

Overview of Mobile Passenger Information Systems in Public Transport

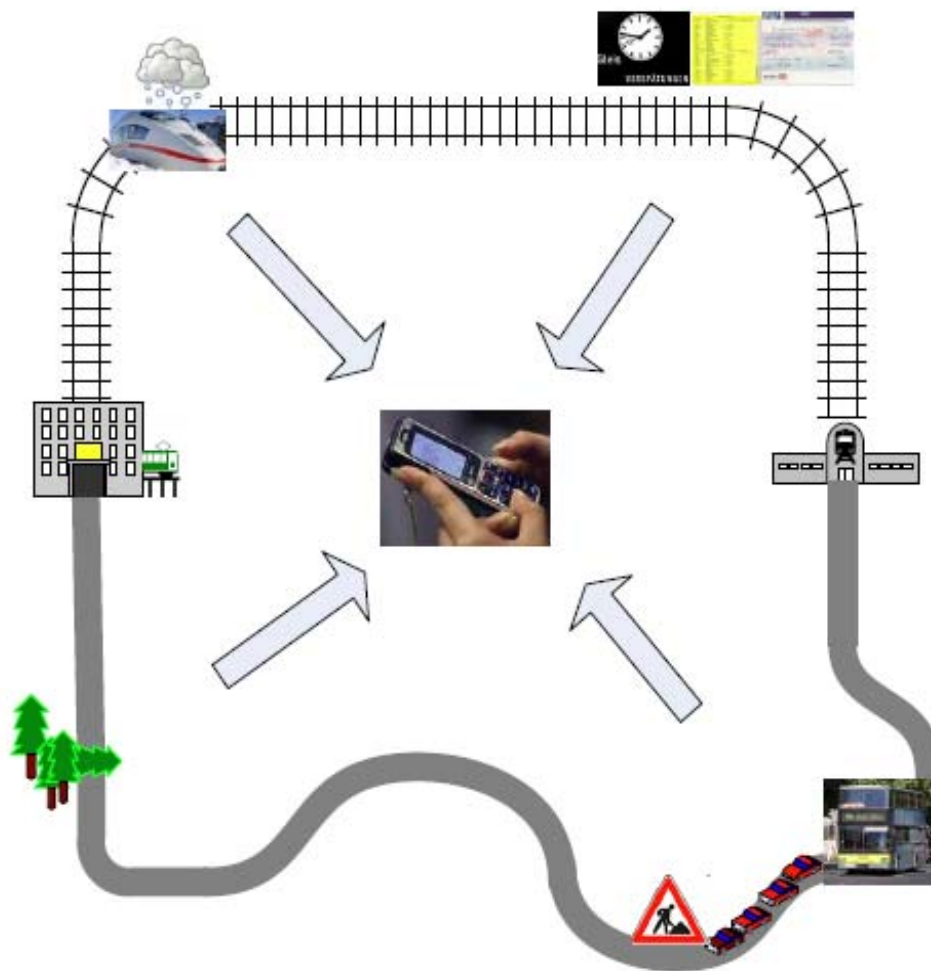
Peggy L. Nguetse Jongo, Marek Meyer, Ralf Steinmetz
Technical Report – KOM-TR-2010-02



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Abstract

Information on schedules, connections delay and the possibility to choose an appropriate route are important services for public transport passengers. Public transport companies in turn need to create systems which offer better quality of services to their passengers. Real-time information on the public transport network reduces waiting time and costs, facilitates journey planning and increases customer satisfaction and loyalty. Systems delivering such information are called Passenger Information Systems (PIS). There are many types of existing Passenger Information Systems. Most of them however are unable to provide tailored information to each passenger.

The large coverage of mobile telephony offers public transport companies new possibilities to inform passengers separately. In several cities public transport passengers are already able to receive information like bus departure times over mobile telephone by request. These services are called mobile messaging. Mobile messaging are provided to mobile phone in different ways: WAP, I-mode, SMS, MMS and Smartphone format; but they are expensive compared with stationary passenger information systems. Another option is to store an application on the mobile phone, which provides all the latest important information on transport network, even without an Internet connection. This is today the cheapest way of passenger information on mobile phone.

This paper provides an analysis of a variety of passenger information systems actually used in different locations all over the world.

Keywords

Passenger information, public transport, SMS, MMS, WAP, I-mode, PDA, Push technology, Pull technology, event based service, mobile messaging



1 Introduction

A mobile phone is nowadays not just a terminal for mobile telephony application; it is a personal computer with a lot of functionalities. These functionalities are already used in different sectors like medicine, banking, government and education. The trend is now to introduce these techniques to the transportation sector, particularly public transport (PT). Static information from timetables are more and more insufficient to plan and organize an exact travel. Oftentimes, there is cancellation and passengers need additional information during the trip to plan their journey. Existing passenger information systems give general information about a travel but they are not able to provide each passenger with its relevant information in case of disturbance. Market research shows that one of the main barriers for not using public transport is the low quality of information [1]. Thus Passenger Information Systems (PIS) may not only improve customers' satisfaction, but also increase the usage of public transport. The spread of mobile phones (in Germany there are 60 million mobile phone users) gives public transport companies new possibilities to supply PT passengers with information and allow the emergence of new passenger information channels called mobile PIS. Such systems should provide personalized and real-time information everywhere and thereby improve passenger satisfaction.

This study analyses the current situation of passenger information systems. The first section gives an overview on the most known communication technologies used to provide information to mobile phone users.

The second section presents a report on different passenger information systems: print media are described such as standard passenger information systems like on-board-display and mobile passenger information systems.

The last part of this report describes some European and German research projects which focused on passenger information systems.



2 Relevant technologies

This chapter gives an overview on the technological foundation of mobile passenger systems. In the first section different mobile network technologies are described. The focus of the second section is on mobile messaging. In the third section methods of content delivering are illustrated.

2.1 Mobile network technology

Sending and receiving messages through a mobile device requires a mobile network. Figure 2.3 gives an overview on the network evolution over the time containing technologies described below.

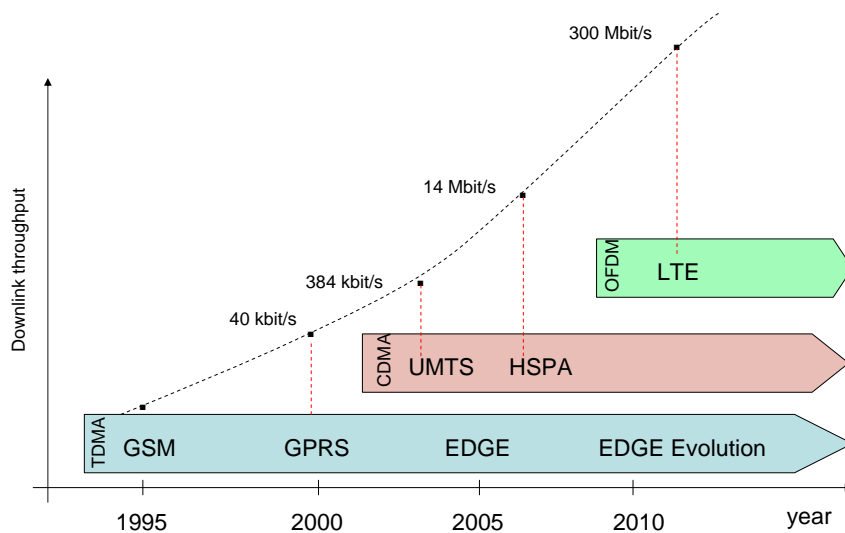


Figure 2.1: Evolution of cellular network technology
[10]

