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Intelligent transport systems — Framework architecture for plug and play (PnP) functionality in vehicles utilizing nomadic devices

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Foreword

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This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies framework architecture for plug and play (PnP) functionality in vehicles and identifies the issues related to exchanging information between occupants (users) and PnP functions. The connection between PnP vehicles and occupants is established by nomadic devices and the exchanging information is bidirectional. The main purpose of architecture is to utilize the PnP vehicle information and enhance the safety state and improve the convenience of occupants in PnP vehicles by adopting various pieces of information of PnP functionality in vehicles including sensors, mechanical equipment, and communication devices.

This document covers subjects related to representation of the status of a PnP vehicle and occupant. The status of a PnP vehicle and occupant is represented as a safety state/availability state and driver information, respectively. Therefore, information exchange between a PnP vehicle and occupants is mandatory.

This system is based on the following assumptions:

— A PnP vehicle is equipped with several sensors such as radar, lidar, camera, vehicle mechanical information such as steering, acceleration/brake, ECU, and communication devices such as WLAN, Bluetooth. In addition, more sensors or devices can be extensible with the advance of technology, and a PnP vehicle can adapt these devices.

— Occupants have a nomadic device such as smart phone, or wearable which can be used to exchange information with a PnP vehicle. The health information of occupants may be delivered to a PnP vehicle.

— The major use case is to inform the status of a PnP vehicle and occupants using the information between a PnP vehicle and occupants.

Intelligent transport systems — Framework architecture for plug and play (PnP) functionality in vehicles utilizing nomadic devices

1 Scope

This document defines framework architecture for plug and play (PnP) vehicles and identifies the issues related to exchanging information between occupants (users) and PnP vehicles with nomadic devices. The purpose of architecture is to enhance PnP vehicles and the occupants' safety state by exchanging the information/availability from PnP vehicles and occupants' information/status.

The function of frame architecture is to define message follows and its effect on safety state between a PnP vehicle and the occupants. This document specifies the framework of safety state representation between the PnP vehicle and the occupants. The state of the PnP vehicle depending on the PnP vehicle's equipment informs the occupants, and the status of the occupants is also transmitted to the PnP vehicle where status information is delivered by nomadic devices.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 17419, *Intelligent transport systems — Cooperative systems — Globally unique identification*

ISO 17423, *Intelligent transport systems — Cooperative systems — Application requirements and objectives*

ISO 21217, *Intelligent transport systems — Communications access for land mobiles (CALM) — Architecture*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17419, ISO 17423 and ISO 21217 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
plug and play
PnP
vehicle which allows attaching, switching and detaching devices, e.g. sensors, actuators or communication devices, in the vehicle at both before and after market, and then the various applications can be implemented using a specific function

Note 1 to entry: Plug and play is a next generation ITS concept.

Note 2 to entry: The information from the PnP function can be monitored and controlled by nomadic devices. It could be a chance to produce small and special batches by small manufacturers, and to keep continuous value improvement of the vehicle by switching devices to improved ones as modern desktop computers do.

3.2
plug and play vehicle
PnP vehicle
vehicle which has PnP functionality

Note 1 to entry: Since PnP vehicles vary in the combination of devices and functionalities in each model even though they have a similar appearance, occupants can recognize the current PnP status of their vehicle.

4   Abbreviated terms

ACC   Adaptive Cruise Control

ADAS   Advanced Driver Assistance System

AVM   Around View Monitoring

Lidar   Light Detection and Ranging

OSI   open systems interconnection

PnP   Plug and Play

RADAR   Radio Detection and Ranging

V2X   Vehicle-to-Everything

WAVE   Wireless Access in Vehicular Environments

CAM   Camera

5   Conventions

This document is based on the conventions discussed in the OSI Service Conventions ISO/IEC 10731 as they apply for communication services. The vehicle data transfer protocol is applicable to OSI layers 5, 6 and 7.

6   Technical information

6.1   General descriptions

Information exchange occurs between a PnP vehicle and a nomadic device of occupants. Depending on the device type and amount of information, the number of information representations is different which also affects the safety state of a PnP vehicle. For information transmission, the environment which is described as follows is assumed.

— A PnP vehicle can detect all information from devices which are connected to a vehicle. Devices include sensors, communication devices, and mechanical equipment. A PnP vehicle can update to a new driver and software when a new device is attached or the existing device is changed or modified. The PnP gateway handles updating, modifying, and managing of all connected devices.

