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Internet Protocol based Integrated On-Board Information System IBIS-IP

Part 1: System architecture

Gesamtbearbeitung

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Foreword

On the initiative of Verband Deutscher Verkehrsunternehmen (the Association of German Transport Companies – VDV) and funded by the Federal Ministry of Economics, the research and standardization project *Internet Protokoll basierte Kommunikationsdienste im öffentlichen Verkehr (IP-KOM-ÖV)* [Internet Protocol-based Communications services in Public Transport] began in September 2010.

The project is supported by 14 partners belonging to industry, universities and public transport companies. It is intended to develop sophisticated communication concepts for comprehensive and continuous passenger information.

Nowadays, comprehensive passenger information is a key factor of competition in public transport, not only when compared to other transport companies but also in comparison with individual transport.

Even today it is common to see that transport companies convey information to their passengers not only about the planned trips, but also provide real-time information like current delays, events or destination changes. On the one hand, such information is provided through public indicator systems or through announcements in vehicles or at stops to people present there. On the other hand, such information can be queried individually by means of specific applications or websites by users.

However, until now it is not possible to provide passengers in public transport with information relevant to their specific journey, i.e. to guide the passengers in the quickest way to their destination with the help of public transport even in the event of an interruption.

In this respect, the widely popular smartphones and tablets offer many and varied possibilities and find a high user acceptance. In this, the transmission of information is based on IP, and should preferably take place between a centrally located data server and the customer device. In case the central data server is not reachable or, the vehicle is not connected to it, communication should also be possible directly between the customer device and the vehicle.

Therefore, the research and standardization project IP-KOM-ÖV is working on three main areas (cf. Figure 1).

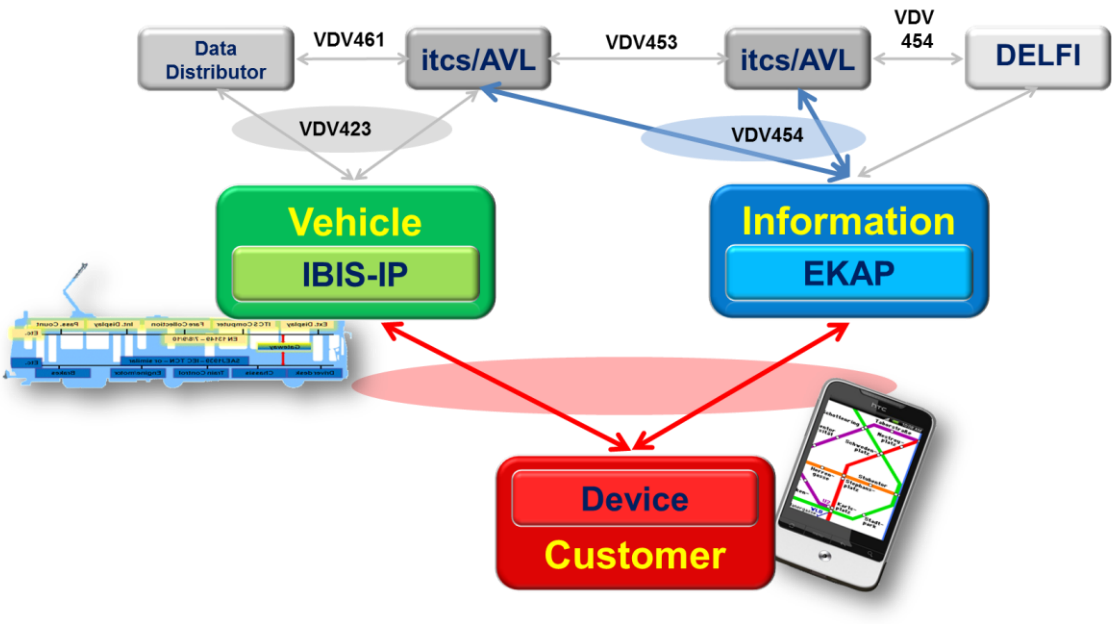

Figure 1: Environment and main focus in the IP-KOM-ÖV project

The first focus (green box in Figure 1) is the specification of a high-performance IP-based communications protocol in the vehicle (IBIS-IP). For one, the aim is to meet the growing needs of the in-vehicle passenger information and communication. For this purpose, the IBIS Wagenbus of the VDV 300 (cf. [1]), developed during the eighties, is converted into a sophisticated Ethernet information architecture. On the other hand, it deals with the definition of an IP-based interface for the transmission of information from the vehicle to the mobile customer device. The present document is the outcome of this part of the research project.

The second focus (red box in Figure 1) is to define the necessary interfaces in order to cater to future applications for individual passenger information using mobile devices of passengers (smartphones, Tablet PC, etc.) through standardization. For this purpose, in the first step, the needs of passengers for specific details were determined. In the second step, uniform interfaces between the real-time communication and information platform (Echtzeit- Kommunikations- und Auskunftsplattform; cf. EKAP third focus) and the mobile customer devices or between the EKAP and background systems were developed. Here, exclusively the data modeling and architectures were investigated and specified. The development of an application for mobile devices was specifically not intended and was only implemented for testing in the simplest form. The results of this part of the research project are documented in VDV 430.

The third focus (blue box in Figure 1) is to define and create an EKAP. The EKAP bundles information from ITCS and other information systems and provides a wealth of information over suitable interfaces to applications on the customer devices in a standardized form. This platform enables developers of apps to dynamically provide customers with individual messages about interruptions. The results of this part of the research project are also documented in VDV 431.

In addition, the practical feasibility of this new standard is verified in lab and field tests.

0 Translation Disclaimer

This document is an English translation of the German document “Internetprotokoll basiertes integriertes Bordinformationssystem IBIS-IP, Teil 1: Systemarchitektur, v1.0” released in January 2014. It is provided for convenience only and has no legal effect.

The translation of this document was done with the greatest possible accuracy. In case of any inconsistency the German original document applies.

1 Introduction

The IBIS vehicle bus standard according to the document VDV 300 represents, on the one hand, one of the most successful and longstanding standards of the Association of German Transport Companies (VDV). Since the 1980s and with the technical means of that time, it stipulated as to which datasets are used for the exchange of information between devices in the vehicle, such as on-board computers, indicators, validators, etc. passenger counting systems and so on.

On the other hand, it is becoming increasingly clear that there is a need for a new standard for the future. The requirements for passenger information are getting more and more diverse increasing the demands of the performance of passenger information.

For a long time, therefore, Internet Protocol-based solutions are being used also for passenger information within the vehicle. In the absence of a mandatory standard, a growing number of project-specific or vendor-specific Ethernet-based solutions have been developed in recent years. Such solutions mean high investments and integration efforts for transport companies as well as for manufacturers and involve significant risks for the project. Likewise, an exchange of information between the IBIS system and customer devices of passengers is only possible through expensive individual solutions. Today, customers traveling in different regions need different apps so as to use the information provided by the operators of public transport.

The integrated on-board information system based on Internet Protocol (IBIS-IP) represents, therefore, a powerful IP-based successor standard of the IBIS Wagenbus. Following the first requirements survey in the VDV release 3001, the need for a new communication medium was determined on the basis of use cases. In addition, specific migration scenarios between old and new systems have been dealt with in this publication. These findings were used as the basis for the concluded specifications in this document.

This document is intended to assist in the process of issuing tenders for new communication systems on vehicles of public transport and thus significantly reduce costs and risks through standard solutions. In order to keep alive this standard, the specifications will be reviewed and updated in the annual round of the sub-committee for communications and information systems (UA-KIS). This applies to the base specification as well as to additional services which could not be defined within the framework of the research project.