2.1.1 GSM

GSM (Global System for Mobile communication) is the most popular standard for mobile telephony systems in the world. It is now used in 219 countries and territories serving more than three billion people and providing travellers with access to mobile services wherever they go ¹. GSM was initially created to provide better voice ser-

¹ <http://www.gsmworld.com>, last visited 16.12.09

vices (called teleservices) and also provide data transmission services (called bearer services). It is the successor of the analogue communication system and operates in Europe in the 900 MHz and 1800 MHz band. In the USA and Canada this spectrum is used for other purposes, therefore the 850 MHz and 1900 MHz bands are used. Other countries use a combination of these bands to operate on GSM networks. These bands are divided in two 25 MHz carriers, the lower one for uplink and the upper one for downlink transmission [3] The 25 MHz carriers are again divided in 124 FDMA (Frequency Division Multiple Access) channels with 8 time slots per carrier, which then form the speech channel. This means that in total up to 992 speech channels are available and any speech channel offers a bit rate of 22.8 kbit/s.

GSM-Railway (GSM-R) is the standard mobile communication network for railways in Europe. It is based on GSM-technology but uses a specific frequency band: In Europe, the frequency band between 876 MHz and 880 MHz is used for data transmission in uplink mode and the frequency band between 921 MHz and 925 MHz is used for data transmission in downlink mode. GSM-R delivers features such as voice group call service, voice broadcast service, railway emergency call, location-based connections, and call pre-emption in case of an emergency [4]. [5] provides a good overview on GSM-R.

2.1.2 CSD, HSCSD

CSD (Circuit Switched Data) is the first form of data transmission developed for mobile phone systems like GSM. CSD uses a single radio time slot to deliver 9.6 kbit/s data transmission to the GSM Network.

HSCSD (High Speed Circuit Switched Data) was introduced in the GSM Phase 2+. It is an enhancement to CSD and gives a user connection to multiple channels at the same time. HSCSD allows theoretical speeds of up to 57.6 kbit/s.

2.1.3 GPRS

General Packet Radio Service (GPRS) is an enhancement of HSCSD for an efficient data transmission speed. GPRS allows a theoretical downlink throughput per cell of 160 kbits/s [4] using 8 time slots in parallel. It is based on wideband code division multiple access (W-CDMA) radio technology offering greater spectral efficiency and higher bandwidth than GSM. GPRS was introduced into the GSM specifications in Release 97 and its usability was further approved in Releases 98 and 99 and supports existing packet-oriented protocols: IP, X.25 [8]

GPRS technology offered a significant advantage in the data transfer capacity over existing cellular systems. It introduces new data services[7]. Some of these services are nowadays intensively used in public transport: multimedia messages service (MMS),

internet applications for smart devices through wireless application protocol (WAP) or SMS (Short message service) which is also supported on GPRS.

2.1.4 EDGE

EDGE (Enhanced Data Rates for GSM Evolution) is a further step in the GSM evolution. Its standardization was finalized by 3GPP in 2000 and the first networks were deployed in 2003. EDGE carries a peak data rate of 384 kbit/s in downlink. The commercial average datarate of EDGE is in the range of 200 kbit/s.

2.1.5 UMTS

Universal mobile telecommunication system (UMTS) offers circuit switched and packet based data transmission, real time and not real time services as well as different carrier services. UMTS is based on W-CDMA (wideband code division multiple access) radio technology. It is an enhancement of GPRS and was developed by 3GPP² (Third-Generation Partnership Project). 3GPP introduced UMTS in phases and annual releases [4].

The first release (UMTS Release 99), introduced in December 1999, defines enhancements and transitions for existing GSM networks in 440 specifications. The most significant change is the new UMTS terrestrial radio access Network (UTRAN). Its architecture allows point-to-point and also point-to-multipoint services (broadcast, multicast) such as real-time and non-real-time services. Wideband Code division multiple access (W-CDMA [9]) is introduced and replaces GSM methods (time and frequency multiplex) for transmission rate. Release 99 provided downlink rates of up to 384 kbit/s and uplink speeds of up to 128 kbit/s, when it was introduced to the market. For Germany the frequency bands 1920 MHz - 1980MHz are reserved for UMTS uplink and 2110 MHz - 2170MHz for UMTS downlink.

2.1.6 LTE

LTE stands for Long Term Evolution. It was introduced in the 3GPP Release 8 and is the next major step in mobile radio communications. LTE uses OFDM (orthogonal frequency division multiplexing) radio access technology together with advanced antenna technology in order to accommodate increasing mobile data usage and new multimedia applications. LTE supports transmission bandwidth up to 20 MHz. It is designed to ensure high performance between 15-120 km/h and still expected to maintain connectivity at speeds between 120 and 350 km/h even up to 500 km/h for some frequency bands [10]. Thus LTE connection will be stable even in highspeed trains.

² <http://www.3gpp.org/>, last visited 18.12.09

2.1.7 NFC

NFC stands for Near Field Communication. It is a very short-range wireless connectivity technology (also known as ISO 18092) developed in 2002 by Philips and Sony. It is based on RFID [12] (Radio Frequency Identification) that uses magnetic field induction. Its main objective is to provide intuitive, simple, and safe communication between electronic devices between a 20 cm range [13]. NFC operates in the standard 13.56MHz frequency band. Currently it offers data transfer rates of 106kbit/s, 212kbit/s and 424kbit/s, and higher rates are expected in the future.

The benefits of NFC mentioned in most publications are: mobile payment, mobile ticketing, the transfer of data from one device to another, the easy pairing of devices, such as mobile phone and Bluetooth headsets, and the download of information, such as passenger information [15] and ring tones from so called smart posters. A well known NFC service in public transport is the Touch and Travel service of Deutsche Bahn ³.

2.1.8 WiMAX

Worldwide Interoperability for Microwave Access (WiMAX) [10, 11] is the standard to provide broadband wireless services requiring high-rate Transmission. WiMAX is a pure mobile broadband technology focusing on providing plain IP connectivity to its customers and is based on IEEE 802.16 standard. IEEE 802.16d supports non-line of sight (NLOS) end-user terminals for fixed wireless broadband, as an alternative to wired access[11].

2.1.9 WLAN

WLAN stands for wireless local area network. This technology introduced the flexibility of wireless access into a restricted diameter, for example office, home or production environments. Since the early 1990s, the industrial, scientific, and medical bands, 2.4 GHz and 5 GHz, have been made available for WLAN, among which the 802.11b and 802.11g protocols are the most popular. IEEE 802.11b operates in the 2.4 GHz band and accommodates data rates of up to 11 Mbits/s, whereas 802.11g, based on orthogonal frequency-division multiplexing (OFDM), operates in the same band and provides data rates of up to 54 Mbits/s. IEEE 802.11a also specifies an OFDM scheme, which is not backward compatible with the original 802.11b. It operates in the 5 GHz band with data rates of up to 54 Mbits/s within 10 m, dropping to about 6 Mbits/s at a distance of 100 m.