— An occupant has a nomadic device which can communicate with a PnP vehicle. A nomadic device has to install an application to express and exchange information with a PnP vehicle.

A device and PnP gateway which are attached and connected to a PnP vehicle can be regarded as a part of an "extended vehicle".

6.2 Framework architecture for in-vehicle PnP

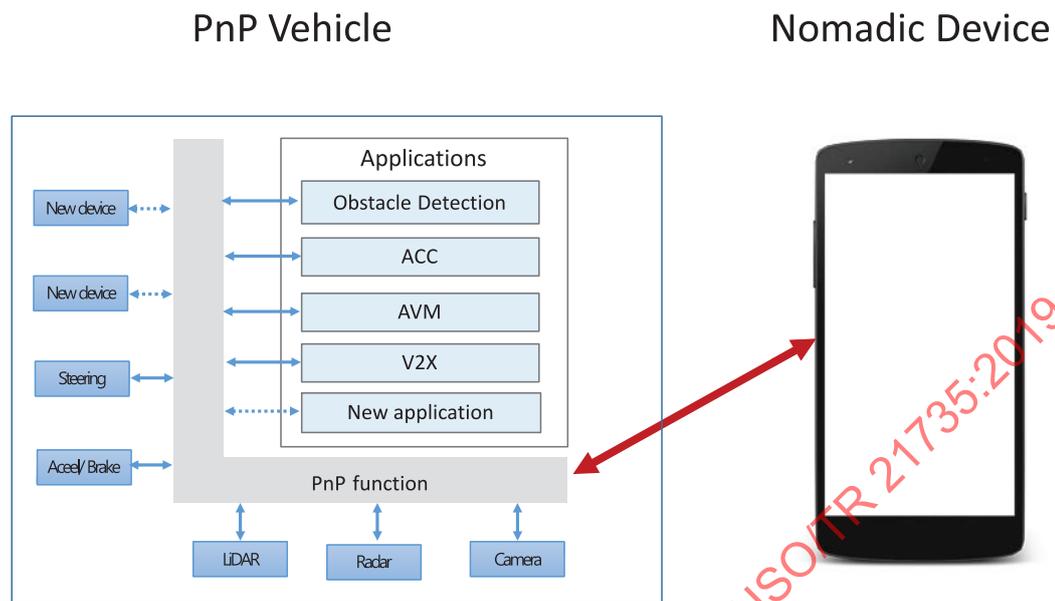PnP Vehicle   Nomadic Device

Figure 1 — Framework architecture for in-vehicle PnP

Figure 1 shows a brief description of the framework architecture for in-vehicle PnP. Former vehicles can only provide limited application functionalities, as well as hardware functionalities, which are mainly provided by the vendors. Applications such as driving assistance and hardware, therefore, are tightly coupled so that it is hard to equip new hardware or applications.

By adopting a PnP framework, a PnP function is layered between hardware and applications in order to abstract each other. It could help in developing a variety of types of vehicle in a short period of time as well as equipping or changing new hardware or applications in after markets. PnP architecture could make vehicles provide a totally different functionality even though they would have the same appearance. A nomadic device is one of the solutions to avoiding confusion and managing a variety of functionalities.

6.3 Information transmission logic

The following steps are information transmission logic from a PnP vehicle to a nomadic device.

— A PnP vehicle checks the status of devices and updates information where updated/new information is gathered and manipulated via a PnP gateway.

— All available information of the PnP vehicle is transmitted to nomadic devices via communication.

— A nomadic device checks the received information from the PnP vehicle and represents possible functions of the corresponding vehicle.

— A PnP vehicle periodically monitors the status of the vehicle using attached devices and this information is sent to the nomadic device.

— The occupant notices and monitors the status of the PnP vehicle using the nomadic devices.

The following steps are information transmission logic from an occupant to a PnP vehicle.

— An occupant inputs the information of the occupant, e.g. the driver's identification, ignition of mechanic operation, to the nomadic device.

— The input or collected information of the occupant is transmitted to a PnP vehicle.

     3

— A PnP vehicle monitors periodically the received information from the nomadic device.