In this first part, the basic architecture of IBIS-IP is defined and described as to how the functionality of individual functions is determined and, based on that, how service-oriented architecture shall be developed. This architecture forms the basis for a vendor-independent architecture that is designed to ensure easy replacement of devices in the vehicle. Furthermore, the functional components are briefly described, and security aspects of the system are summarily discussed. This document concludes with definitions of communication architectures.

Having defined the system architecture of IBIS-IP in the first part, the second part, VDV 301-2, specifies the implementation of the technical interface based on XML structures.

2 Scope

IBIS-IP describes general rules of communication for communication between IP-based devices of customer information in individual vehicles of public transport, and specifies the protocol used in this communication. IBIS-IP provides particularly an IP-based successor standard for the IBIS Wagenbus defined in VDV 300. Mapping of all IBIS Wagenbus standard functionalities was, therefore, explicitly taken into account in the development of IBIS-IP. The proven master / slave architecture is evolved to a service-oriented architecture in order to enable sustainable flexible network technology advancements. On the one hand, with the definitions the focus is on a powerful communication medium and also independence from any manufacturer in regard to the peripherals.

The system architecture and the relevant applications presented in this document provide only for the integration of non-safety-related systems. A linking of safety-related systems can be implemented through defined interfaces (e.g. Gateways), in which the interface providers must be free of side-effects with respect to both systems.

3 System structure

In the following chapter, groups of functionalities are described, into which the functionalities of the IBIS-IP system are divided, and the IBIS-IP is classified in the communicative context. Finally, an introduction to the terminology is given which is used in the course of the document.

3.1 Basic architecture of IBIS-IP

After the requirements analysis (cf. VDV release 3001), the following players that exchange data with an IBIS-IP system of a vehicle were identified (cf. Figure 6):

- the vehicle that provides information about the vehicle to the IBIS-IP system through interfaces (e.g. door status, odometer information),
- the devices that host the IBIS-IP system on the one hand and on the other hand, enable first of all communication with other nodes through interfaces,
- route control with which the IBIS-IP system communicates for the purpose of traffic signal priority / switch control or beacon locating,
- the mobile customer device that exchanges passenger information data with the IBIS-IP system,
- ticket sale and verification devices which require information about the location in the public transport network,
- the ITCS that exchanges current real-time data with the IBIS-IP system and
- other data provision and disposal systems that exchange data with the IBIS-IP system which are not real-time data. This includes, for example, network data, timetable data, tariff data, configuration data, log data, interruption messages etc.

Such a list is, of course, open to new requirements and can be expanded in the future. On the basis of these players, also significant functionalities can be determined which must be available within the IBIS-IP system to operate these:

- basic functionalities that enable linking the IBIS-IP system to devices and vehicle systems through corresponding interfaces,
- customer communication functionalities that combine all relevant information for passenger information and make it available through corresponding interfaces,
- ticketing functionalities that identify and provide all relevant data for ticket issuing and verification,
- driver communication functionalities that take all relevant information from the driver and provide all relevant information to the driver,
- back office communication functionalities that enable exchange of data with the background systems and the ITCS.

In addition to this:

- also driving operation functionalities that include all functions dealing with determination of one's current position in the public transport network and the resulting forecast and
- vehicle operation functionalities that help manage the IBIS-IP system.

This results in the scheme shown in Figure 2, which represents the essential task managers of vehicle system and the interfaces to external systems. The figure is detailed further in chapter 4.3, Figure 6.

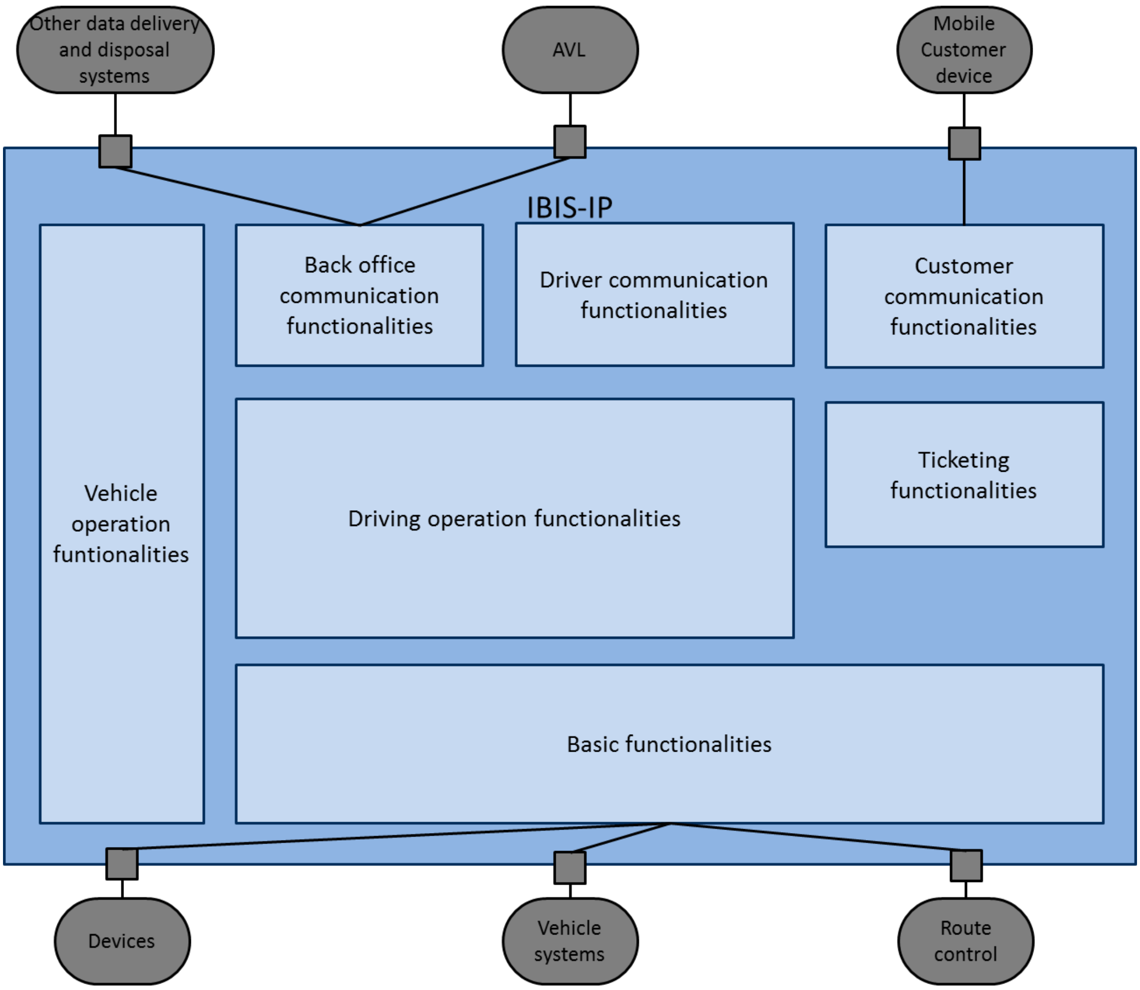

Figure 2: Classification of IBIS-IP in the communicative context.

Since the white box of Figure 2 deals with a number of different functions, one must speak correctly of functional groups (cf. chapter 3.2), e.g. of the group of the basic functionalities.

