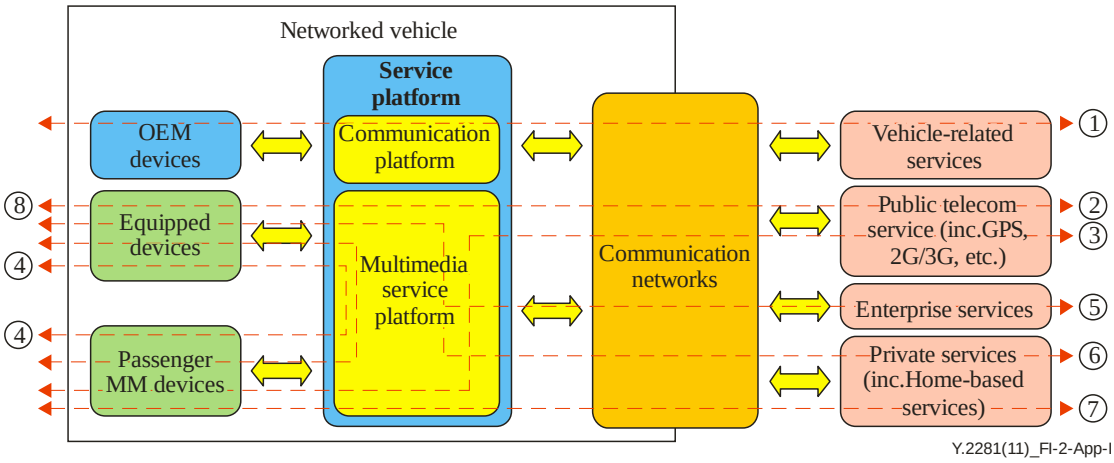

Figure I.2 – Classification of use cases for communication of a networked vehicle

Each use case is explained in Table I.1.

Table I.1 – Use cases of networked vehicle

Use Case	Objectives	Examples	NGN/Networked vehicle supports
1	Monitoring, operation and maintenance of networked vehicle	• Monitoring of networked vehicle status by communication with OEM devices • Optimization of networked vehicle operation and maintenance • Upgrade of relevant drivers for OEM devices and networked vehicle support system (may be VGP)	• Broadband with managed capability • Security • Mobility management
2	Use of public telecom services by using equipped terminal devices	• Radio programmes over FM/AM • GPS services • Telephone voice services • Internet access services • TV over mobile (e.g., DMB/DVB-T etc.) • Other public services, as appropriate	• Broadband • QoS • Security • Mobility management
3	Use of public telecom services by using passenger-owned terminal devices		
4	Sharing of resources and capabilities between equipped MM devices and passenger-owned MM devices	• Sharing music/video stored in passenger device(s) to vehicle music player (including the other direction) • Distributing video to the rear seat viewers and vice versa • Network gaming inside the networked vehicle (using vehicle equipped devices and passenger devices)	• Mounting devices into VGP with open I/F • Content protection (e.g., DRM) • Content distribution
5	Extension of business life while seated in a networked vehicle	• Use of company presence services (similar as Messenger) • Use of electronic signature to approve enterprise administration	• VPN • Security • QoS
6	Extension of home life while seated in a networked vehicle by using equipped devices	• Seamless use of personal/family scheduling • Seamless use of information from a networked vehicle to information stored in a home and vice versa	• VPN • Security • Connectivity to home network
7	Extension of home life while seated in a networked vehicle by using portable devices		
8	Use of public telecommunication access network for less stringent safety services	• Change of road conditions	• Security • Mobility management

Appendix II

Comparison between ITS station reference architecture and NGN functional architecture

(This appendix does not form an integral part of this Recommendation.)

II.1 Features and detailed functions of ITS station reference architecture

[ETSI EN 302 665] defines the ITS communication architecture using the following configuration and features of the ITS station reference architecture:

