NAVCOM – WLAN Communication between Public Transport Vehicles and Smart Phones to Support Visually Impaired and Blind People

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Abstract. Visually impaired and blind people want to move or travel on their own but they depend on public transport systems. This is sometimes challenging. Some problems are to find the right vehicle, signalling their wish to enter or leave the vehicle and getting information of the upcoming stations. To solve these problem very specialized equipment was develop. In this paper we show a solution with standard WLAN components and a standard smart phone, that might solve these problems. Hopefully this raises the life quality for the people with special needs.

Keywords: Mobility, accessibility, vehicle communication, WLAN, smart phone, IBIS, public transport.

1 Introduction and Motivation

Mobility is a very important factor for a self-determined life. People want to move or travel on their own whenever and wherever they want. Most people can use their car, their bike or just go by foot to nearly any place they want. But not everyone is able to move or travel independently.

People with special needs depend on travelling by public transport like trains, busses, subways and trams. For seeing persons travelling by public transport isn't a big challenge. They can see an arriving bus, can choose the rights train on a crowded railway station or recognize the next stop when they are in the vehicle. Visually impaired and blind people don't have these options. Visually impaired and blind people want to be able to choose the right bus choose to leave on the suiting station. To find the right platform or to move in public places on their own is substantial.

In the project series Ways4all [1] the aim is to create a barrier-free system for orientation and movement in public space for people with special needs. The concept includes components which allows indoors and outdoors navigation, communication with public transport and public infrastructure to ensure safe travel. Several parts of this system are already implemented, like for instance the consultation of numerous sources of public transport schedules, the concept of indoor guidance [2] and the implementation of a barrier-free user interface for smart phones [3].

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In this paper we describe the communication between a public transport vehicle and the person's smart phone, the project NAVCOM.

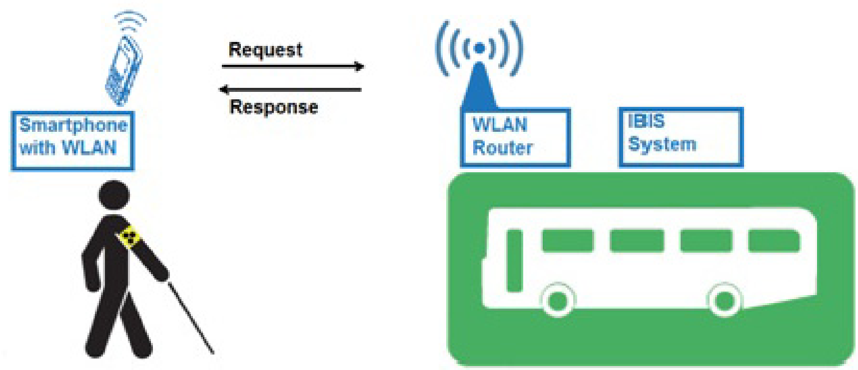

Fig. 1. Overview of NAVCOM System

1.1 Related Work

The projects of the ways4all series are not the only research projects that support people with reduced mobility.

The PAVIP system allows visually impaired users with a portable hand-held device (Milestone) communication and interaction with the corresponding counterpart. There is a radio module installed in the handset, where data between vehicles or appropriate information points and the handset can be exchanged. Every component (i.e. vehicle or check-in points) requires one PAVIP box. The PAVIP box can transmit various information to the user's devices, like the bus number, the direction or the next stop. [4] The user must log on with an RFID chip with 13.56 MHz at the bus stop (check in). This chip provides the essential information to find the suitable public transport vehicle. A disadvantage of this system is only that static information is specified at check-in points. These points are also difficult to locate. The range of passive RFID tags is only a few centimeters and must be found by the user at each bus stop.

Apex Prague TYFLOSET® is designed as a unified system for all types of acoustic information and orientation in the Czech Republic. The blind person uses a command station where he or she can activate all voice information and the guidance systems. The blind person can request an acoustic report on the number of the bus and the driving direction of the arriving vehicle at a public bus stop. As far as the blind person wants to break into the vehicle, he/she confirms his/her intention to the driver with his command through a key transmitter. The feedback from the system will also be given via the external speaker of the vehicle (same like PAVIP). The blind person can use additional annexes to TYFLOSET® system such as the acoustic position marking on buildings, in sunsets, at intersections with traffic signals operate, and so on in a similar way. Following the introduction of visual information systems for passengers in the form of large-area displays, the system TYFLOSET® allows providing audible information with identical content for blind and partially sighted people. The company Apex GmbH uses the frequency 433.95 MHz for TYFLOSET®, so a reach of 100m can be made possible. [5]

