Trailblazers - A Community Driven Navigation System For Mobility Impaired People[1]

Authors

Sven Stegelmeier, Martin Stein, Mark Thomé and Piotr Wendt

{sven.stegelmeier | martin.stein | mark.thome | piotr.wendt}@ informatik.haw-hamburg.de

Studiendepartment Informatik

Hochschule für Angewandte Wissenschaften Hamburg

Abstract

In this paper we propose a navigation system running on mobile devices for mobility impaired people who are bound to wheelchairs. The environment in many countries throughout the world is hardly suitable for wheelchairs. With the Trailblazers System people are able to find ways around obstacles like steps and cobbled streets. Common navigation systems include data for roads only and are therefore suitable for car navigation. Trailblazers has more fine grained knowledge and includes also barrier free ways like e.g. footways and bicycle lanes. As a result Trailblazers can provide a barrier free movement service in form of a fine grained navigation system for people in wheelchairs. The main problem is the acquisition of the necessary GPS data for the above mentioned ways. To overcome this challenge we propose a community driven system in which the users of the system detect barrier free ways in their environments and provide these ways for the community. The system is able to detect barrier free ways based on the positions of the users. In this way the existing GPS maps are extended. Additionally Trailblazers offers a way to enter detailed information about barriers, encountered during a trip, into the system in form of a point of interest. To reduce the amount of work to be done the system further tries to detect these points of interests in a semi automatic way.

Keywords

Navigation System, Routing, Map Annotation, GPS, Community

[1] Presented at the ASK-IT (Ambient Intelligence System of Agents for Knowledge-based and Integrated Services for Mobility Impaired users) Conference in Nizza, France, 26 – 27 October 2006

1. Introduction

Trailblazers is a navigation system for people with physical disabilities who are bound to wheelchairs. The environment in most cities throughout the world is hardly suitable for people in wheelchairs. Obstacles like steps, cobbled streets, too high angled ramps or kerbs are not seldom and can end a trip leaving only frustration to the common wheelchair user. But of course an obstacle is only an obstacle if you can't move around it. E.g. whenever someone encounters steps, there is often a ramp nearby to overcome this obstacle. Or sometimes there are other ways around cobbled streets to the desired destination. The problem is, that these ways are hard to see, especially for someone in a wheelchair. We address exactly this problem and propose in this paper a navigation system which has knowledge about these ways. The rest of the paper is organized as follows. First the detailed objectives of the project are listed in section two. In section three a circle of three simple use cases is introduced which describe how the system works. The overall architecture is shown in section four and this paper ends with a conclusion of our current work in section five.

2. Project Objectives

The objectives of the Trailblazers project can be split into two parts. First there is the technical part of developing a navigation system for barrier free movement which can be used by people with mobility impairs to find ways around obstacles. The application runs on a mobile client device which is easy to handle for the user, for example a PDA or cell phone. The maps together with the barrier free ways should be provided by a server application. The users use a smart client application to request barrier free ways and track their positions on the map. Furthermore obstacles like steps should be marked on the map as points of interest. When moving with the client device in different environments, a continuous connection to the server cannot be assured due to low bandwidth or areas without Universal Mobile Telecommunications System (UMTS) or Wireless Local Area Network (WLAN) connections. Thus the application has to support an online and offline scenario. To support different disease patterns and different types of wheelchairs the software should be able to show ways based on the abilities of the user. E.g. an electrical wheelchair has disadvantages in mobility compared to a non electrical wheelchair. To facilitate this, the software should detect the context of the user and automatically make the right decisions for barrier free ways.

The second part of the project objectives is to unite all users of Trailblazers by activating a large community. The power of this community should be used to detect barrier free ways and to add these into the system. This should overcome the challenge of data acquisition for barrier free movement. This data is needed because existing map material is only suitable for car navigation. With this community driven way of users enabled to collect content the data itself is always up to date.

