"FreeSEAT"

Identification of Availability of Seat-Ressources in Public Transport

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Abstract
The availability of a free seat in a public passenger train can be an important factor for a traveler to decide for using a public transport for his travel or not. "FreeSEAT" addresses the regional train network as well as the international train operators by development of a system for detecting free and occupied seats just in time and present this information at the railway platform while a train is approaching the terminal. A new developed sensor element which is able to be easy installed in existing seat-structures of passenger coaches, in regional trains and even a tram is the base of that service. This sensor operates with own energy and is able to detect if a seat is occupied by a human being. This information is collected within a wagon by a small wagon data-concentrator device using radio data transmission and is furthermore transmitted together with information about the actual location of the vehicle to a central server application. This application offers information services based on this occupancy information and actual location of the wagon/train. In this way it is possible, to display the availability of free seating capacity shortly before the train arrives at a railway station to raise the comfort of the travel for the valued passengers avoiding hurdling through the train looking for a free seat (the "train rally") and reduce standing time in the station. The system gives also relevant information about the movements of the passengers within a train when the train approaches the railway station of after leaving the station and thus paving the way for new value added services to be developed in near future as e.g. short term reservation of a seat, support the dispatching of connecting trains and busses and even increase the efficiency of the fleet management.

Keywords:
Seat occupancy detection, mobility, convenience, services, localisation, cost effectiveness, flexible, resource management, passenger transport, free seat

Motivation

The requirements of a traveller concerning comfort of travel in public transport depends on the distance, the price and the luggage she/he has to carry. In urban transport, where the distances are within some kilometers and the travel time is about 10 to 30 minutes – covered e.g. by tram or local trains - it is not a very important issue to find a seat. If travel distance and/or time is longer, to find a convenient seat with reasonable effort becomes a significant factor for the decision to use a public train or go by car. Bussiness people and members of the ”internet generation” are expecting fast and reliable information about their ride and where they can find a free seat to have a convenient trip.

This information has to be presented reliable and in time latest when the train arrives at the station so that the passenger has enough time to make his way to the right door of the selected wagon where she/he can enter a wagon with high chances to find the right seat. For the operators of the public transport it is also essential to keep the hop-on hop-off times at the platforms as short as possible to keep their time schedules.

Today’s only information: the wagon composition display (”Wagenstandsanzeiger”)

Todays the only information for a traveller about possible free seat capacity is the train composition display (german ”Wagenstandsanzeiger”) which indicates, where coaches of the premium/first/economy class are located within the train and at which section of the platform the wagons will stop so that the traveller can move to an appropriate position on the platform for entering the wagon when the train arrives. Normally after entering the wagon, the ”seat seeking rally” or ”train rally” starts (Unless she/he payed for an extra reservation some time in advance).

Remark of a bussiness traveller: ”*I took the train but I did not find a place to sit for two stations, so next time I only will take the train if I’m informed where I can find a seat. Why is there no information possibleWHERE a free seat could be found..*”. This remark leads to the project ”FreeSEAT”.

System architecture

The FreeSEAT – System consists of several components starting with the sensorelement under the seats of the wagon(s). The detection is done by an sensorelement controlled by an small embedded zero power micro controler. The element is fully self contained and receives its energy by an small builtin battery. The builtin energy source shall last for an operation of several years.

The result of the detection is packed into a radio telegram and transmitted to a more sophisticated wagon“concentrator” device which is located somewhere in the railway wagon. This device is the only device which needs an energy source by the wagon’s energy lines as it handles also the issues to gather the actual position delivered by an GPS receiver and do all communication to the next level system, the ”FreeSEAT”- database and service center. It also can handle some local functions as display of seat capacity on an local display, inform the train guide and more.

At preprogrammed locations, event driven and/or according a time schedule the information is transmitted to the “FreeSeat”-Center using standard communication as e.g. GSM/GSM-R data services.

This Datacenter operates a database and further software applications feeding services based on the received information. One of these services now can feed the information to an electronic display at the platform indicating where available free seats on the approaching train can be found. So the passengers can enter the train at exact that door where they can find their place fast and convenient. Also new levels of reservation services can be achieved. A seat reservation can be done virtually at the moment where the train arrives. The systems approach supports such services accessible by smartphones (Apps).

Information of seat capacity and their usage is also relevant to the train operator and even the train guide for optimization of the dispatch and operations. So additional wagons can be put into operation when a train is aproaching where nearly all seats are already occupied.