3.2 Terminology

In this chapter, the terms used later in the course of the document are introduced briefly.

Functional component

As part of the development of the IBIS-IP system architecture, the entire functionality of the system was split into parts with concretely nameable functional tasks - into so-called functional components (cf. chapter 4).

A functional component represents an encapsulation of functionality regardless of the manner of its implementation. A functional component can be, among other things

- an abstract interface to another system or device,
- an application,
- a service or
- a device.

Since, in the present document, only part of the functional components will be specified and implemented in the form of services or applications on devices the broader term "functional component" is used in the description of the functionality. This also takes the fact into account that the division into functional components was carried out with varied elaborateness.

Functional components are highlighted by using the following

`Font.`

Functional Groups

A functional group combines interrelated functional components together under one umbrella term.

Service-oriented architecture

IBIS-IP uses a **service-oriented architecture**. In Information Technology (IT), a service-oriented architecture is understood to be an architectural pattern that is based on the use of structured software modules, so-called services.

Service

A **service** represents a piece of software that encapsulates interrelated functionalities and makes them available through a specified interface. Besides the functionality, the definition of the functional scope of a service depends also on the fact which data belongs together or from which source the data originates.

Services run in the context of an operating system and, possibly, of a larger application on a device. But the architecture is determined completely independent of the devices being used, as the case may be.

The implementation of the functional component into services and the specification of the corresponding interfaces are described in Part 2 of the present document. Also the relation between a service and the associated functional component is explained there.

Operations

Services provide their functionalities through a series of operations.

Example 1:

The interrelationship between the device, service and operation is illustrated in Figure 3 with reference to a general case and in the example of the service SystemManagementService (an implementation of the functional component `System Management` *in the form of a service (cf. chapter 5.1.2 and Part 2 of the present document)).*

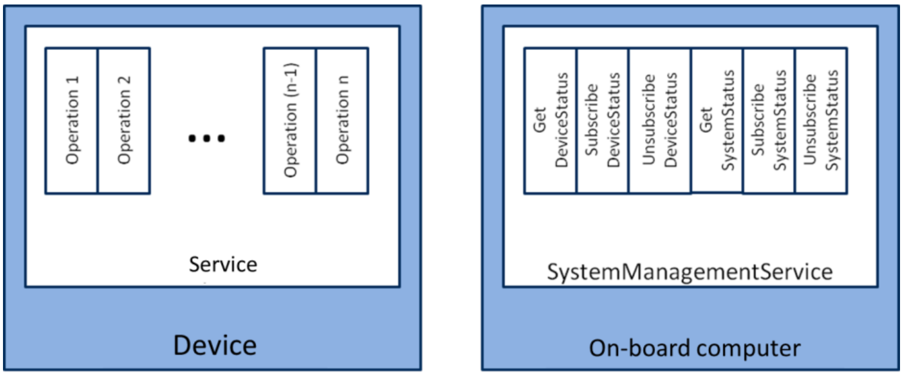

Figure 3: Classification of the terms device, service and operation.

In the example, the service "System Management Service" is running on the device "on-board computer. This service includes operations that allow querying once the status of the device (GetDeviceState) or the system state (GetSystemStatus). In addition, there are operations with which one can sign up for a subscription to certain information (e.g. SubscribeDeviceStatus, SubscribeSystemStatus) and also unsubscribe (e.g. UnsubscribeDeviceStatus, UnsubscribeSystemStatus).

More explanation about operations and services can be found in Part 2 of this document.

4 IBIS-IP system architecture

4.1 Determination of functional components

Based on the requirements described in the VDV release 3001 (cf. also [2]), all functional components were determined which are necessary so as to handle use cases described therein.

Moreover, for the development of an IBIS-IP system architecture

- the data flows in the different scenarios of the VDV release 3001 and
- the associated calls were analysed.

This resulted in a hierarchization of functional components that also form the basis for hierarchical service-oriented software architecture. Details on the specified services can be found in Part 2 of the document.

The following explains the procedure for determining the hierarchical structure with an example.

4.2 Hierarchization based on an example

The use case 6.1.1.6 "Transmission of a target text to an external indicator" of VDV release 3001 was analysed.

The following functional components are involved in this use case:

- *Driver MMI* (cf. also chapter 5.7.1)
  The functional component that provides the GUI (graphical user interface) to the driver, determines all information which the driver requires and passes on all driver inputs.
- *Journey Information Determination* (cf. also chapter 5.2.1)
  The functional component that determines the required location and time-specific information concerning the current trip, based on a setting by the driver or the control center.
- *Customer Information Determination* (cf. also chapter 5.3.1)
  The functional component that determines the data, based on the current network locating and information about the current trip, which is relevant to the passenger information.
- *Network Locating* (cf. also chapter 5.2.2)
  The functional component that determines the current location in the public transport network, on the basis of local data concerning an active trip (normally, based on the *Journey Information Determination)* and the *Physical locating* (GPS coordinates, distance pulse counter, door criterion).
- *Physical Locating* (cf. also chapter 5.5.6)
  This refers to the functional component that provides data about the physical location or about the devices (GPS receivers) through *Vehicle interfaces* (distance pulse counter, door signal).
- *Vehicle Interfaces* (cf. also chapter 5.5.5),
  The functional component that enables other services access to vehicle interfaces.
- *Passenger Display* (cf. also chapter 5.3.2),
  This refers to the functional component that handles the public visual presentation of information for the passenger.

The obtained flow of data is shown in Figure 4.

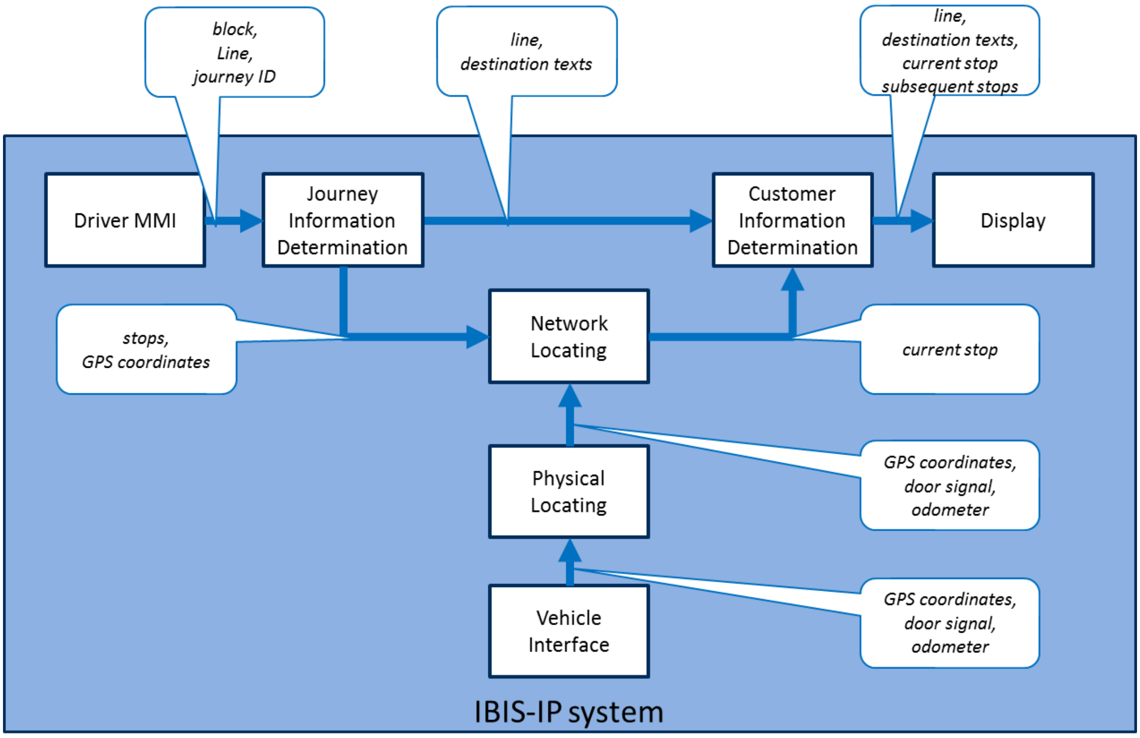

Figure 4: Illustration of data flows in the use case "Transmission of a target text to an external indicator". The data flow is in the direction of the arrows.