3. Use Cases

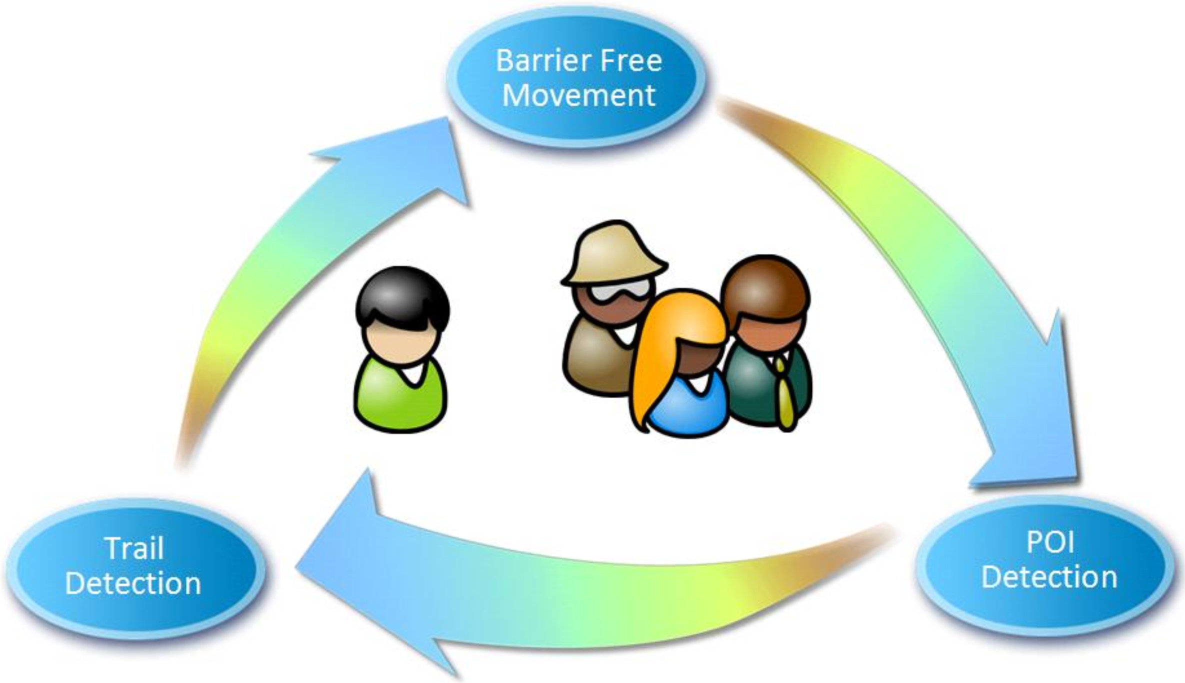


Figure 1 – Trailblazers Use Cases

In figure 1 the three use cases Trailblazers consists of are shown. They all work up a circle. Inside the circle there is the above mentioned community of mobility impaired people. Each community user will have his benefit out of the use case “Barrier Free Movement” which is the primary use case. The user has to provide two locations to the system and gets a barrier free way between those locations as the answer from the system. Alternatively the user can just view the barrier free ways around him if he does not want to go to a specific location or does not know the exact address. After viewing the barrier free ways in his area, he can take one of the ways at his own will.

Like already mentioned the main problem for Trailblazers is the acquisition of suitable GPS data for barrier free ways. With suitable we mean the exact coordinates (in longitude and latitude) of sidewalks, footways, bicycle lanes and all other wheelchair friendly ways. For achieving the goal of data acquisition the use case “Trail Detection” was developed. The system is able to detect barrier free ways based on the position of the users. This happens during usage of the system. The idea is that the community users explore the area they are already familiar with and provide these ways to all other community members. In this way the existing GPS maps are extended and the world will be explored in a new way. And during each routing with “Barrier Free Movement” the data is updated as well.