³ <http://www.touchandtravel.de>, last visited 01.06.10

2.1.10 Bluetooth

Bluetooth is a universal radio interface that enables portable electronic devices to connect and communicate wirelessly via a short range of 10 m to 100 m. The data rate throughput is up to 723.2 Kbps, or 2.1 Mbps with enhanced data rates introduced in 2005. Bluetooth technology, which was originally only used by Ericsson, has gained support of Nokia, IBM, Toshiba, Intel and many other manufacturers. The goal of Bluetooth is to eliminate the need for wires, cables and connectors between cordless or mobile phones, modems, headsets, PDAs, computers, printers, projectors, local area networks, and so on [17]. Bluetooth paves the way for new and completely different devices and applications. The primary application area of Bluetooth to date has been in mobile and wireless consumer products such as mobile phones (nearly 60 % of the market).

2.2 Mobile messaging

Mobile messaging is defined as the capability to send and receive messages through mobile devices. This service has intensively been used in many mobile applications. Some of these applications use mobile messaging for informing users or as a way to interact with other users. SMS, EMS, MMS, I-mode and WAP are the most used mobile messaging services.

2.2.1 SMS

SMS (Short message service) or (silent messaging service) is a standard communication service in GSM. It allows exchange of short messages of up to 160 alphanumeric characters between mobile device users. SMS was originally a part of GSM standard but nobody used it until millions of young people discovered it as an instrument of remote conversation. In 2001 more than 20 billions of SMS messages were sent every month and this number has been growing rapidly [6]. SMS is not just used for sending logos, horoscopes and ringtones. It is also used for serious applications like market prices, email notifications or traffic information.

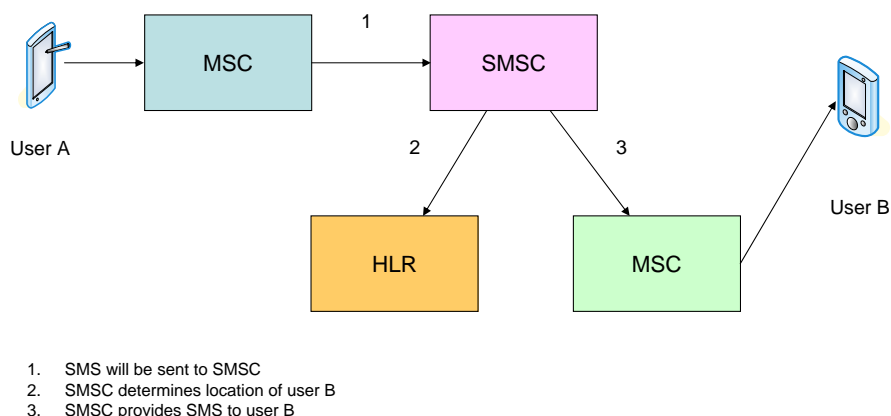


Figure 2.2: SMS architecture

Figure 2.2 shows the architecture of a SMS system. The SMSC [4] (Short Message Service Center) receives a message and directs it to the appropriate mobile device. Before sending the message, the SMSC finds the roaming customer by consulting the HLR [4] (Home location register). After receiving the request, the HLR responds to the SMSC with the status active or inactive [4]. If active it will direct its message directly to the mobile; otherwise it will hold on and attempt to deliver it when the user turns his mobile device on.

2.2.2 MMS

Multimedia Messaging Service (MMS) is a store and forward messaging service that allows subscribers to exchange with their mobile devices multimedia messages like text, pictures, songs and videos or a combination of all four. It is an evolution of SMS. The structure of MMS is significantly different from SMS. MMS uses GPRS as carrier medium and the Internet Protocol (IP). Its constitution is comparable to an email. If you want to send or receive a MMS, you need a compatible phone that is running over a GPRS or 3GPP network. Figure 2.3 shows an architecture of a MMS system. If the mobile phone is offline, the Multimedia Message will be stored and sent as soon as the phone is switched on [4]. MMS allows sending messages from mobile phone to email, and vice versa.

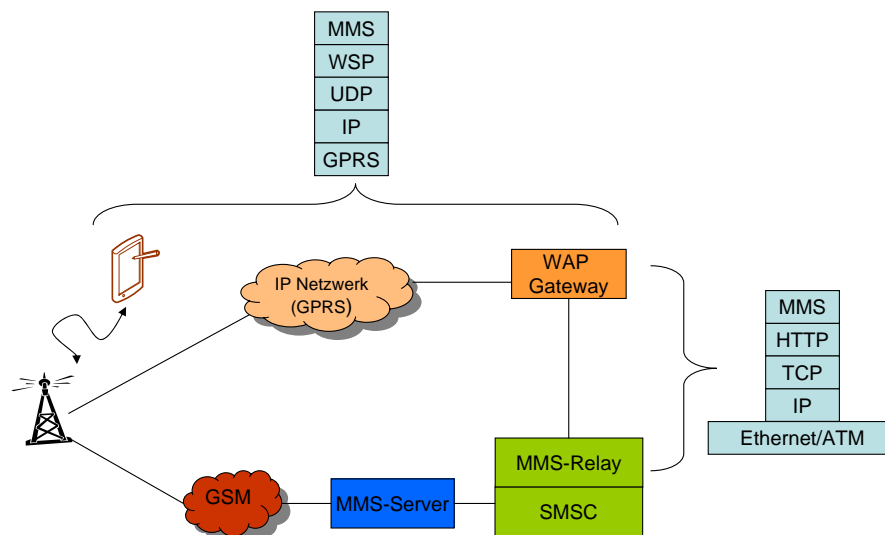


Figure 2.3: MMS architecture

2.2.3 WAP

WAP stands for Wireless application protocol. It was created in 1997 and developed by a group called WAP Forum founded by Ericsson, Phone.com, Nokia and Motorola. WAP is a standard that allows mobile devices, such as digital mobile phones, PDAs, pagers and other wireless devices to securely access and interact with Internet, intranet and extranet contents, applications and services [23]. This includes the ability to have email, push and pull information from the internet. The WAP protocol is based on existing internet standards such as HTML, XML, and TCP/IP, it is designed to operate over many wireless networks, such as GSM and UMTS. [6] Most Internet technologies originally have been designed for desktops and larger computers. The advent of wireless mobile devices creates a new challenge for network designers and Internet Service Providers

(ISPs) due to the limited processing power and memory, restricted power supply, varying input and representation forms, and display sizes of these devices [24]. WAP is designed to provide applications that support data, voice and the internet over wireless communication networks from mobile end devices.

WAP Push

WAP Push [23] is defined in WAP 1.2, it is a push technology for WAP. A WAP Push message is an encoded message that displays a message (alert message) to the user, and gives them an option of connecting directly to a particular URL via the mobile phone's WAP browser.