Using this method, the direction of data flow has been verified for a number of use cases. This approach was used mainly to check if the functional components represent a useful encapsulation, that is to say, whether always the same or at least a few different bursts of information must be provided by the functional component in question. Consequently, it was possible to produce also an orchestration for the architecture which was necessary for the implementation of service-oriented architecture. This process is illustrated in Figure 5 as an example for the use case mentioned above.

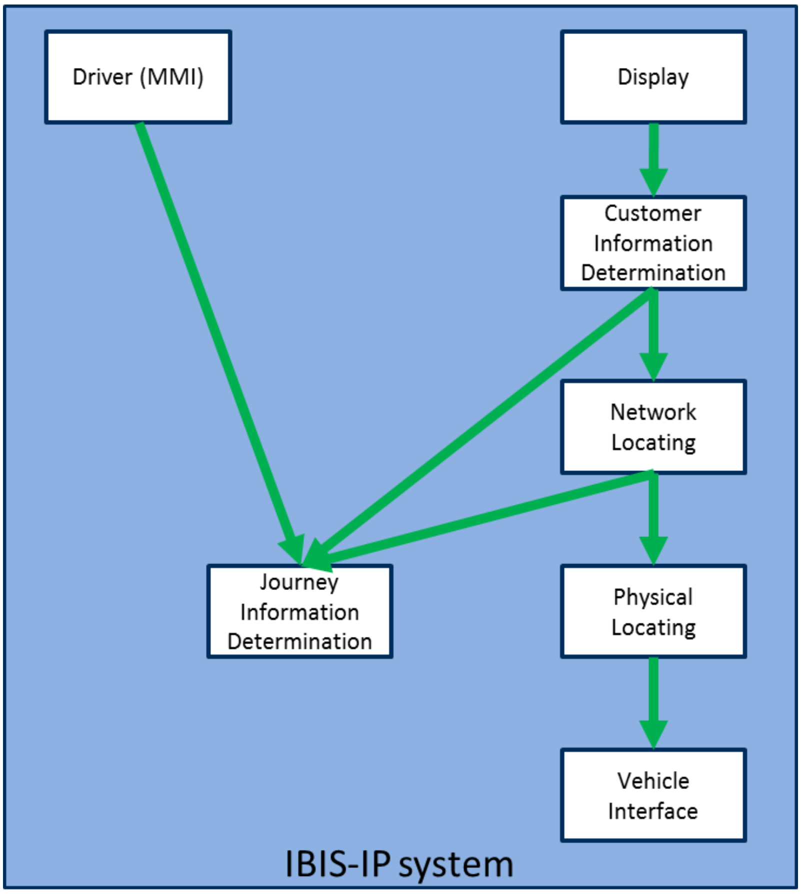

Figure 5: Hierarchization through an arrangement of functional components according to direction of calls.

The following applies to Figure 5 and the following figures:

- Functional components further below provide data to functional components further above.
- Functional components further above are, therefore, the active information users (client role), who retrieve data from passive information providers (server role).
- Functional components further below usually do not know the service of a functional component that queries data.
- Functional components or devices further above know the services of functional components from which they must retrieve data.
- The green arrows must be understood in the sense of "uses functionality of", e.g. the functional component `Customer Information Determination` uses a functionality of the service of the functional component `Journey information determination` that is provided by this service (namely, the functionality to determine the current line / course; cf. Figure 4).

4.3 The IBIS-IP system architecture

If we conduct this analysis for other use cases involving all identified functional components of the IBIS-IP system, the result would be an overall view of the system as shown in Figure 6.

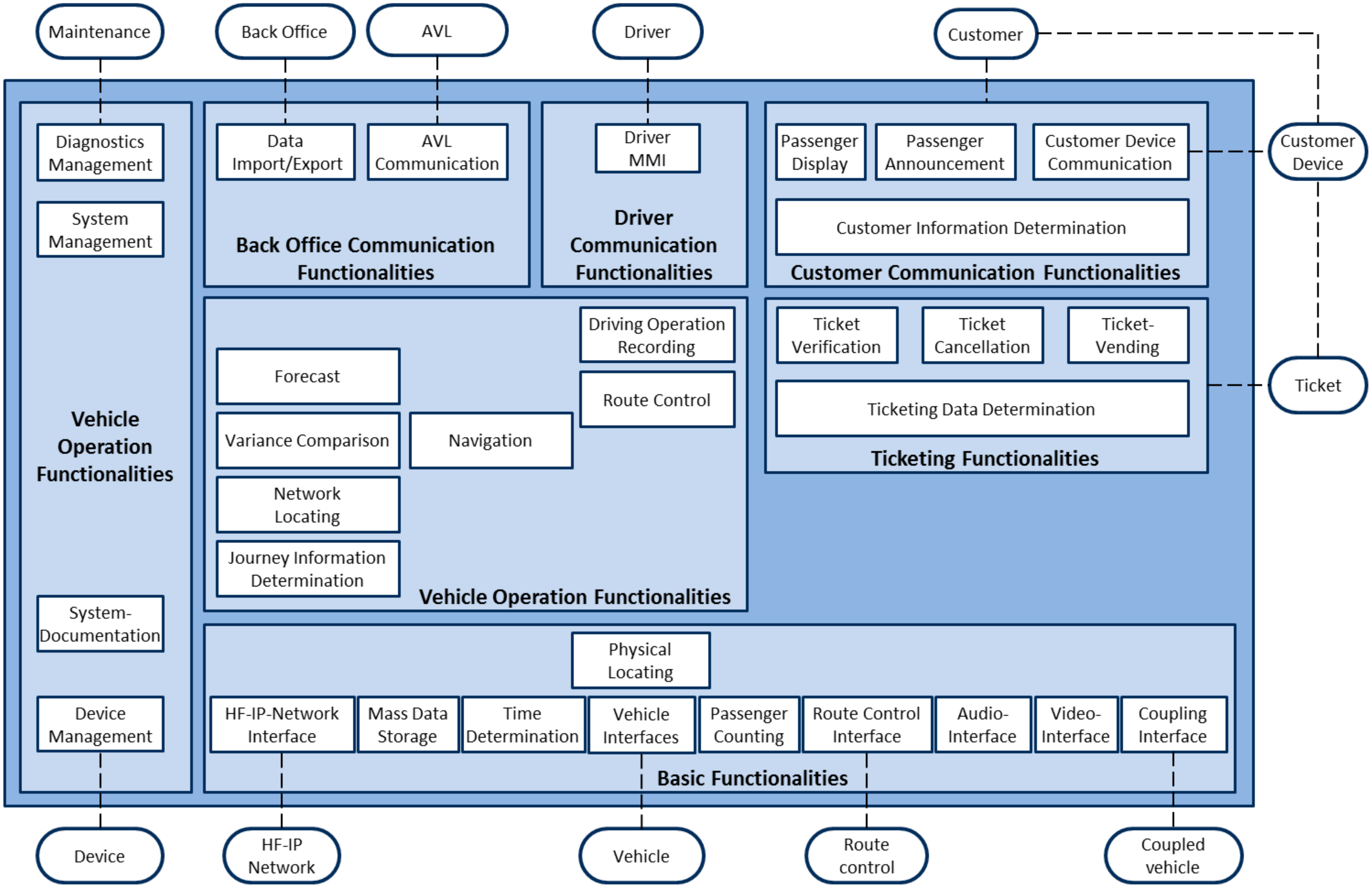

Figure 6: Hierarchy of the groups of functionalities and functional components in the IBIS-IP system.