People who are bound to wheelchairs suffer from different kinds of different disease patterns. These patterns must lead to a better customization of the barrier free movement service. A barrier free way for one user is not necessarily useable for another user. E.g. someone in a normal wheelchair who is doing sports can easily take cobbled streets or ramps while another user in an electrical wheelchair cannot take a ramp or move over cobbled streets because his wheelchair is too weak or too heavy. Thus the system needs additional information about the level of mobility which is needed for a certain barrier free way. To acquire this data we also want to use the community. Trailblazers enables each user to define points of interests which are detailed descriptions and photos of barriers they encounter on their way. These points of interests have also a type which is used by the system to make a decision based on user profiles.

As above mentioned the use cases work up a circle. The idea behind the circle is the WEB 2.0 [1] paradigm. This paradigm enables the user in the web to be actors and not only get information. Sites like Wikipedia [3] are a good example of the success story of WEB 2.0. Indeed the above described system is very similar to Wikipedia. Users enter new detected trails and points of interests into the database and by doing that, strengthen the system even more to provide a barrier free movement service. In Wikipedia some users enter new articles into the system and by doing that empower the information service of Wikipedia. Thus the basic idea behind the whole system can be explained in the following sentence: build up a community and provide them with the right tools to help each other.

3.1 Barrier Free Movement

This use case is very common to the well known routing use case provided by car navigation systems. The user enters an origin and a destination address, the system calculates the best suitable route and displays the route and the users current position on a map (see figure 2).

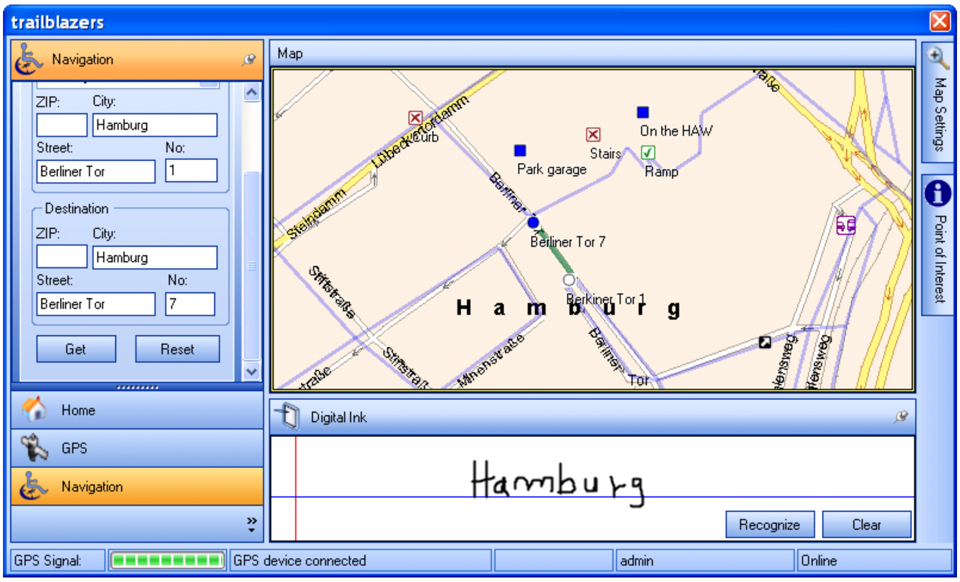


Figure 2 – Trailblazers smart client application, map annotation

The base of our map data is a map generated by the Microsoft MapPoint WebService. This map is enhanced by user collected trails and points of interest. The trails are painted on the map as blue lines. Trails are barrier free ways. During a route request the system calculates a barrier free way based on these trails and draws them as a green line on the map. The points of interest are displayed as small icons in the map. When clicking on one of these icons the user is able to get detailed information about the selected point of interest (see figure 3).