— The PnP vehicle controls the vehicle based on the received information in an emergency case.
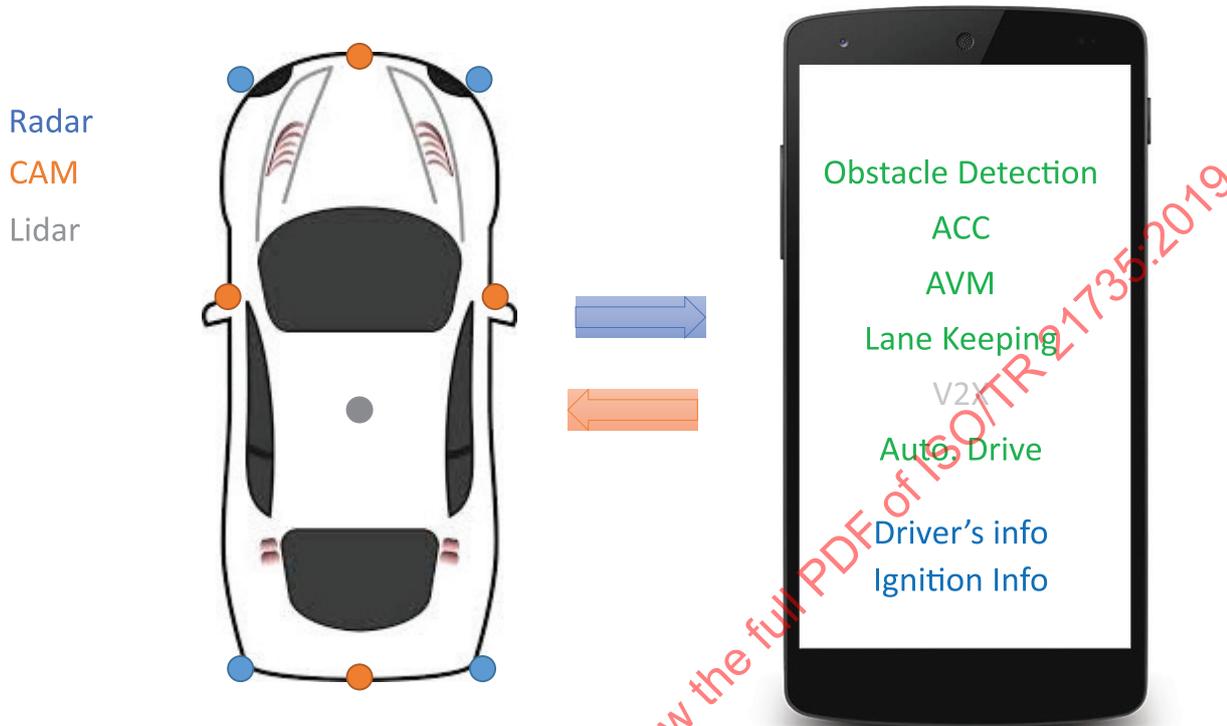

Figure 2 — Information transmission between a PnP vehicle and occupant

6.4 Information from a PNP vehicle to occupants

6.4.1 General

Information is transmitted from a PNP vehicle to nomadic devices via following steps. When sensors, communication devices, or operating devices are plug-in, the PnP gateway gathers each device's information. Then, the PnP gateway defines available or supportable conditions by combining gathered information. For example, obstacle warning/lane keeping warning function is triggered by a radar or CAM with lane detection function, is installed in a PnP vehicle. ACC and limited ADAS function will be provided if a PnP vehicle has a computer with accelerate/decelerate function and steering control function, respectively. These various safety functions/states are transmitted to nomadic devices.

Self-driving can be categorized with the location acquisition and autonomous driving. The location acquisition can be achieved by combining various sensors such as GPS with vision, Lidar with vision, or GPS and Lidar with vision where the required software may be different depending on the combination of supported devices. The PnP gateway provides safety state and coverage of available functions to nomadic devices based on various combinations.

6.4.2 Sensor related information

— Radar: Radar normally detects obstacles in the near distance and can be applied for ACC and AVM.

— CAM: CAM can be applied for AVM and lane detection using vision sensing.

— Lidar: Lidar provides localizing function with precise environment measurements where detection of obstacles and map comparison technology are applied.

6.4.3 Communication related information

— WiFi: WiFi device can detect and communicate with another WiFi device which can be used for data collection of the vehicle's environment.

— WAVE: WAVE device can detect and communicate with another vehicle which enhances the safety of the vehicle using vehicle-to-vehicle communications or vehicle-to-nomadic communications.