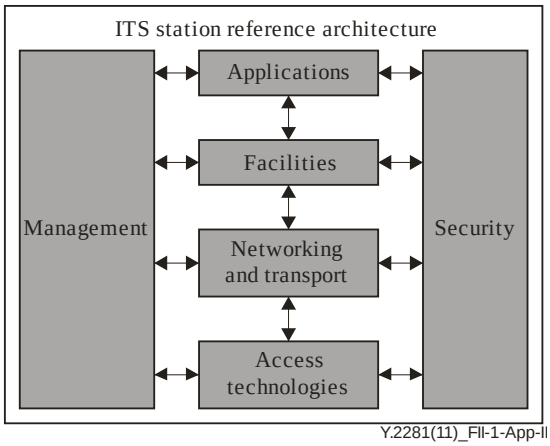

Figure II.1 – ITS station reference architecture

ITS station reference architecture is the functionality contained in ITS stations which are part of ITS sub-systems such as personal ITS sub-system (e.g., in hand-held devices), central ITS sub-system (part of an ITS central system), vehicle ITS sub-system (in cars, trucks, etc., in motion or parked) and roadside ITS sub-system (on gantries, poles, etc.). ITS station is the functional entity specified by the ITS station reference architecture, and it is composed of six entities such as 'Access' representing OSI layers 1 and 2, 'Networking and Transport' representing layers 3 and 4, 'Facilities' representing layers 5, 6 and 7, 'Applications', 'Security' and 'Management'.

Detailed functions in each layer have been also identified in [ETSI EN 302 665], as shown in Figure II.2.