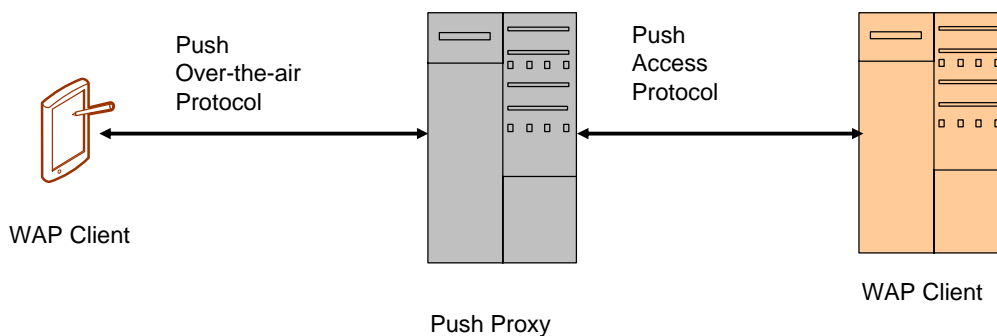


Figure 2.4: WAP Push Framework

A WAP Push operation (see Figure 2.4) is realized by allowing a Push Initiator (PI) to transmit push content and delivery instructions to a Push Proxy Gateway (PPG) [23]. The PPG delivers push content to the WAP client. The PI is an application that runs on an ordinary web server. It communicates with the PPG using the Push Access Protocol (PAP). The PPG uses the Push Over-The-Air (OTA) Protocol to deliver the push content to the client [6].

2.2.4 I-mode

I-mode was created in 1999 by the Japanese network operator NTTDoCoMo⁴. It is a mobile Internet access service, allowing users to easily access the Internet with only a cellular phone, removing the barriers previously felt by general consumers when connecting to the Internet. I-mode uses a packet-switched technology which does not need a connection every time, eliminating the need to log on or off. I-mode works just as well with GSM, GPRS, UMTS and PDC-P and uses the following protocols [6]: HTTP (between the gateway and the content server) and TCP/IP (between mobile device and gateway). I-mode users utilize a wide of services: e-mail, tickets, sports results, games and financial services. I-mode also allows exchanging mails and pictures. The number

⁴ <http://www.nttdocomo.com/>, last visited 16.12.09

of i-mode subscribers grows to more than 8 million at the end of June, 2000 and at the same time, the number of official i-mode web sites provided by information providers (IP) amounts to more than 500, and there are more than 15,000 unofficial sites today. E-Plus launched its i-mode service in Germany in 2002 but remained unsuccessful to date. The main reasons were the limited imaging capabilities, high prices and the previous ties to special I-mode phones.

2.3 Technology of content delivery

The common services for information delivery used by passenger information systems are based on the pull paradigm. Push and event-based services are still not used in this area.

2.3.1 Pull/Push modus

Pull modus: In a normal request/reply model, a client (mobile device) requests information from a server. This server responds by transmitting information to the client. This technology is used by commercial services like Jamba for sending ringtones to mobile phones.

In contrast to the Pull modus, there is also a **Push modus**, which is also based on the client/server model. The server transmits its content without explicit client's request. The figure 2.4 shows an overview on Pull and Push modus. The Push modus is server initiated. There are three ways to realise the Push initiator

- Push - event based message: a message is sent to a user activated by an occurrence based application, e.g. Event notification in logistics using the advantage of RFID tags and wireless sensor network.
- Push - scheduled message: a message is sent to a user activated by a time schedule based application, e.g. deadline notification
- Push - personal profile: a message is sent to the user activated by an application based on profiles and preferences of the users, e.g. sales actions

2.3.2 Event-based systems

Nowadays, event-based systems are important in many domains like logistics, finance, traffic monitoring and supply chain management. They are used to inform users for unexpected occurrence in a system. A common example is disaster notification in a catastrophe region (early-warning system). Research in event-based systems can be categorized into three broad areas:

- Event production: Event producers are generally wireless sensors nodes or RFID readers.

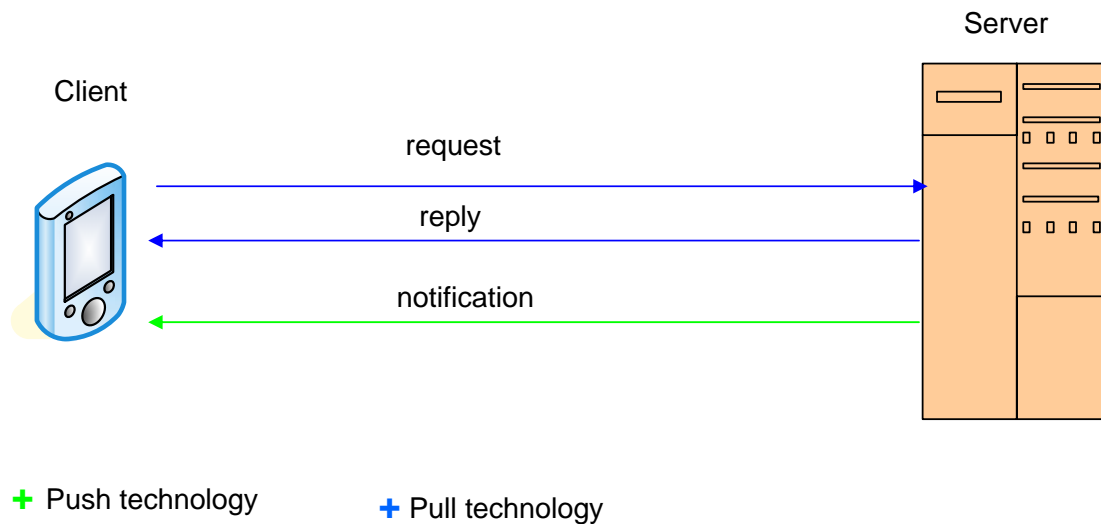


Figure 2.5: Comparison of pull vs. Push
[23]

- Event transportation: is a middleware used to connect the event producers and consumers; it is used to transport the event notification.
- Event consumption: Event consumers are complex event processing engines or business applications.

The event-based interaction model has characteristics inverse to the request/reply model [27]. The initiator of communication is a server called event producer. A client (event consumer) receives information from the event producer without any request. In an event-based system, components communicate by generating and receiving event notifications[27].