— V2X: A PnP vehicle connects another vehicle, devices, or other infrastructures using vehicle-to-everything communication based on WiFi, WAVE, ZigBee, or other installed communication-based devices.

6.4.4 Mechanical related information

— This information includes basic accelerating/decelerating and steering functions where the overall or part of mechanical operation can be controlled by the PnP computer depending on provide services such as cruise control, automatic driving or parking assistance

6.5 Information from occupant to PnP vehicle

6.5.1 General

Information flow from nomadic devices to a PnP vehicle is the reverse of a PnP vehicle to nomadic devises however, the type of information is different. The information from a PnP vehicle to nomadic devices is automatically detected information which is mainly related to the safety level of the vehicle, whereas the information from a nomadic device to a PnP vehicle is the information manually input by the occupant. For example, the occupant sets the mechanical ignition of the PnP vehicle into the nomadic devices, e.g. engine-on, seat-heating on, or air conditioning on. Then, the ignition information is transmitted to a PnP vehicle and the vehicle sets up the status based on the received information. The occupants also set the identification information into the nomadic devices, and then this information controls the specific PnP vehicle. The PnP vehicle only works when the corresponding nomadic devices send the specific signal.

Another type of information is the set up of the safety state, i.e. selection of control functions. For example, the occupant wants to operate the ACC function among various functions, e.g. ACC, AVM, Lane keeping, and only selected functions can be used. This provides more options to the occupant for controlling the PnP vehicle.

6.5.2 Occupants' information

Information from occupant is mostly input or ignition signal to PnP vehicles based on the current PnP vehicle's status which is information from the PnP vehicle.

7 Use case scenario

Several use cases will be provided based on the above-mentioned functions. Any user scenario which is described or other users' actions utilizing the PnP functionality with nomadic devices can be denied, accepted, or modified by regulations or policies from manufacturers, governments, or any other organization if required.

7.1 Use case 1 — Acceptance and denial of service usage

7.1.1 Overview

A PnP vehicle provides several possible service lists to a nomadic device. Then occupants accept or deny a specific service.

7.1.2 Description

A PnP vehicle can generate various services by combing the information of a PnP vehicle's sensors and/or communication devices. Then the following services may be provided by a PnP vehicle.

— Obstacle detection: Radar, CAM;

— ACC: Radar, CAM;

— AVM: Radar, CAM, Lidar;

— Lane Keeping: Radar, CAM, Lidar;

— V2X: WiFi, WAVE, Cellular.

Then, the occupant selects the specific service using a nomadic device. Depending on the selected service lists, the PnP vehicle can extend or reduce the service coverage.

7.1.3 Example

Figure 3

PnP functionality provides all possible services to occupants by detecting the devices in vehicles using a nomadic device as depicted in the above figure. If a new device is added or the existing device is removed, the possible services are updated and this information is sent to the occupant's nomadic device. The below figure represents a new service (AVM and lane keeping) added by detecting Lidar compared with the above figure.
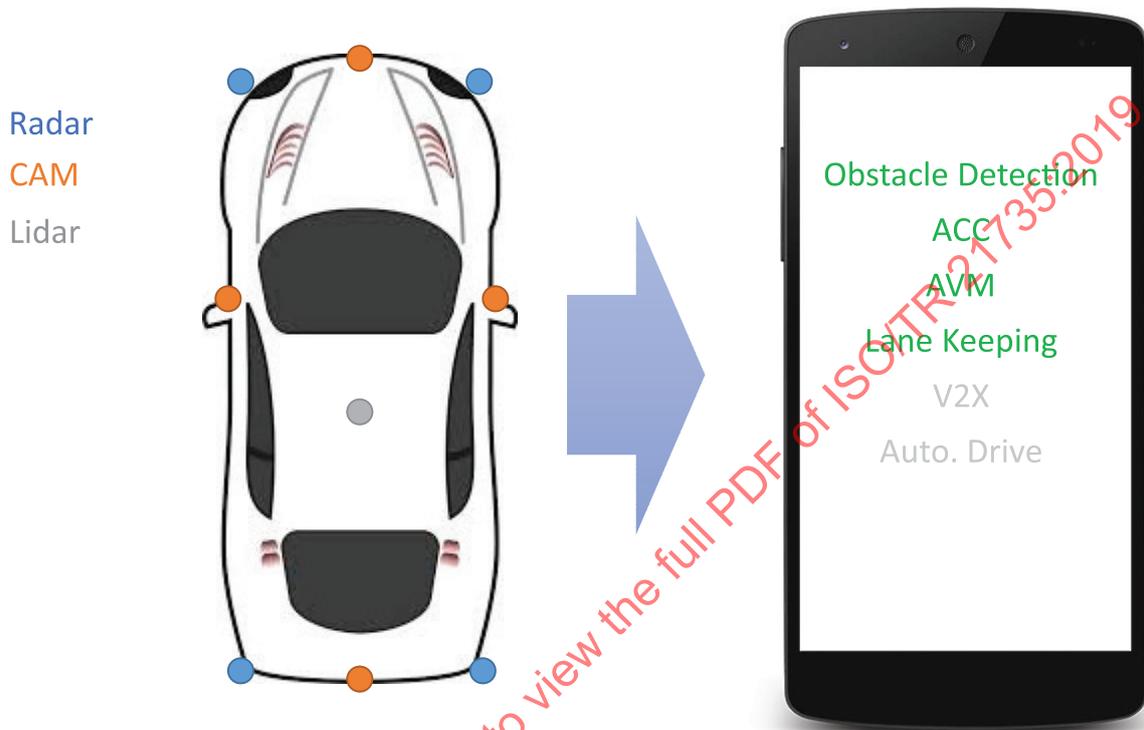