The medium blue rectangle represents the IBIS-IP system and the white boxes are the functional components. The light blue rectangles represent groups of functionalities. Oval elements outside the IBIS-IP system are participants with whom the IBIS-IP system communicates through interfaces (not necessarily IP interfaces). They can be devices, organizational units or individuals.

In this figure, another, coupled vehicle appears in addition to the players mentioned in chapter 3.1. Since in the IBIS-IP architecture, each vehicle by itself represents a closed system, this is the link of another IBIS-IP system, for which corresponding interfaces need to be provided.

5 Groups of functionalities

This chapter explains the functionality of the functional components. The description follows the functional grouping of the functional components, which has already been used in chapter 3.1, i.e. into functionalities of the

- vehicle operation,
- driving operation,
- customer communication,
- ticketing,
- back office communication,
- driver communication and
- basic functionalities.

A detailed technical description, including the transition into services, is given in Part 2 of this document.

5.1 Vehicle Operation Functionalities

The vehicle operation functionalities include functional components which are intended to manage the operation of all devices and services that belong to an IBIS-IP system. Specifically, they are functional components such as

- Device Management
- System Documentation
- System Management and
- Diagnostics Management.

An overview of the functional components that belong to the functional group is given Figure 7.

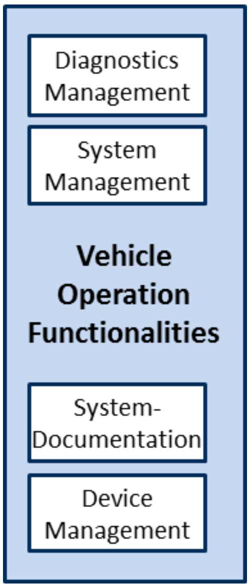

Figure 7: Overview of the functional group Vehicle Operation Functionalities

The functional components of the vehicle operation functionalities control particularly the system startup and are used to monitor the overall system at runtime. Details on the implementation of system startup and system monitoring can be found in Part 2 of this document.

5.1.1 Device Management

The functional component `Device Management` is distinguished from other functional components by the fact

- that it is present on every device of an IBIS-IP system and
- that it always starts automatically.

Through the `Device Management` of a device

- other services on a device are launched or stopped;
- information on the statuses of all services on the device is provided and
- information about the status of the device is provided;
- error messages are held out for diagnostics management.

This is generally done through communication with the functional component `System Management` (cf. chapter 5.1.3). Every device that has to be controlled and monitored in IBIS-IP by the `System Management` must possess a `Device Management`.

5.1.2 System Documentation

The functional component `System Documentation` is intended for

- collecting,
- logging and
- publishing

of

- System configuration data
- Status messages and error messages related to the system status.

In particular, the reference configuration of an IBIS-IP system can be queried through the `System Documentation`.

5.1.3 System Management

The functional component `System Management`

- controls and
- monitors

the IBIS-IP system

- at the start-up,
- during the operation and
- on shutdown.

In the event of a malfunction of a service, appropriate action (by restarting or stopping the faulty service, launching an alternative service, notification of other services) can be initiated through the `System Management`. In addition, the `System Management` allows the service personnel to intervene through a suitable interface for the `Diagnostics Management` (cf. chapter 5.1.4) by monitoring the current IBIS-IP system or by controlling.

5.1.4 Diagnostics Management

The functional component `Diagnostics Management`

- represents the interface between the workshop personnel and the IBIS-IP system.

For this purpose, it provides a web interface through which

  - the status of all devices and
  - the status of all services are displayed in human readable form and
  - services can be launched or stopped manually.

This is done through an interface between the `Diagnostics Management` and the `System Management`.

Furthermore,

- the configuration of the IBIS-IP system and of individual devices can be changed.

This is done through an interface to the `System Documentation` or to the individual devices.

In addition, any available optional device or service-specific service web interface can be accessed through the `Diagnostics Management`.

5.2 Driving Operation Functionalities

The driving operation functionalities include within the IBIS-IP system the functional components that are significant for the execution of public transport operations.

Thus, in this functional group, the information necessary for indicators, operational control systems and ticketing is determined based on timetable data, depending on time and space related locating in the public transport network, and made available within the services availing the IBIS IP. An overview of the functional components belonging to the functional group is given in Figure 8.

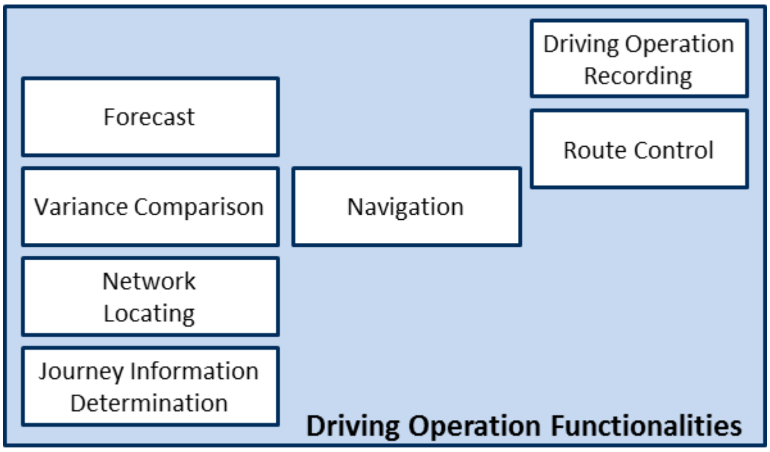

Figure 8: Overview of the functional group Driving Operation Functionalities.

5.2.1 Journey Information Determination

The functional component `Journey Information Determination`

- determines all relevant reference data based on a trip identification concerning this trip

and it can optionally

- pass on to the **querying service** (e.g. when data is requested through the `Driver MMI` for information only) or
- **use as a current system-wide trip** (e.g. if a new trip is set through the `Driver MMI` or the ITCS).

5.2.2 Network Locating

The functional component `Network Locating` is intended

- for determining the current position in the network.

Normally, this is done on the basis of

- reference data of the `Journey Information Determination` (cf. chapter 5.2.1) and
- realtime information of the `Physical Locating` (cf. chapter 5.5.6).

5.2.3 Variance Comparison

The functional component `Variance Comparison` is used;

- to determine the timetable status (earliness, delay) of a vehicle

based on the comparison of the actual position of a vehicle with respect to the expected position of the vehicle according to the timetable.

5.2.4 Forecast

The functional component `Forecast` is used

- to determine the expected arrival and departure times at the subsequent stops.