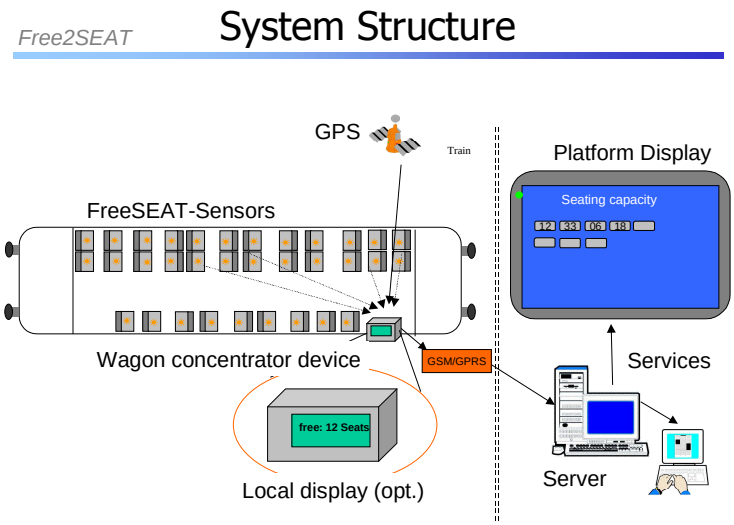

Figure 1 – System Structure “FreeSEAT”

The Wire Frame of ”FreeSEAT”

As stated above, short traveling distances of less than about 20km or travelling time less than 30 minutes are not that adressed field of this project. This project has its focus on regional trains with

- travel distances between 50-300km
- travel time of more than 30 minutes and up to 3 hrs

and generally wagons already in use for beeing refitted.

Also results of the first stages of FreeSeat – which is a 3 stage R&D projekt started in 2008 – showed, that daily travellers (”Pendler”) have their priority to step into the train at a wagon, where they have possible shortest way at the exiting station – e.g. when changing trains.

Goals of FreeSEAT: flexible system – increasing usage – increasing the number of passengers

The intended system has following goals:

- in the wagon(s) a local sensorsystem has to detect, if a seat is occupied by an human beeing
- this information has to be transferred from the wagon to a central system for further processing
- depending on the actual location of the wagon, ”FreeSEAT”-information has to be delivered to specific receivers, this only a few minutes before the train actually arrives at the platform.

This means, that the all over system has to be very flexible to follow up the actual situation, meet information timings and also various options of presentation spots at the platforms.

Challenges

As all R&D projects, also FreeSEAT has faced some challenges on the technical focus as well as on the operational framework.

Framework ”Challenges” – interfaces, costs, flexibility

Before looking onto the technical challenges, there are also some remarks to concerning operational Challenges which are mainly sourced in the liberalized world of train transport, where there are now different actors possibly concerned with ”FreeSEAT”: The **owner of the wagon**, the **wagon operator**, the **train operator**, the **platform operator**, in some cases also the network infrastructure operator too.

Therefore the FreeSEAT system has several interfaces to connect to, which might also change from day to day as a specific wagon might be operated on line 1 today, but moved to serve line 2 tomorrow. Also platform operators might change as lines served are changed, therefore another datainterface has to be addressed today than those used yesterday. Last not least also some issues concerning data security have to be met. Also the possible impacts of ”FreeSEAT”-Information to the management of the flow of travellers, the operation of trains and more have been investigated. Allover, the concept of ”FreeSEAT” has received high attention by all parties informed about, thus confirming their valuability for the market.

Another question to be answered is the financiation as there are different actory involved when operating the full information chain. This enables the generation of a completely new service done by an independent entity operating the whole ”FreeSEAT” system and services.

An appropriate business concept has been developed by the consortium.

Technical ”Challenges” – lowest power consumption, long lifetime, detection method
There is NO cabling allowed, it should be possible to install the sensor and system components in a railway coach within reasonable time and with low effort and keep operational costs low. Therefore, the sensorelement must be very small of size and battery powered. And the sensor must work for long time withouth the need to be replaced. The sensors technical status has to be monitored continuously, technical failures must be recognised fast and beeing handled with low effort.

But the “biggest” challenge at all was simply to find a way to detect a human body occupying a seat by just ”looking” through the bottom of the seat without changing the seat’s structure itself and not getting a false positive detection when e.g. a bag is placed onto the seat.

Approach and Solution
Studies and evaluation of existing sensors for detection of an occupied seat (mainly used in automotive applications) showed, that none of them can be used to meet our goals. Also intensive evaluations of some ultrasonic sensors did not bring appropriate results. Using video surveillance was not mandatory because of costs, vulnerability against fraud and complex juridical issues.

So a completely new concept to detect the occupation of a seat has to be invented and a sensor element was developed using radio frequency transmission in a new way to detect the presence of an human body by ”looking” through the seat. The “FreeSeat”-Sensor (“Besessenheitssensor”) - shown in following figure 2 - is able to properly detect a person occupying a seat (1). The developed sensor (3), mounted underneath the seat, is capable to ”look” through the seat’s structure (2) and detect if the seat is occupied (only) by a human

beeing. The detection is not disturbed by the other elements installed nor does the sensor use high emission of radio waves. The information ist further transfered also by radio to the wagon concentrator device (4) and furthermore to the central systems and application.