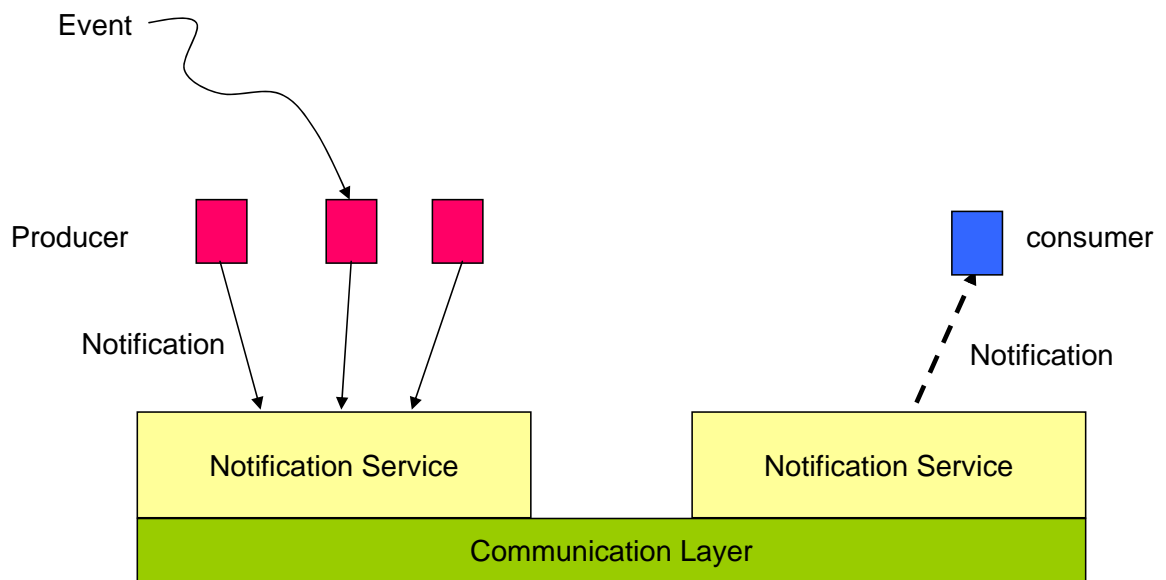


Figure 2.6: Interaction in event based system
[27]



3 Passenger Information Systems: PIS

The demand for quality of information in public transport is also increasing. The classic information media (print media: timetables, network map, etc) can not provide real time and personalized data and are not accessible for disabled persons. Passenger Information Systems (PIS) are electronic systems which provide necessary information to passengers at all times and in different situations in order to assist with their trip-making and route choice decisions. These systems are nowadays multilingual, multimodal, and accessible for severely handicapped people and can provide secured and personalized information. The information should be always up to date, serve the right address whilst the response time should be reasonable. PIS can be categorized by the type of channel, the technology of information delivery, the phase of travel (on-trip, pre-trip), the ergonomic aspect, as well as the type of information.

3.1 Categorization according to information channel

Public transport services provide information nowadays in different ways. The choice of information channel always depends on the location and the technical options of the passenger (eg. display screen). In the Infopolis project [22] many system modes have been evaluated. These are:

- **Print Media**

These are printed documents in the form of books or flyers in which passengers can find static information for their trip. They are available in travel offices or at the train and since 2008 also on the Internet. The disadvantage is that information is often not up-to-date.

Example: OBB timetable from Linz to Salzburg [26] (Austria)

- **At-Stop Display**

This system usually displays time (departure time, arrival time), vehicle (line number, direction) and geographical information (route layout). Some of these systems give information about service disruption. These systems are found at bus stop, train station and metro platforms. This service highly improves the conditions of the journey because it decreases the uncertainty and discomfort of waiting for the bus. In this context, it minimizes the waiting time through enabling some last minute shopping without fear to miss the bus.

Example: Infoplus-Brussels, Helsinki Metro Display (Finland)

- **On-Board Display**

The first role of an on board display is to provide passengers with information

while the train is moving. This information is for example the destination of the vehicle, the name of the next stop, connections information and service disruptions. On-board information will decrease for instance the stress to miss the right stop for those passengers who are not every-day users of that specific line.

- Home/Office Terminal

A small group of systems largely confined to France: MINITEL in France and in Germany IFA Kernel. This type of system can provide information like timetables, stop or station name and map of the route.

Examples: EFA-Trier, French Minitel-Nantes

- Public Interactive Terminal (PIT)

These are information systems that mainly provide information to travellers before their trip to enable them to make decisions about modes, route and departure time. Data communication between this terminal and control centres is based on telephone lines with modems or TCP-IP protocols. They are very often located near public transport stations.

Example: POLIS-Greece, DIGIPLAN-France

- Enquiry Office Terminal

It differs to the PIT because the users are information personnel of transport companies. The intention is to help personnel to answer passenger questions. This system is flexible and answers have to be quick and compact. Data communication between this terminal and control centre is based on telephone lines or frame relay protocol TCP-IP. They are very often located near public transport stations.

Example: Mobil2000-Heidelberg, EFA-Heilbronn

- Web Sites

Passenger information over web sites is a very rapidly growing group of systems. Web applications are quickly developing because they give the possibility to link to other systems. The sites are often multilingual when English is not the national language.

Examples: Thalys-Italy ⁴, DB (Deutsche Bahn)-Germany ⁵, BVG-Berlin ⁶, RMV-Rhein Main Area ⁷, Virgin train-United Kingdom ⁸

- Handheld Terminal

Handheld terminals (PDA, mobile phone, portable computer, smart phone) offer a significant possibility of providing useful PT information to travellers and allow them to have access to location information. This area is developing very fast for example with WAP based communication, the Touch and Travel service using the

⁴ <http://www.thalys.com/>, last visited 05.01.10

⁵ <http://www.db.de/>, last visited 05.01.10

⁶ <http://www.bvg.de/>, last visited 05.01.10

⁷ <http://www.rmv.de/>, last visited 05.01.10

⁸ <http://www.virgintrains.co.uk/>, last visited 05.01.10

NFC technology and mobile phone applications. Mobile phone applications are nowadays the cheapest way to provide passenger information during the trip. It consists of an application stored on the mobile end device and provides the latest travel information. The most known applications are DB Navigator⁹. for iPhone and DB Railnavigator¹⁰. for Android.

Figure 3.1 shows in which time each of the described information channels above is available.

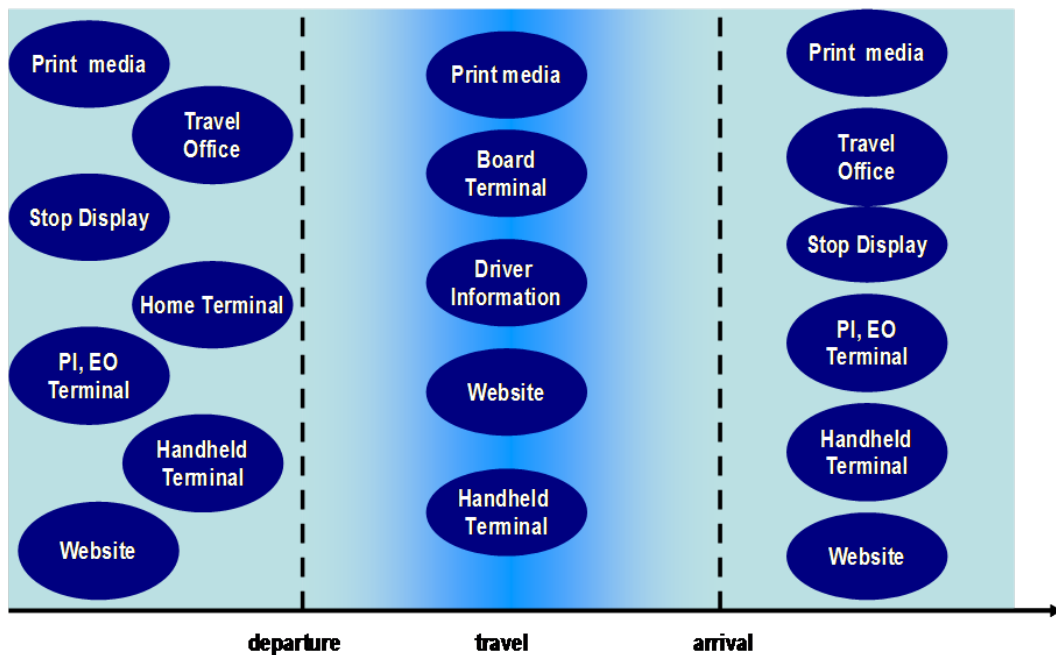


Figure 3.1: Classification of Passenger information systems according to time-context

3.2 Temporal categorization of PIS

Passenger information are categorized by three temporal categories [25]:

- Before the trip: e.g. itineraries, timetables, tickets and transport mode
- During the trip: e.g. waiting time, disturbances on the network and itineraries after disturbance
- After the trip: e.g. information about city, cultural or commercial activities.