This is done in the simplest case, taking into account the reference data of the trip, and considering the current timetable status. The quality of this forecast depends on how well the target reference can reflect the real situation. It is not for this VDV recommendation to define how the forecast can be optimally determined. This must be defined project-specifically.

5.2.5 Driving Operation Recording

The functional component `Driving Operation Recording` is used

- to record relevant operational events resulting from driving operation and to link with current network and position information.

For example, by this a passenger counting dataset can be linked to the associated stop. It is not for this VDV recommendation to define the frequency at which this data needs to be recorded. This must be defined project-specifically.

5.2.6 Navigation

The functional component `Navigation` is used

- to determine navigation information on the current trip.

This is done taking into consideration the trip distance information about the current trip, which is determined either on the vehicle or at the control center. It is not for this VDV recommendation to define the quality with which this data needs to be determined. This must be defined project-specifically.

5.2.7 Route Control

The functional component `Route Control` is used

- to determine information on required route control actions (traffic signal priority, switch control, etc.).

This is generally based on the trip distance data of the current trip and the information about the current location. It is not for this VDV recommendation to define with which local accuracy it needs to be done. This must be defined project-specifically.

5.3 Customer Communication Functionalities

The functional components of the functional group of customer communication functionalities are used for either public passenger information (display, announcement) or they allow a passenger to retrieve individual information (e.g. possibilities of interchanging) or to transmit the same (e.g. a stop request). The interface itself is specified in the document VDV 431-2. In Figure 9 there is an overview of the functional components summarized in the functional group.

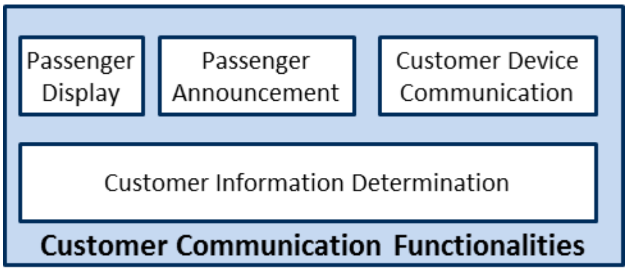

Figure 9: Overview of the functional group Customer Communication Functionalities.

5.3.1 Customer Information Determination

The functional component `Customer Information Determination`

- determines all information relevant to passenger information and

- represents the source of all passenger information data (public as well as individual) that is transmitted in an IBIS-IP system.

Such a uniform source is necessary so as to prevent inconsistencies in the passenger information, which could arise if passenger information devices would independently retrieve data from various data sources.

5.3.2 Passenger Display

The functional component *`Passenger Display`* is a device for visual, public passenger information.

On the *`Passenger Display`* a software application runs

- which retrieves the passenger information to be displayed from the *`Customer Information Determination`* (cf. chapter 5.3.1) and processes it for visual display.

The statements of chapter 5.1.1 continue to apply to the device.

5.3.3 Passenger Announcement

The functional component *`Passenger Announcement`* is a device for acoustic, collective passenger information.

On the device for *`Passenger Announcement`* a software application runs

- which retrieves the necessary announcement information from the *`Customer Information Determination`* and reproduces it acoustically.

The statements of chapter 5.1.1 continue to apply to the device.

5.3.4 Customer Device Communication

The functional component *`Customer Device Communication`* is used

- to offer a bidirectional interface between the *`Customer Information Determination`* and the customer devices.

Through this interface, for example, passenger information is transmitted from the vehicle to the customer device and a stop request from the customer device to the vehicle. Basically, this interface provides bidirectional communication for future developments or needs of passengers.

5.4 Ticketing Functionalities

In the functional group of ticketing functionalities, all functional components are put together that support the sale, verification or validation of electronic and paper tickets. The functional components intended for this can be found in Figure 10.

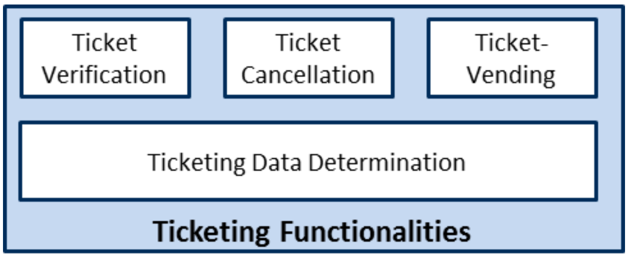

Figure 10: Overview of the functional group Ticketing Functionalities

5.4.1 Ticketing Data Determination

The functional component `Ticketing Data Determination` determines all information relevant to ticketing, taking into account the current location in the network and the tariff data valid in this network and makes it available to all the participants in IBIS-IP. Furthermore, the `Ticketing Data Determination` is capable of verifying on the basis of given data if a ticket is valid or not.

5.4.2 Ticket Verification

The functional component `Ticket Verification` is a device which is able to verify the validity of a ticket on the basis of data read from the ticket including the `Ticketing Data Determination`.

The statements of chapter 5.1.1 continue to apply to the device.

5.4.3 Ticket Cancellation

The functional component `Ticket Cancellation` is a device which is able to validate a ticket on the basis of data delivered by the functional component `Ticketing Data Determination`. In the simplest cases, this can be done by a corresponding stamping. In more complex cases, corresponding information of the `Ticketing Data Determination` can be written.

The statements of the chapter 5.1.1 continue to apply to the device.

5.4.4 Ticket Vending

The functional component `Ticket Vending` is represented by a vending machine and includes the following functions:

- provision of a MMI for the sale of tickets.

The machine obtains the information necessary for the sale from the functional component `Ticketing Data Determination`.

The statements of the chapter 5.1.1 continue to apply to the device.

5.5 Basic Functionalities

The functional group of basic functionalities includes in IBIS IP a range of functional components that provide either an interface to peripheral devices or deliver the basic information with less functional complexity. Figure 11 illustrates this functional group.

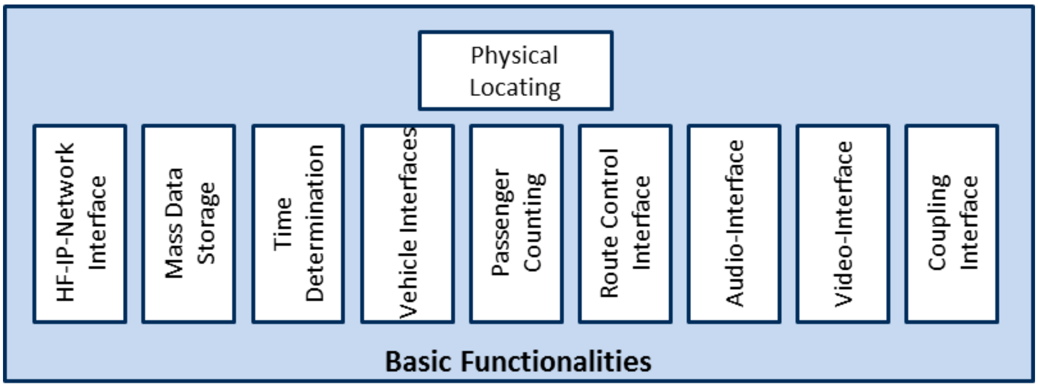

Figure 11: Overview of the functional group Basic Functionalities.

5.5.1 HF-IP Network Interface

The functional component *HF-IP Network Interface* is used

- to provide an interface between the IBIS-IP network and an HF network.

An HF network means analogous, digital and IP data radio systems.

5.5.2 Mass Data Storage

The functional component *Mass Data Storage* is used

- to store, write and to read data.