The Digital Speech (DISA) should make acoustically accessible the visual information displayed on billboards to blind and visually impaired persons. Therefore stations are equipped with appropriate devices which visually displayed information can translate into language. "For the spatial detection of the speech output, which can be integrated into existing systems in a simple manner, there is a signal that can be requested by the visually impaired through a separate radio transmitter in the wider area of a station."[6]. The system provides assistance to get knowledge about punctuality of transport and driving off the stop lines for the visually impaired. Unfortunately, it is not possible that the transmitter, communicate with the vehicle, to localize this, or to issue a stop request.

RAMPE Project – Interactive Auditory Information System for the Mobility of Blind People in Public Transports – extended mobility in public transport is made possible to blind and visually impaired people. The system makes use of Personal Digital Assistants (PDA) with wireless support. This system can be used at bus and tram stops and major towns for the use of public transport. The user is given the major route information by the PDA that is Wi-Fi router connected to the RAMPE at the stop (Lines, schedules or additional information, such as delays, or vehicle arrival notifications of the operator). This information is given by the RAMPE access point (hotspot) and can be played back using the application on the PDA. The RAMPE system provides no way of user interaction with the vehicle. [7]

1.2 Summarizing

All these projects help people with special needs to find their way in public transport. But at a closer look we can find some advantages and also disadvantages. All these related projects have a wide range and a fast signal transmission. But there are also some dis advantages. These projects are using specialized hardware for the hand tool and also for the vehicle. There are also now standards in the used radio system (Apex and DISA 434MHz, PAVIP 868MHz, RAMPE 2.4 GHz)

2 Implementation of the NAVCOM System

The project NAVCOM tries to bring together the best features of each of these projects. As a wireless radio technology Wi-Fi is used, which is normally available on most smart phones. Based on wireless technology a standard wireless router with open source software could be used as IBIS slave. The user has the opportunity to communicate directly to the vehicle by using his personal mobile phone with a special application. Each request of the user will be confirmed by feedback of the system and by voice output. So passers-by are harassed by outside speakers of the vehicle no longer. Direct wireless connection via socket allows transferring only relevant information. A connection to the Internet would be possible, but was not currently enabled.

2.1 System Architecture

Nowadays public transport systems are connected by an Intermodal Transport Control System (ITCS)[1] . Data between the public transport vehicles and a control unit can be exchanged over an air interface. Inside the vehicles, the IBIS bus supplies all components with information. By example, the outdoor display receives the right destination and the line number from the IBIS bus. The IBIS bus is an old fashioned and low speed protocol. It is designed as master and slave system and the main activity is to transmit information to all components. This information can be easy received with an IBIS-to-RS232 Connector. Unfortunately it is impossible to transmit data back to the IBIS Master, without a change in the IBIS system. With the help of a USB-to-serial converter the information can be analyzed by a wireless LAN Router. On the wireless LAN Router the default firmware was replaced by a Linux-Distribution for Embedded devices called OpenWrt [8]. This step is required to run customized services on the Router. Some available Routers have just one USB Interface, so a USB Hub is used to connect multiple devices. With an USB audio stick different sounds can be triggered by the Router. Visually impaired people should localize the vehicle with the help of acoustics. These sounds can be enabled by a USB-Relay-Board. A second relay triggers a stop request. It has the same function as the button in the bus, which visualizes the driver the stop request by a signal lamp. The lamp is switching off on the next bus stop. Multiple wireless LAN Clients (i.e. smart phones) can connect to the Router and use the custom service on the router to trigger the following actions:

- Play the bird sound to localize the bus
- Request the next bus stop
- Entry request to enter the bus
- Exit request to leave the bus

2.2 Router Operating System

The Linux distribution OpenWrt [8] supports more than 100 different Router devices. A well-structured software developing kit can be downloaded from the Internet. After the selection of the router model the software developing kit generates the right cross-compiler for the Router CPU. Now services on the router can be developed. With the packaging system opkg on the programs can be easily installed on the router. It also takes care of all dependencies of the program and the libraries.

All components are standard devices and available on the market. This enables a low cost solution.