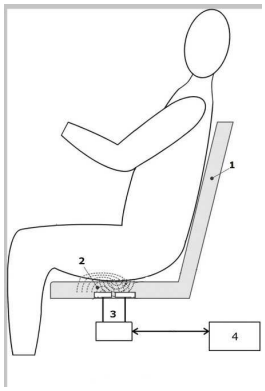

Figure 2 – Working principle of "FreeSEAT"

Figure 3 shows a function model and some samples of measurements indicating the clear signal differences, about 10dB difference between empty and occupied seat and about 3 dB difference between human occupancy or non-human occupancy.

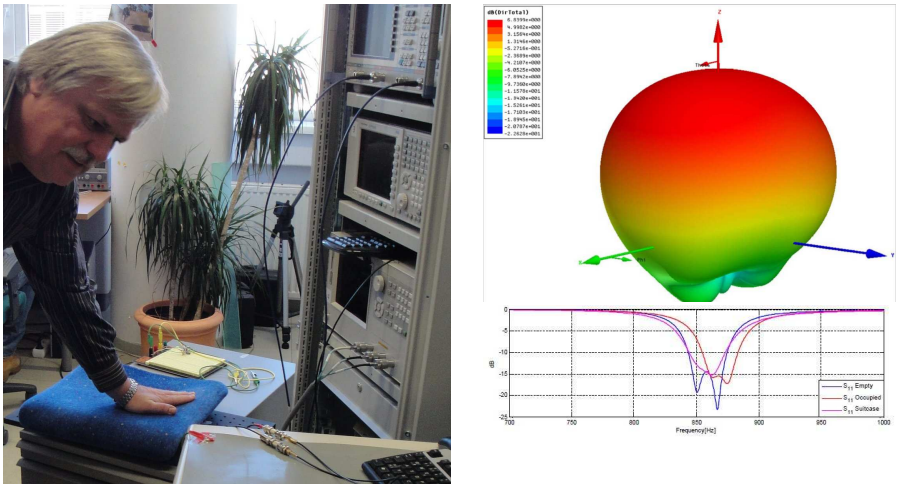

Figure 3 – First function model of "FreeSEAT" sensor & sample measurement results

Output: Cost effective, flexible and reliable

The selected system approach ensures flexibility and cost efficiency. Sensor elements can be easy mounted/replaced without the need to use special tools or sending the wagon to a workshop. No cabling of the sensors is necessary (autonomous operation over long time). Also

the wagon concentrator is small and easy to be installed and maintained by remote access. The operation and monitoring of the technical status of the wagon's equipment can be obtained by an independent entity, thus releasing the wagon owner or the transport operators from additional effort for handling and maintaining the system. The system has no connection to the railways signalling system nor to the wagon's electronic system.

Universal usage of information delivered by the system

The information can be used in various ways from guiding the passengers directly to wagons with available seat capacity, supply information selectively according the actual location of the coaches to specific displays at specific railway stations. Dispatcher and train guides receive appropriate information about conditions in a (connecting) train e.g. already used seating capacity. The system can be used in trains as well as in busses or elsewhere (e.g. waiting areas and even non transport related applications)

Easy roll-out, low total cost of ownership, maximum flexibility

The sensors are fixed by glue within minutes and can be maintained and exchanged fast and easy. Wagons with and without sensors can be mixed without impact to the "FreeSEAT"-Service at all. Equipped wagons are not bound to specific routes but can be used freely. Following Figure shows the situation of installation in an test train:

1 …. FreeSEAT- Sensors (mounted underneath the seats)
2 …. Wagon concentrator device receiving radio telegrams by the sensors
(installed in the instrumentation compartment over the door)

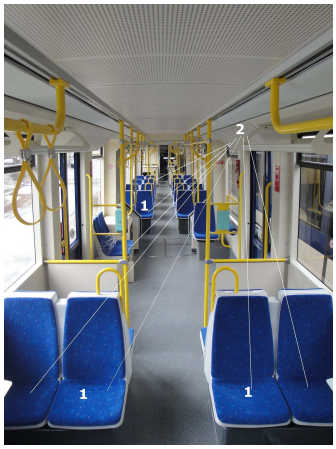

Figure 4– Installation framework for pilot

Status and Outlook

The FreeSEAT – System is now beeing on the road to serialisation. Parallel to that, the database applications are developed for storing the informations centrally. First pilots will be used to proove the stability and reliability of the information gathered and their potential for the already defined customer services. Mid of 2013, first applications and services shall be available for pilots or even commercial use. Possible further services are connection to a short term reservation system, passenger guidance by lanelights, electronic train displays and optimisation of connecting lines. Even non-transport related applications have already been identified by the project.

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Project details

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Website:	**www.freeseat.at**

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