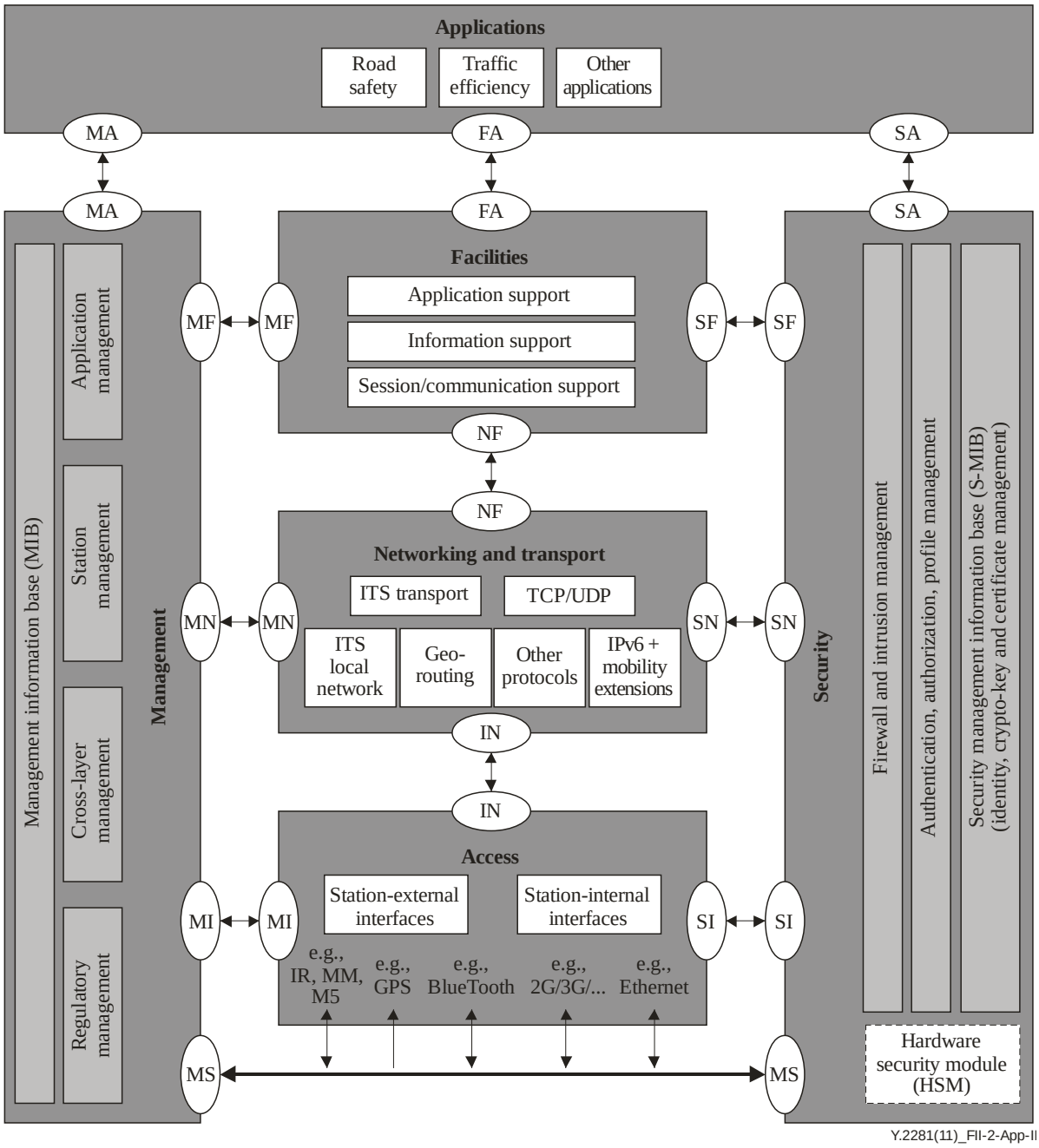

Figure II.2 – ITS station reference architecture with detailed functions

II.2 Analysis between two architectural models

An analysis of features and detailed functions, shown in clause II.1, reveals that the ITS station reference architecture has a structure quite similar to the functional architecture model of NGN, although some of the terminology ("Facilities", "Transport" and "Access technologies") in the ITS station reference architecture is used in a different way in NGN. Considering this different usage of terminology, this appendix shows a way to harmonize the ITS station reference architecture model into the functional architecture model of the networked vehicle over NGN, based on the analysis of features and detailed functions. Table II.1 shows a summary of the analysis between the ITS station reference architecture and the NGN functional architecture defined in [ITU-T Y.2012].

Table II.1 – Features and comparison between ITS station reference architecture and NGN functional architecture

ITS station reference architecture	Corresponding NGN functional architecture	Rationale
Access technologies	Transport functions	Even called "Access technologies" but this part generally represents the transport function itself. NGN applies at "Station external IF" but not at "Station internal IF".
Networking and transport	Transport control functions	This generally handles networking protocols such as IPv6, TCP/UDP, etc., so it should correspond to "Transport control functions".
Facilities	Service control and service/application support functions	"Facilities" is the most difficult part to map because of the different usage of naming, but it is mainly involved in "session support" and "ITS application". Thus, this should correspond to "Service/application support functions" in NGN.
Applications	Applications	This part mainly involves providing ITS applications, so it corresponds to "Application functions" in NGN.
Management	Management	Mostly the same but need to consider ITS specific requirements should be considered.
Security	Security	Mostly the same but need to consider ITS specific requirements should be considered.

Based on Table II.1, a possible mapping of the ITS station reference architecture into the NGN functional architecture can be depicted, as shown in Figure II.3.

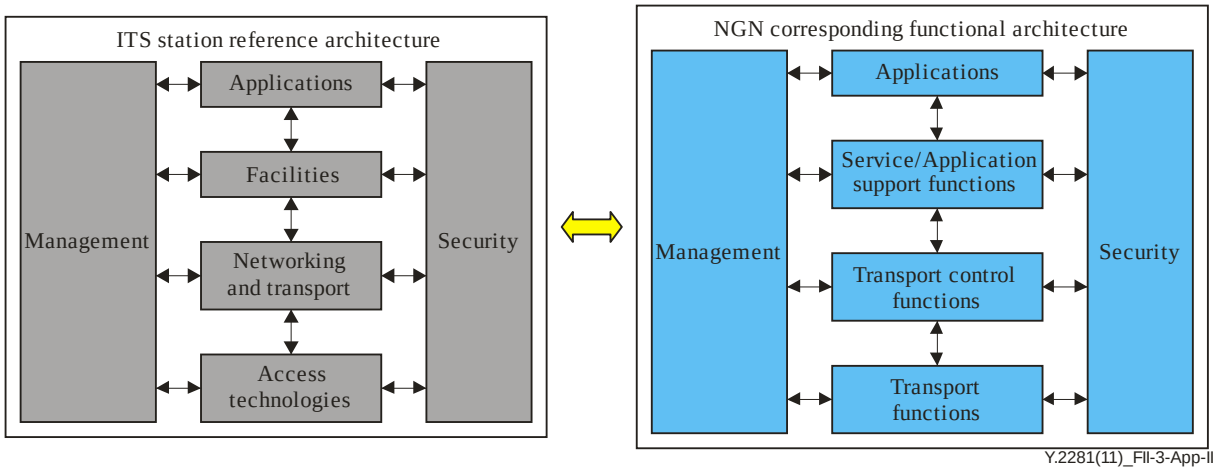

Figure II.3 – Correspondence between the ITS station reference architecture and the functions of NGN functional architecture

One of the fundamental considerations is to address the support of ITS specific aspects driven by service requirements, operation, administration and management of ITS. When ITS specific services need NGN capabilities, NGN functions should be incorporated into ITS station features, as shown in Figure II.4. Most of the detailed functions in the ITS station reference architecture are well mapped with the relevant functions of the NGN functional architecture, except for "Information support", the role of which is not clear, and the difference between "Application support" and "Communication support".

II.3 Features and functions for a networked vehicle

A networked vehicle should be operated as a part of ITS as well as a part of communication objects, used for public and private communication services and applications. This means that a networked vehicle should have enough capabilities to support ITS specific features and general communication features. Therefore, it is highly anticipated that combined (or harmonized) functions to support both features would be incorporated into a networked vehicle.