2.3 Client Components

The Communication between the bus and blind people will be done by a mobile application. This application was first created for Nokias mobile operation system Symbian, because it's the most popular system for Blind People. New requirements and because of the missing Symbian support in the near future we migrated our basis

[1] Former known as Rechnergestütztes Betriebsleitsystem RBL.

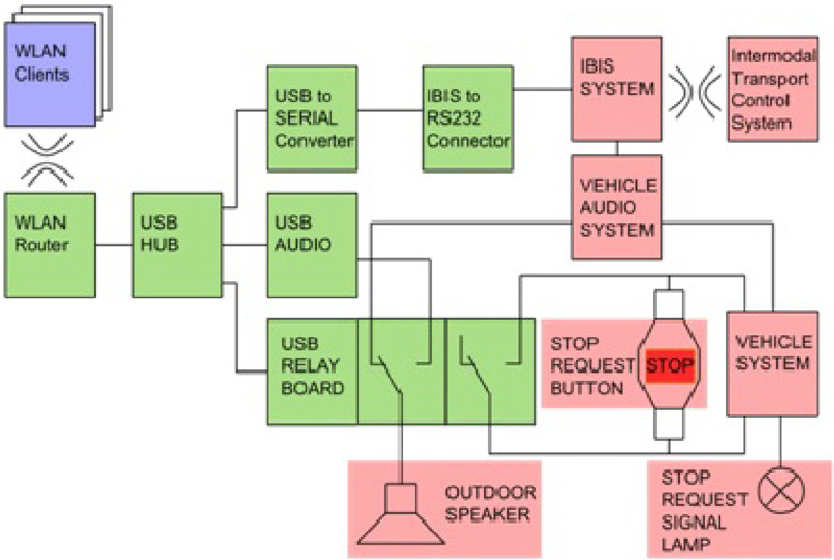

Fig. 2. System overview of vehicle components

application to the widely spread system Android. Another main reason for the Android system was the wide open architecture which allows activating a lot of features for disabled people. The bus and the application communicate over a wireless LAN connection. On this connection we enable a socket connection between the router (bus) and the application (blind people). By this connection we send commands to each device. Each Command will be connected to a sequence of simple messages. In general it sounds like a simple process but in detail there are a lot of problems.

Problem 1 – Finding possible WLAN connections. Each WLAN has its own name, called SSID (Service Set Identifier). It's impossible to connect with the first founded SSID because in city areas the possibility to find more than one WLAN connection is nearly by 100%. So we need to define our own SSID Schema. Why we need a Schema and can't use exactly one SSID? The reason is because there will be more than one bus using this system in the future. So it's also possible that more than one bus can cross meeting point of blind people and we can't identify on a quick way which bus is the correct one for their journey. So we defined a Schema with a Prefix "NAVCOM" to filter all founded SSIDs to a qualified amount of possible SSIDs. Combined with the Number of the Bus and the name of last bus stop we can define the bus line and the driving direction.

Problem 2 – Establish new Connection. Connecting with a wireless network is a simple user process. First the user selects a wireless connection and the second step is that the device will connect to the selected connection. The technical problem hap-pens at the android framework because enabling, disabling, connecting and disconnecting wireless connections are asynchronous processes. The implemented solution is doing one step by another step. First the application is searching for new connections, second the use is selecting a connection and third the application will connect to this connection. At the first description there are no differences between theory and practice, but there is another special fact of connecting to the needed wireless connection. Our implementation disabled and enables first the wireless functionality of the user's device. Many tests at the design and development phase have shown the problematic of problems using the android framework. Re-establishing a connection or selecting another connection by using an established connection hasn't worked as expected. The connection wasn't able to establish or networks wasn't found by the application. So we focused the source area of those problems and we were trouble shooting to find out this stable solution. One disadvantage is that the duration of the connection process is about 2-3 times longer than without our "workaround" to get a nearly 100% stable solution.

Problem 3 – client / router communication and how we can tell blind people what will happen now. "Normal" people can use all wits. So they can see the bus is coming to the station, or the bus will stop at the station and also when the bus is leaving the station. Simple interactions like the using of the entry button of the bus are not the same for Blind people. Blind People can use our "Entry Button" for telling the busdriver that they want to entry the bus, but Blind People need a feedback for this action, that the system is working properly or not. So we designed our communication with a feedback process that each command will get an answer from the other site of communication. In this example the application will send the message "EW" to the router and the router will answer with the message "EW-A". The Letter "A" is our "Acknowledged" Part of an answer message. This schema of original message and acknowledged extension will be used at all command sequences between the router and the client.