This can include data of a video system as well as trip and network data that are transmitted from the back office to the vehicle.

5.5.3 Time Determination

The functional component *Time Determination* is used

- to determine the exact time and
- to provide a time server for synchronizing the time between the participating devices of an IBIS-IP system.

5.5.4 Passenger Counting

The functional component *Passenger Counting* is a device that is used

- to register the number of passengers boarding and alighting the vehicle or
- the percentage of vehicle occupancy and to make the information available.

The statements of the chapter 5.1.1 continue to apply to the device.

5.5.5 Vehicle Interfaces

The functional component *Vehicle Interfaces* is used

- to provide interfaces between IBIS-IP network and information about vehicle-internal communication systems (such as MVB, BusFMS, odometer, door signal).

For naming the functional component, the plural form was consciously chosen because functionally and technically there can be several interfaces.

5.5.6 Physical Locating

The functional component *Physical Locating* is used

- to determine the geographical coordinates,
- to determine the distances or odometer pulses and
- to determine locating-relevant information (beacon information).

5.5.7 Route Control Interface

The functional component *Route Control Interface* is used

- to provide an interface between the IBIS-IP system and the device for route control.

Devices for route control can be, for example, analogous radio units or devices for inductive message transmission.

5.5.8 Coupling Interface

The functional component `Coupling Interface` is used

- to provide a communication link between the IBIS IP systems in two or more coupled vehicles.

It is important to note that IBIS IP treats the individual vehicles as closed networks. A resolution of the coupling information and treatment must be handled by this interface.

5.5.9 Audio Interface

The functional component `Audio Interface` is used

- to provide functionalities for IP based audio communication in the system.

There is of course a close connection to the announcement devices, such as a passenger announcement system.

5.5.10 Video Interface

The functional component `Video Interface` is used

- to provide functionalities for IP-based video communication in the system.

5.6 Back Office Communication Functionalities

The functional group of back office communication functionalities provides functions in the IBIS-IP that allow an exchange of information between the vehicle and a back office system. Here, primarily communication with the operation control center (AVL) is obvious. But also the transmission of software, firmware or data updates is ensured by the functional components of this functional group. The functional components needed for this can be found in Figure 12.

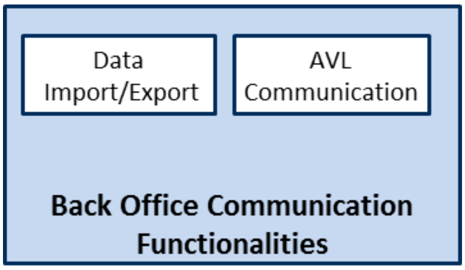

Figure 12: Overview of the functional group Back Office Communication Functionalities.

5.6.1 Data Import/Export

The functional component `Data Import/Export` is used

- to exchange data between the vehicle and a back office system, such as
    - Firmware updates
    - Timetable data
    - Ticketing data
    - Diagnostics data
    - Logging data and so on.

5.6.2 AVL Communication

The functional component `AVL communication` is used

- to exchange current operationally relevant information with the CAD-AVL.

It is not for this VDV recommendation to standardize the air (wireless) interface between the vehicle and the control center, but only the necessary data for the data exchange between vehicle and control center.

5.7 Driver Communication Functionalities

The functional group of driver communication functionalities makes the functional component(s) available, which are necessary for an interaction between the driver and the IBIS-IP system (cf. Figure 13).

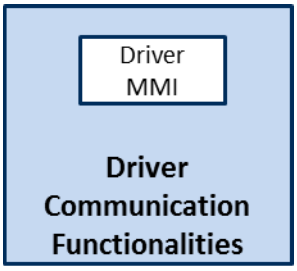

Figure 13: Overview of the functional group Driver Communication Functionalities.

5.7.1 Driver MMI

The functional component `Driver MMI` is

- the interface between the IBIS-IP system and the driver.

It enables

- the driver's inputs and
- the presentation of information concerning the operational (current network position, current delay, instructions and messages, etc.) or functional status (error messages from devices, etc.) of the system in text or graphics mode.

6 System security

The IBIS-IP system has a number of interfaces through which it is connected to other participants (cf. chapter 4.3). Therefore, it could potentially interfere with other systems or, inversely, other systems can interfere with this system.

To prevent external interference with the IBIS-IP system, the IBIS IP must be protected with contemporarily adequate safeguards against unauthorized intrusion.

To prevent infringement of safety-relevant components (e.g. vehicle braking system), interfaces to these systems must be designed in unidirectional form or, in the case of bidirectional communication, in such a way to rule out failure of safety-relevant components.

7 Communication with services

In a detailed examination of individual functional components, it is apparent that the transmitted information can be usually assigned two different groups:

- There is information that generally keeps changing at very short (<1 s) intervals and for which a fast and simultaneous transportation of information to consumer is more important than a reliable transfer of information (cf. VDV 301-2, chapter 4).

- As against the above, there is information that changes rarely (> 1s). If it changes at all, it must be ensured that all consumers are reliably made aware of this change (cf. VDV 301-2, chapter 4).

Bearing the IP standard protocols from the OSI layer 4 in mind, we come to the conclusion that for the rapidly changing information due to the simultaneous transmission to many participants, the UDP protocol is most suitable; alternatively, the TCP protocol for longer valid information due to the security of transmission.
By using the UDP protocol for rapidly changing information, it is ensured that this information is distributed simultaneously to all consumers. To ensure compatibility with the IP protocol IPv6, broadcast mechanisms must be dispensed with and, instead, UDP multicast must be used (cf. VDV 301-2, chapter 4)).
In a more detailed examination of the tasks and communication processes with longer valid information, it was apparent that the HTTP protocol built on top the TCP protocol facilitates much functionality that is necessary for these processes. Therefore, the decision is to use the HTTP protocol for the transmission of reliable communication within IBIS-IP.

Moreover, it is quite imaginable that also other IP-based communication protocols could be used (e.g. SNTP for time synchronization or the RTP protocol for streaming of audio and video data). However, these are not yet specified in this issue.

7.1 Structuring the information content

Since all currently established interface descriptions in the domain of public transport (e.g. SIRI, VDV 453, VDV 454) are built on the XML format, the XML format is to be used as well for the transmission of information between two services in IBIS-IP. This also applies to the interface developed as part of the IP-KOM-ÖV architecture for mobile applications (cf. VDV 431-2). In the implementation of XML-structures also the SIRI standard [5] has been taken into consideration for the sake of homogeneity of the data from the information systems.