Figure 3.2 shows a classification of passenger information. It is available on each step of a travel.

⁹ <http://www.bahn.de/p/view/buchung/mobil/iphone.shtml>, last visited 05.01.10

¹⁰ <http://www.bahn.de/p/view/buchung/mobil/railnavigator.shtml>, last visited 05.01.10

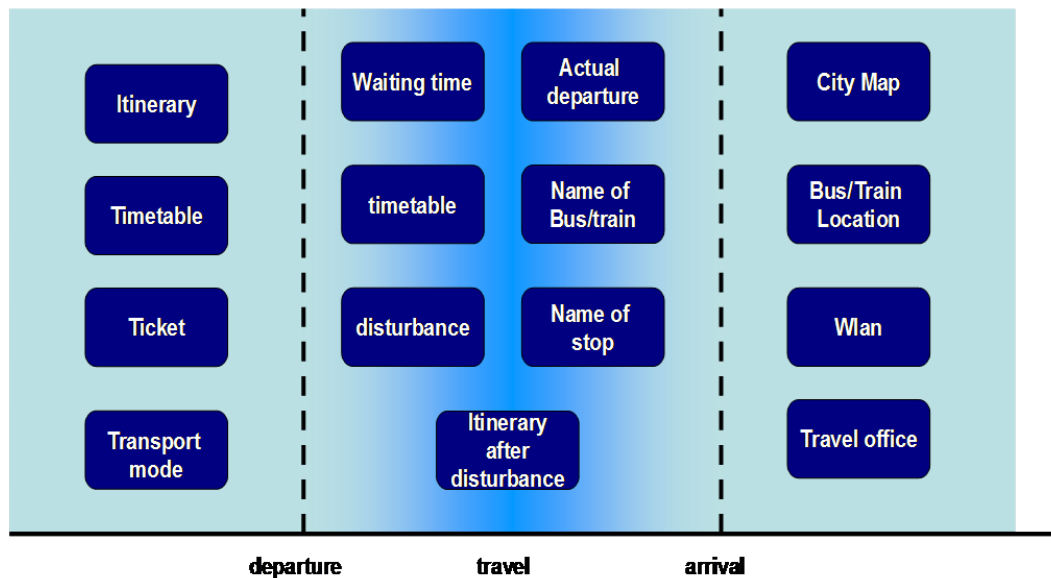


Figure 3.2: Classification of Passenger information according to time-context

3.3 Categorisation according to technology of content delivery

This chapter focuses on mobile passenger information systems. The main feature of these systems is the possibility to receive personalized information everywhere during a trip. The development of the mobile telephone industry has permitted new possibilities for receiving information. The conventional method is the use of a vocal channel. This channel is expensive and due to the velocity of the vehicle not always available. Another method are short text messages (SMS, MMS) or an Internet service (WAP or i-mode). SMS is the most common technology because it is cheaper compared to the other options. MMS is sometimes used for ticketing.

3.3.1 Passenger Information System via mobile device

Mobile phone application is a service available on mobile device. It can be used in public transport to provide passengers with information on the trip. With such systems, it is possible to serve the user individually according to his needs. HaCon¹¹, is a software company that provides IT solutions for public transport. It develops leading traveller information systems used in 16 countries and supports numerous platforms and entry channels, whether mobile, stationary or for the PC at home, both online and offline. In this section, information channels used by mobile devices are described.

SMS Services

With this service passengers can use SMS features of mobile networks to get travel information on their mobile phone. It is a cheaper alternative to WAP. Passengers need

¹¹ <http://www.hacon.de/> last visited 05.07.10

to send a request message including address and or departure time to a SMS service number of the PT company. The SMS service number is available on the Internet or at the stop station. After a short time, the passenger will receive a return message from the system with the list of busses and their arrival times to the queried bus stop and line number. Some companies offering SMS services are: HVV (Hamburger Verkehrsverbund) ¹², GVH (Grossraum-Verkehr Hannover) ¹³, VGN (Verkehrsverbund Grossraum Nuernberg) ¹⁴, VVS (Verkehrs- und Tarifverbund Stuttgart) ¹⁵.

WAP Services

This is another kind of online passenger information on mobile phone or other mobile phone device. The goal is to develop a comprehensive solution, to provide passengers with information at any place. The information are sent via a WAP gateway to the mobile phone. The requirement to use WAP Push services is to have a WAP enabled mobile device. Some companies offering WAP services are: WAP Service Deutsche Bahn¹⁶, WAP Service Norway¹⁷, WAP Service Austria¹⁸.

MMS

In public transport MMS is used for ticketing [31]. DB provides this service to its passengers. Until 10 minutes before train departure it is possible to book a train ticket via mobile phone. All that is needed a connection to "mobile.bahn.de" and select the desired destination of travel to book it. A few minutes later an MMS is being sent directly to the respective mobile phone. This service costs only the same like a normal MMS in mobile networks. Many cities in Germany and in Europe already provide this service. It is also very common in air traffic for ticketing and check-in.

DB Railnavigator¹⁹, DB navigator²⁰

These are Java applications for mobile phones, which allow storing schedules, maps and station plans. After the start, you have the option of setting up routes by entering start and destination station. Especially if you drive routes regularly, this is very comfortable. But there is also the possibility to obtain a complete departure table station. In some devices, it is also possible to store a desired component directly in the calendar.

¹² http://www.hvv.de/fahrplaene-strecken/fahrplaene-mobil/#seperator_2, last visited 05.01.10

¹³ http://www.gvh.de/mobile_fahrplanauskunft.html, last visited 05.01.10

¹⁴ http://www.vgn.de/mobile_dienste/sms-auskunft/, last visited 05.01.10

¹⁵ http://www.vvs.de/fahrp_mobil_sms.php, last visited 05.01.10

¹⁶ <http://www.wap.bahn.de/>, last visited 06.01.10

¹⁷ <http://www.wap.web2051.no/>, last visited 06.01.10

¹⁸ <http://www.wap.linzag.at/>, last visited 06.01.10

²⁰ <http://www.bahn.de/p/view/buchung/mobil/iphone.shtml>, last visited 06.07.10

The Personal Roadmap organizer with Palm OS (all versions since 2.0.) offers convenient access to all connections of a timetable period between two stations or bus stops. The roadmap may, after it was once stored, be used multiple times and is therefore ideal for commuters. You can calculate your personal timetable on the Internet and sent it as a PDF file to your e-mail account.