In this regard, the ITS station reference architecture covers the ITS specific service features but not enough to support communication features, specifically the need to adopt capabilities from the communication functions to support mobility, security, management capability and connectivity. It is anticipated to use capabilities provided by NGN for such features rather than develop different functions because a networked vehicle is also a part of communication objects, whether it is moving or stationary. Therefore, functions for a networked vehicle, especially over the NGN environment, are harmonized using both the ITS station reference architecture and the NGN functional architecture, as shown in Figure II.4.

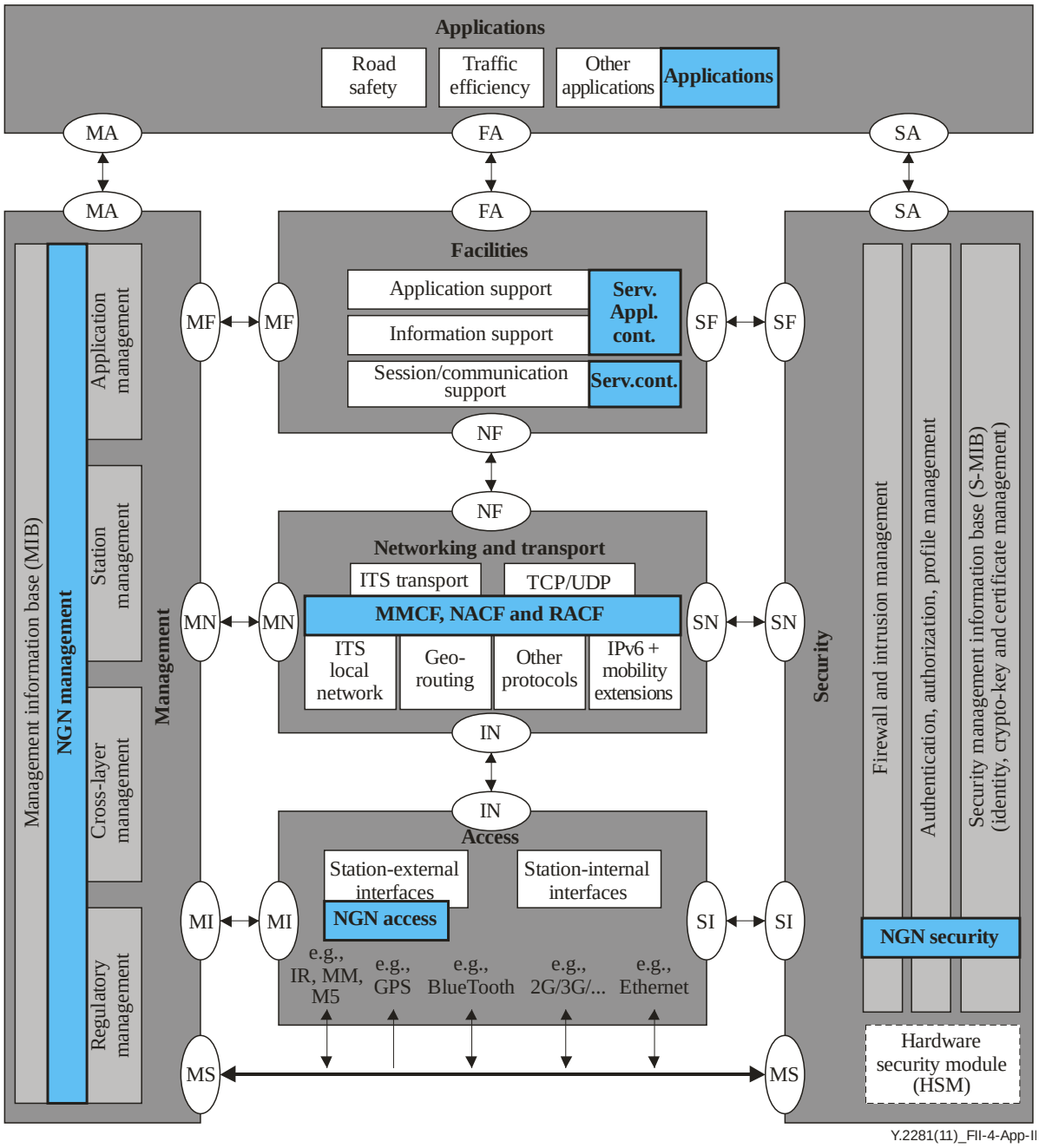

Figure II.4 – Arrangement of the relevant NGN functions into the ITS station reference architecture

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