8 Terminology

Term	Description
Audio Interface	Functional component in IBIS-IP that enables IP-based language communication between customers and driver or the control center.
AVL communication	Functional component in IBIS-IP that provides communication between ITCS and vehicle.
Back Office communication functions	Umbrella term in IBIS-IP that summarizes the functional components which enable communication with background systems outside the vehicle.
Basic Functionalities	Umbrella term in IBIS-IP that summarizes the functional components which make basic functionalities of the vehicle available.
Beacon locating	Based on fixed locating points

	(beacons), vehicles passing the beacon can determine their current position in the network.
Client/Server	Interrelated as carriers of information and receivers of information within a network.
Component	From the viewpoint of the IBIS-IP system, a component is a participant in the network communication.
Coupling Interface	Functional component in IBIS-IP that provides an interface for configuration and communication when two or more vehicles are coupled.
Customer Communication Functionalities	Umbrella term in IBIS-IP that summarizes the services which are directly associated with the Customer Communication.
Customer Device	This can be the simple mobile phones, smartphones/PDA, navigation systems or Notebooks.
Customer Device Communication	Functional component in IBIS-IP that handles the entire operating and information interface in the mobile customer device.
Customer Information Determination	In IBIS-IP, the functional component Customer Information Determination is used as a source of information for all types of passenger information.
Data Import/Export	Functional component in IBIS-IP that provides communication between the "back office" and vehicle for the exchange of files.
Device Management	Functional component in IBIS-IP that provides an interface to controlling and monitoring of a *device*.
Diagnostics Management	Functional component in IBIS-IP that handles the entire operating and information interface to the personnel of the workshop.
Driver Communication	Umbrella term in IBIS-IP that summarizes the functional components which enable interaction between driver and IBIS-IP.
Driver MMI	Functional component in IBIS-IP that handles the entire operating and information interface to the driver.
Driving operation recording	Functional component in IBIS-IP that assumes the task of recording data related to the driving operation (e.g. drive profile data, passenger counting, etc.).
Ethernet	Basic network technology for communication among computer networks.

Forecast	Functional component in IBIS-IP that determined forecasts for the arrival and departure time, including interchange connections at successive stops for the current and, as the case may be, subsequent trip.
Functional component	A functional component represents an encapsulation of functionality regardless of the method of its implementation. A functional component can be, among other things • an abstract interface to another system or device • an application • a service or • a device.
Functional groups	A functional group summarizes several functionally related functional components into one umbrella term.
Functionality	The functionality signifies the parts of a system that has concretely nameable functional tasks such as “Validate ticket”.
Gateway	A Gateway is the linking of two mostly different networks. Such linking can be implemented merely physically but also by utilizing software technology.
HF-IP Network Interface	Functional component in IBIS-IP that provides an interface between the vehicle IP network and an HF-IP network (UMTS, WLAN, GPRS and similar).
IBIS	The Integrated On-board Information System is an obsolete communication standard for exchange of passenger information (cf. [1]).
IBIS-IP	Internet Protocol-based successor standard of IBIS according to VDV 300.
IBIS System	A Master/Slave based network on vehicles for passenger information in the public transport system (cf. [1]).
IBIS Wagenbus	Communication medium based on IBIS (cf. [1])
Journey information determination	Functional component in IBIS-IP that determines the current trip or the current trip route, including all related data that is assigned to a trip or a trip route.
Mass Data Storage	Functional component in IBIS-IP that assumes the task of storing

	and provision of files.
Master/Slave architecture	Describes a special type and method of communication within a network. In this, the Master coordinates the communication processes of the rest of the participants (Slaves).
Navigation	Functional component in IBIS-IP that provides information to the driver for finding the route in the traffic network.
Network Locating	Functional component in IBIS-IP that provides information about the current position on the trip route.
On-board computer	In the age of IBIS this has been the central controlling computer (IBIS-Master). In more advanced communication architectures, this can also be only an MMI.
Operation	Services provide their functionalities through a series of operations.
Orchestration	Arrangement of services within a service-oriented architecture.
OSI layer	Internationally standardized definition of network protocols based on seven layers.
Passenger Announcement	Functional component in IBIS-IP that processes acoustical information intended for the passengers.
Passenger counting	Functional component in IBIS-IP that determines the number of boarding and alighting passengers or the percentage of vehicle occupancy and makes the information available.
Passenger Display	Functional component in IBIS-IP that processes visual information intended for the passengers.
Physical Locating	Functional component in IBIS-IP that provides trip route independent information to determine the location.
Route Control	Functional component in IBIS-IP that initiates route control actions, like acting on signal systems (among other things on traffic lights) depending on the current location and the reference data provided.
Route Control Interface	Functional component in IBIS-IP that provides an interface to route control.
Service	A service represents a piece of software application that encapsulates functionally associated func-

	tionalities and makes it available through a specified interface. Besides the functionality, the definition of the functional range of a service also conforms as to which data belongs together or from where the data is sourced.
Service-oriented architecture	This describes a system architecture which, independent of the communication medium, encapsulates information and can exchange it between services.
Streaming	The transportation of digital video or audio data over a network.
System architecture	Shows the system of linking of entities which must be available to each other for communication.
System Documentation	Functional component in IBIS-IP that stores and makes available the system configuration data.
System Management	Functional component in IBIS-IP that assumes the total control of services and devices in IBIS-IP.
Ticketing	Umbrella term in IBIS-IP that summarizes the functional components which are directly associated with the ticketing process.
Ticket Cancellation	Functional component in IBIS-IP that provides an interface for ticket cancellation and ticket validation systems.
Ticket Vending	Functional component in IBIS-IP that provides an interface for the ticket sale systems.
Ticket Verification	Functional component in IBIS-IP that provides an interface for ticket verification systems.
Time determination	Functional component in IBIS-IP that determines and provides time information.
Variance Comparison	Functional component in IBIS-IP that determines the time variance between the current and planned timetable status.
Vehicle Interfaces	Functional component in IBIS-IP that provides an IBIS-IP-system with non-IBIS-IP vehicle data from sources outside the IBIS-IP system.
Vehicle Operation Functionalities	Functional group in IBIS-IP that summarizes the functional components which are associated with the structure and the operation of the IBIS-IP network in the vehicle.
Video Interface	Functional component in IBIS-IP that enables transmission of video

	data based on IP in the system.

9 Abbreviations

Abbreviation	Description
App	Application primarily found on mobile devices of passengers
BMWi	Bundes Ministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)
EKAP	Echtzeitkommunikations- und -auskunftsplattform. (Real-time Communication and Information Platform) Cf. VDV 431-1.
ELA	Elektroakustische-Anlage (Public Address system, PA)
HTTP	Hypertext Transfer Protocol
IBIS	Integrated On-board Information System
IBIS-IP	Integrated On-board Information System based on Internet Protocol
IBIS-IP	Integrated On-board Information System based on Internet Protocol
IP	Internet Protocol
IP-KOM-ÖV	Internet Protokoll basierte Kommunikationsdienste für den öffentlichen Verkehr (Internet Protocol based Communication Services for Public Transport)
IPv6	Internet Protocol according to Version 6. Its earlier version was the Version 4 (IPv4).
IT	Information Technology
ITCS	Intermodal Transport Control System
TSP	Traffic signal priority
MMI	Man-Machine Interface
OSI	Open Systems Interconnection
RTP	Real-time Transport Protocol
SIRI	Service Interface for Real Time Information EN 15531
SOA	Service-oriented architecture
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VDV	Verband Deutscher Verkehrsunternehmen (Association of German Transport Companies)
XML	“Extensible Markup Language” is a specification of the World Wide Web Consortium (W3C). XML is a mark-up language which is used for platform-independent exchange of data.

References

[1] VDV recommendation 300: “Integriertes Bordinformationssystem IBIS“ (Integrated On-board Information System IBIS)

[2] VDV Release 3001: “Kommunikation im ÖV (IP-KOM-ÖV) - Technische Anforderungen für Anwendungen im Integrierten Bordinformationssystem (IBIS)“ (Communication in Public Transport – Technical Requirements for Applications in the Integrated On-board Information System (IBIS))

[3] VDV recommendation 453 “VDV-Ist-Datenschnittstellen“ (VDV Actual data interfaces)

[4] VDV recommendation 454 “VDV-Ist-Datenschnittstellen“ (VDV Actual data interfaces)

[5] EN 15531 “Service Interface for Real Time Information”

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