3.3.2 Passenger information system using Push modus or event based systems

Passenger information systems using push or event-based technologies allow a transfer of information without any request when an occurrence is present. This paradigm is already used for public transport companies by actualising information on on-board-terminals and station terminals. The trend is now to introduce this communication paradigm to passengers using mobile devices. Push and event based services are still rarely used, many research topics are made on this area. An example of a public transport company already offering this service is City-Traffic Bonn which provides multi-modal mobility information. It offers pre-trip and on-trip information via SMS, WWW and WAP [28].

3.4 Quality of mobile passenger information systems

According to the standard ISO 9000:2005, quality means the degree to which a set of inherent characteristics fulfils its requirements. The quality indicates to what extent a product satisfies the existing requirements. In this section we will define some parameters that can be used later to define the quality of software and information in passenger information systems.

3.4.1 Software quality

ISO 9126 ²² is an international standard for the evaluation of software. The standard is divided into four parts namely: quality model, external and internal metrics, and quality metrics. ISO/IEC 9126-1 describes the quality model and its characteristics. The parameters of quality model can be applied by passenger information systems.

- Efficiency: defines relationship between the level of performance of the software and the amount of resources used. Its attributes are: Time behaviour (How quickly does the system respond?) and resource utilisation (Does the system utilise resources efficiently?).

²¹ <http://www.rmv.de/coremedia/generator/RMV/Fahrplaene/RMV2go>, last visited 06.07.10

²² <http://www.sqa.net/iso9126.html>, last visited 06.01.10

- **Functionality:** addresses a set of attributes that defines if a software (in this case PIS) satisfies its requirements. The attributes of functionality are: suitability (Can the software perform the tasks required?), accuracy (Is the result as expected?), interoperability (Can the system interact with another system?) and security (Does the software prevent unauthorised access?)
- **Maintainability:** is defined as the probability of performing a successful repair action within a given time. In other words the maintainability measures the ease and speed with which a system can be restored to operational status after a failure occurs[21]. Its attributes are: analysability (Can errors be easily identified?), changeability (Can the software be easily modified?), stability (Does the software continue functioning if changes are made?) and testability (Can the software be tested easily?).
- **Portability:** This characteristic refers to how well the software can be applied to another environment. The subcharacteristics of this parameter are: adaptability (Can the software be moved to other environments?), instability (Can the software be installed easily?), conformance (Does the software comply with portability standards?) and replaceability (Can the software easily replace other software?).
- **Reliability:** is an attribute of any computer-related system that defines if a system is functioning at a given time t . It defines the capability of the system to maintain its service provision under defined conditions for a defined period of time. One aspect of this characteristic is fault tolerance. It is the ability of a system to withstand component failure ⁴⁶.
- **Usability:** defines the effort needed for using a system. Usability testing is a method by which users are asked to achieve tasks in order to measure the product's ease-of-use, task time, and the user's perception of the experience. Its attributes are: comprehensibility (Does the user comprehend how to use the system easily?), learnability (Can the user learn to use the system easily?⁴⁶), operability (Can the user use the system without much effort?) and attractiveness (Does the interface look good?). This test is often used in relation to software applications (PIS) and Web sites.

3.4.2 Information quality

Information quality defines how reliable the information is and how it can be used as a basis for decision process. There is a large number of quality criteria. These criteria depend on the context and the importance of their use. The IQ-community (Information Quality) considers the quality of information in accordance with R. Wang [19]. Wang defines the quality of information in four categories, these are:

⁴⁶ <http://http://www.itzdata.com/programs/paper.pdf>, last visited 04.07.10

⁴⁶ <http://www.ascilite.org.au/conferences/perth04/procs/chua.html>, last visited 04.07.10

representational, accessibility, contextual and intrinsic of information quality. In this section we define some criteria of information quality that can be applied for information provided from passenger information systems.

- Accuracy: has been defined as the extent to which data is correct and reliable [19]. Accuracy is most important in passenger information. False information have enormous consequences for the passengers' decision making as well as customer satisfaction with PT companies.
- Completeness: is defined as the extent to which data is not missing and is of sufficient breadth and depth for the task at the hand[19]. Completeness is also very important for passenger information because provided information are needed to make a profound decision regarding the travel.
- Actuality or timeliness: Information are actual when they depict the actual property of the described object promptly. Actuality is closely related to accuracy and completeness. Actual information are necessary in public transport [18]. They allow the passenger to continuously update the data on his journey in order to avoid taking wrong decisions based on passed data.
- Relevance: Information are relevant when they provide necessary information to users[18]. It defines key data which has the highest value for the user, in this case the passenger. Relevance of information is very important for the decision process during a trip. It has a direct influence on price, travel time and convenience of the passenger during his stay in public transport.
- Understandability: Information is understandable when they can be immediately understood by users and can be used for their own purposes[18]. If a passenger in public transport gets an incomprehensible information, he needs at first time to decode the information. This can take a lot of time and of course cause that the passenger is angry and unsatisfied. For these reasons, it is important in the public transportation to get easy to understand information.

3.4.3 Other quality criteria

Some other features that are not defined in the standard for software and information quality are also used to characterise systems. We defined some of these parameters in the following section.

- Personalization: is a process of tailoring information to individual users' characteristics or preferences. Personalization is a means of meeting the customer's needs more effectively and efficiently, making interactions faster and easier and, consequently, increasing customer satisfaction and the likelihood of repeat visits ⁴⁰. Many portal sites of transport companies, such as RMV (meinRMV) allow site visitors to personalize their services with selected preferences.

⁴⁰ http://aiimcommunities.org/wiki/Index_p,last visited 06.07.10

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- **Fault tolerance:** is the property that enables a system to continue operating properly in the event of failure of some of its components. This means in computer system that, in the event that a component fails, a backup component or procedure can immediately take its place with no loss of service.
 - **Information delay:** Information delay is the time difference between the expected time information and the incoming time information. A large information delay contributes to a deterioration in the efficiency of a system. Information delay may cause the information is worthless. A relevant reason for information delay is the problem of filtering the relevant data.
 - **Availability:** Barlow and al. [20] defines availability as the probability that the system is operating at a specified time t . Passenger information systems must be always available because an unexpected event can occur at any time and passengers need to be well informed in realtime.