Problem 4 – losing wireless connection. Blind people will also leaving. Our concepts integrated the possibility of using an Exit-Button, but we want to get a proper usage of our system. So the router needs to know which client "is alive" and which client leaved or "died". The solution for this problem is the usage of solution nr 3. The Router sends a Heartbeat to the client and the client will send an answer back. Each site will accept a timeout of 5 seconds. By overrunning this timeout the router and the client will close the connection. The Client also will tell the user that the connection was killed because of missing communication to the router in a user friendly way.

3 First Test Results

To confirm our system implementation we tested three different scenarios.

- **Scenario 1:** The person is inside the moving public transport vehicle. The main goals are to get the upcoming stops and to request a stop at the next station.

- **Scenario 2:** The communication between a slowly moving person and a non moving vehicle. The target of the person is to find the right transport vehicle on a public place.
- **Scenario 3:** The person is waiting on a station and wants to send a request for entering the vehicle to the driver.

For the test setup we installed a WLAN Router in a car (VW Touran). The router (Cisco Linksys WRT160NL) was arranged in the trunk and also near the windscreen. The test for scenario 1, was done on an 12.5 km track in the city of Kapfenberg. The vehicle was moving between 0 and 50 km/h. The traffic was medium. The test for scenario 1 worked very well. The person and the WLAN route have a fixed distance, and are moving with the same speed. There were no problems to establish a connection and the test person got all messages and was able to send stop-request. The test for scenario 2 and 3 were done in the parking place of the FH Joanneum and a nearby industrial area.

The results for scenario 2 were also very satisfying. The connection to the router was established without problems. After the connection with the right line, the request for bird twitter was send and the person was able to hear the vehicle. There were no problems with the signal strength.

For the test scenario 3 are the results not satisfying. About 50% of the tests ended with a failure. We recognized that the timing for the WLAN search and the connection to the route is not well organized. To get a suitable result the timing of the search process and the start of the connection should be automated form data as the right arrival time and the position of the person.

4 Outlook and Conclusion

In our test of the system we showed that this solution based on standard component, is a practical approach to solve the problems of visually impaired and blind people with public traffic vehicles. One existing problem is the delay of the WLAN connection. Scanning the networks and establishing a connection requires about 4 to 7 seconds. For scenario 1 and 2 is this time sufficient, but for fast moving public transport vehicles this could be a problem. For further development we are using special antennas and better accessible spots for the router on the vehicle. Also some improvements of the software settings will provide a better timing of the connection process.

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References

1. Ways4all (2012), http://www.ways4all.at (visited January 2012)
2. Kiers, M., Bischof, W., Krajnc, E., Dornhofer, M.: Evaluation and Improvements of an RFID Based Indoor Navigation System for Visually impaired and Blind People. In: 2011 International Conference on Indoor Positioning and Indoor Navigation; Paper, Guimarães, Portugal (September 2011)
3. Krajnc, E., Knoll, M., Feiner, J., Traar, M.: A Touch Sensitive User Interface Approach on Smartphones for Visually Impaired and Blind Persons. In: Holzinger, A., Simonic, K.-M. (eds.) USAB 2011. LNCS, vol. 7058, pp. 585–594. Springer, Heidelberg (2011)
4. PAVIP (2012), PAVIP Transport Flyer, http://www.bones.ch/bones/media/downloads-ger/pavip/Flyer%20PAVIP%20Transport.pdf (visited January 2012)
5. APEX (2012). System TYFLOSET® – Ein elektronisches Orientierungs- und Informationssystem für Blinde und Sehbehinderte, http://www.apex-jesenice.cz/tyfloset.php?lang=de (visited January 2012)
6. CAT: DISA – Digitale Sprachausgabe – Fahrgastinformationssystem für Blinde und Sehbehinderte im öffentlichen Personennahverkehr (2012), http://www.cat-traffic.de/DE/06_html_oepnv/06_oepnv_1.php
7. Baudoin, G., Venard, O., Uzan, G., Rousseau, A., Benabou, Y., Paumier, A., Cesbron, J.: The RAMPE Project: Interactive, Auditive Information System for the Mobility of Blind People in Public Transports. In: Proc. of the 5th International Conference on ITS Telecommunications, Brest, France (2005)
8. OpenWrt (2011), OpenSource WLAN router firmware, https://openwrt.org/ (visited January 2012)