Radar
CAM
Lidar

Obstacle Detection
ACC
AVM
Lane Keeping
V2X
Auto. Drive

Figure 4

Occupants can decide the usage of services by checking function lists and devices set in the nomadic device. For example, if the occupant denies using Lidar due to low reliability, then this information is transmitted to the in-vehicle PnP system via the nomadic device. Then, the new service lists are updated by removing the function lists which are related to use Lidar.

7.2   Use case 2 — Ownership exchanging

7.2.1   Overview

A PnP vehicle can receive ownership from a nomadic device.

7.2.2   Description

A PnP vehicle can be operated by a specific signal, i.e. ownership information, from a nomadic device. This ownership information can be used in several nomadic devices. This ownership contains PnP device service access authorization lists as well as a vehicle itself. Therefore, the provided service lists may be different depending on the occupants' ownership. This use case can be applied to a car sharing application.

7.2.3 Example

Suppose several occupants have ownership of the PnP vehicle, i.e. user A, B, and C. User A wants to use all possible PnP vehicle services, and user B wants to use some parts of the services, and user C wants to use the minimum function of the PnP vehicle. Then, each user has the distinct service lists depending on each user's ownership although the vehicle can be shared by all users. The ownership is saved and delivered by using a nomadic device where this ownership information is exchanged with the PnP vehicle.

7.3 Use case 3 — Suggestion of optimum functional package

7.3.1 Overview

A PnP vehicle can gather various pieces of information such as the road status and occupants driving behaviour. Then the PnP vehicle suggests the optimum functional package to the occupant using a nomadic device.

7.3.2 Description

A PnP vehicle contains various information such as road status, possible service list, and occupants' driver behaviour. Based on this information, the PnP vehicle suggests activation of a functional package. The following examples maybe included in the functional package:

— Gathering service lists: Obstacle detection & ACC, ACC & Lane keeping, V2X;

— Autonomous driving.

For long distance driving using highway or congested roads, the PnP vehicle suggests autonomous driving to the occupant using nomadic devices.

7.3.3 Example

A PnP vehicle receives all possible traffic information from the nomadic devices, then the PnP vehicle recommends useful service sets to occupants. For example, if the expected driving route has long and straight roads, PnP vehicles suggest using the lane keeping service.

Another example is application for handicapped persons. If the information on handicapped persons is transmitted to a PnP vehicle using nomadic devices, the PnP vehicle may suggest as many as possible services or some special functions for a specific person. The selection of service can be decided by occupant or can be mandatory by law.

7.4 Use case 4 — Mandatory operation of functional package

7.4.1 Overview

A PnP vehicle detects the occupants' information using nomadic devices. Based on the occupant's information, a PnP vehicle can operate some mandatory services.

7.4.2 Description

A PnP vehicle can be applied to a car share application. When several occupants use a PnP vehicle, the primary owner of a PnP vehicle may want to operate some mandatory functions of a PnP vehicle without the occupant deciding this. Depending on the occupant information, the PnP vehicle can set up some functions in advance where this function cannot be changed by the occupants.