4 Related research projects

- DELFI
Durchgängige Elektronische FahrplanInformation [16] is a project initiated by the German Federal Ministry of Transport. The main objective is to provide a central information system for passenger information in Germany. This information is available via website request and also via mobile devices.
- EU-Spirit²³
It is a cross-border and Internet-based travel information service for customers of public transport available via website and mobile device⁴¹. It is an extension of the DELFI project but has a European scope. The main objective of this project is providing door-to-door travel information for customers, calculating itinerary between stops, addresses or points of interest in different European regions. The information service includes PT information and additional services like map service and fare and tourist information. The information of the EU-Spirit is for free and is provided via the customer's local information system in his mother tongue⁴². Following regions offer the EU-Spirit service: Denmark²⁴, Luxemburg²⁵ and Sweden²⁶, Germany-Berlin Brandenburg²⁷.
- BAIM²⁸
Barrierefreie ÖV-Information für mobilitätseingeschränkte Personen is a research project with the objective to support active participation of self-limited mobility people (disabled and elderly) on public transportation. This will be achieved by using innovative information technology.
- mAIS²⁹
(mobiles Automatisches Informationshilfe System) is a research project of the country Schleswig-Holstein and the European Union divided in two sub-projects: mAIS 1 and mAIS 2. His goal is to provide mobile and Internet-based information services for all group of passenger as well as the integration of public transport information to mais-system.
- Polis
Polis is a network of leading European cities and regions created in 1989 and

²³ <http://www.eu-spirit.com/>, last visited 16.12.09

⁴¹ <http://www.eu-spirit.com/>, last visited 16.12.09

⁴² <http://www.eu-spirit.com/>, last visited 16.12.09

²⁴ www.rejseplanen.dk, last visited 16.12.09

²⁵ www.mobilitit.lu, last visited 16.12.09

²⁶ www.resplus.se, last visited 16.12.09

²⁷ www.vbbonline.de, last visited 16.12.09

²⁸ <http://www.baim-info.de/>, last visited 16.12.09

²⁹ <http://www.mais-sh.de/>, last visited 1.07.10

working together to develop innovative technologies and policies that address the economic, social, environmental dimension of transport [2]. Polis supports the exchange of experience and the transfer of knowledge between European local and regional cities and actively supports the participation of Polis members in European projects and is also partner in several of those projects. The next section describes some of these projects that have a relationship to public transport.

– ASK-IT³⁰

ASK-IT is an integrated project, partly funded by the European Commission⁴³. The main idea behind the ASK-IT project is to develop services (technical aids, information facilities) based on innovative information communication technologies that will allow people with a handicap (blind, visually impaired, handicapped, sick, illiterate develop etc.) to enhance their mobility. These services were implemented in seven European cities and furnish information and services outside the home and during the trip.

– CIVITAS

Stands for City-Vitality-Sustainability, is a program of cities for cities and co-financed by European Union. It helps cities to achieve a more sustainable, clean and energy efficient urban transport system by implementing and evaluating an integrated set of technology and policy based measures in the field of energy and transport. Some examples of CIVITAS projects are:

* Project CARAVEL³¹ in Stuttgart

Event-oriented traffic management improving the traffic situation in case of public events such as football games, open-air concerts and traffic disturbance (incidents)

* Project Archimedes³² in Aalborg, Denmark

Provides pre-trip and on-trip passenger information on the mobile phone (start in September 2010)

– LINK³³

Is the European forum for intermodal passenger travel³³. The main idea is the creation of a door-to-door intermodal passenger travel information service and ticketing.

• Distel³⁴

Distel is a research project financed by BMWi(Federal Ministry of Economics and Technology) for the period from 2006 to 2009. Its main objective was to allow

³⁰ <http://www.baim-info.de/>, last visited 16.12.09

⁴³ <http://www.baim-info.de/>, last visited 16.12.09

³¹ <http://www.caravel-stuttgart.de/>, last visited 16.06.10

³² http://www.civitas.eu/measure_sheet.phtml?lan=en&id=543, last visited 16.06.10

³³ <http://www.linkforum.eu/>, last visited 16.12.09

³³ <http://www.linkforum.eu/>, last visited 16.12.09

³⁴ <http://www.linkforum.eu/>, last visited 16.12.09

an efficient management and a wide passenger information and such as coordination of information exchange between vehicle of different public transportation services.

- Service To Go

Service To Go or ANFISMO (Anfahrts- und Informations- Service für Mobile Endgeräte) is a project developed at KOM [29]. It is based on structured mobile SOA (service oriented architecture). Its objective is to allow the use of regional information services on mobile devices (cell phones, smartphones, or web-based) to support users in their new situation, for example attending an event in an unfamiliar city. Furthermore, ANFISMO supports the localization and information exchange between friends who are in the same city or attend the same event.

- RTIG

RTIG (Real Time Information Group) is an organisation in the United Kingdom supporting the development of bus passenger information systems. The RTIG is the central focus point for those involved in bus RTI (Real Time Information). It allows the members to act as a group to influence policy and solve interoperability, technical and integration issues. It also allows them to act as a group; e.g. to bid for radio spectrum, which the individual members would find difficult on their own, or to influence European standards⁴³.

- PROMISE

Has been a joint collaboration by various European companies and institutes. The objective has been to provide travellers an easy access to real time and position dependent traveller and traffic information.

- ROMANSE

(Road Management System for Europe) is a project started in Southampton during May 1992 as a pilot scheme to develop a flexible solution to increasing congestion. By making better use of existing infrastructure and resources, ROMANSE aimed to maintain sustainable economic and social transport systems. Utilising intelligent transport systems, ROMANSE would provide accurate, timely and accessible information to travellers both before and during their journeys⁴⁵. People could then make informed choices about their route, time of journey, and most importantly, method of transport. The system would even allow them to change route whilst travelling to avoid congestion and by so doing would maximise the efficiency of the existing network⁴⁵. ROMANSE provided real time information to travellers, network managers and transport providers across the City of Southampton and the southern part of Hampshire⁴⁶.

⁴³ <http://www.dft.gov.uk/transportdirect/community/rtig>, last visited 16.12.09

⁴⁵ <http://www.romanse.org.uk/biog2.htm>, last visited 04.07.10

⁴⁵ <http://www.romanse.org.uk/biog2.htm>, last visited 04.07.10

⁴⁶ <http://www.romanse.org.uk/biog2.htm>, last visited 04.07.10

- Green Mobility ³⁵

Green Mobility is developed by: HTTC, B2M, raumobil and YellowMap. The project develops application scenarios for Internet services explored and developed in THESEUS³⁶. It also creates new innovative services that will be usable on Internet and mobile networks.

³⁵ <http://www.greenmobility-project.de>, last visited 04.07.10

³⁶ <http://theseus-programm.de/>, last visited 04.07.10

5 Conclusion

The evolution of computer technologies is inevitable in public transport companies. Computer technologies provide solutions for better passenger information which make the use of public transport easier, more attractive and more reliable. An increase in the number of public transport passengers will help to save energy, decrease pollution and preserve the environment.

This report has presented the situation of current passenger information systems used by public transport companies. General cellular network technology was first introduced. After that, passenger information systems were described and categorized. In the last part of this report some European and German research projects, which focused on passenger information systems, were described.

Public transport passengers want to have information at any time of their travel, before, during or after their trip. Current public transport companies offer many channels of information delivering: displays (stop, board), terminals (at home, at office, at train station, interactive) or websites (on computer, on mobile device). These information are mainly available in a request/reply mode (pull technology).

Whilst the use of pull technology to provide information technology is widely spread in public transport, the event-based paradigm is still not sufficiently used. Its utilization in public transport would increase the chance to receive only updated, relevant and more personalized information. Many applications, particularly in public transport and logistics are event driven. Such applications can be more flexible and better through the utilisation of event-based systems. Event-based systems can already replace traditional IT systems, or at least complement them. However, the break-through of event-based systems is likely not in the near future; since there are very few examples of experience with really complex event-based systems and there are still missing standards.

Since event based and push services are still relatively new and not well researched to date, particularly in public transportation, we strongly recommend intensifying activity in this area.



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