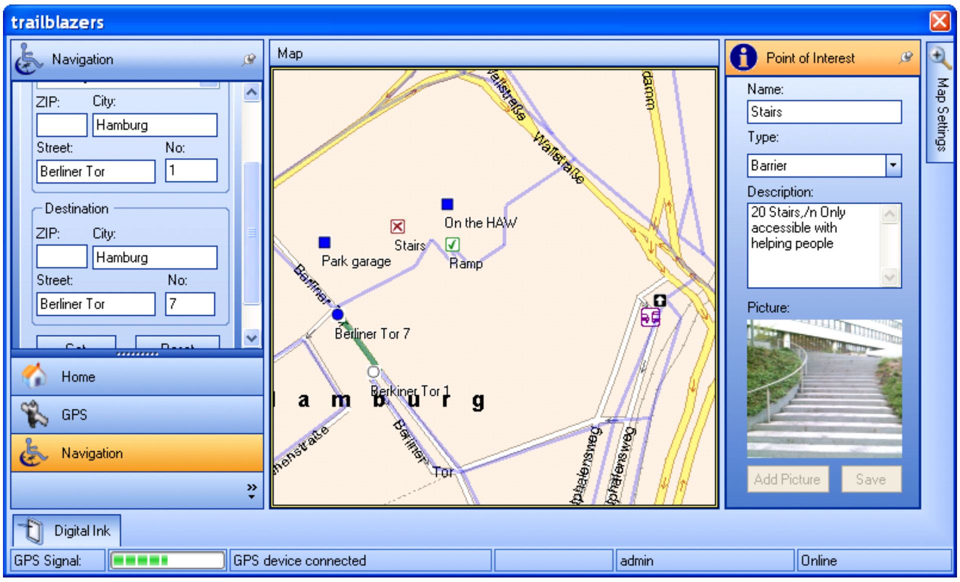


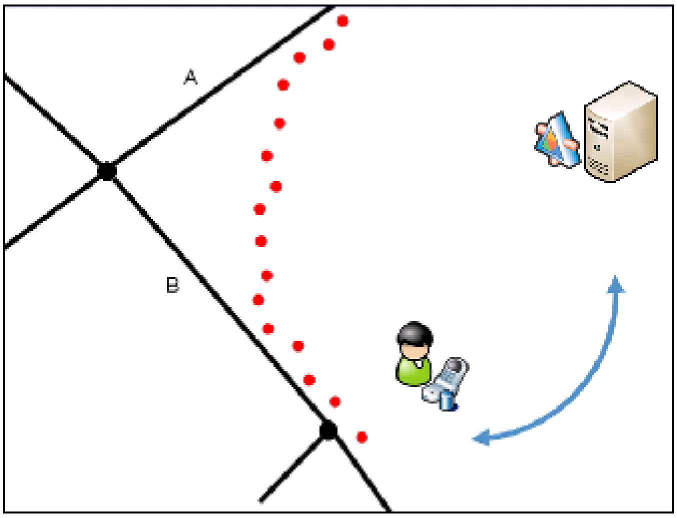
Figure 3 – Trailblazers smart client application, Point of Interest

As the Trailblazers software runs on mobile devices there are a couple of limitations, like restricted power and memory. All these limitations have to be considered at design time of the software. Due to the matter of fact that mobile internet connections, e.g. via General Packet Radio Service (GPRS) is still expensive it is very common that the device is not connected to the Trailblazers server all time. Therefore the smart client application supports both online and offline scenarios. Once the user is connected to the Trailblazers server the user can download a route and is able to store it on the mobile device. Each previous calculated and stored route is accessible in the offline scenario. The user is also able to manipulate offline data, e.g. adding a new point of interest. The data will be synchronised with the server the next time the user connects to the Trailblazers server. Data reconciliation is one of the major issues we have to handle. To achieve this we implement patterns and best practices provided by Microsoft Mobile Client Software Factory [5]. All data transfer is designed and implemented as simple web service calls.

This is a very first prototype of our smart client application. Further versions will support speech recognition and speech output. Both will be a major feature of our application because a lot of users hardly cannot handle such a small device while entering data with a stylus.

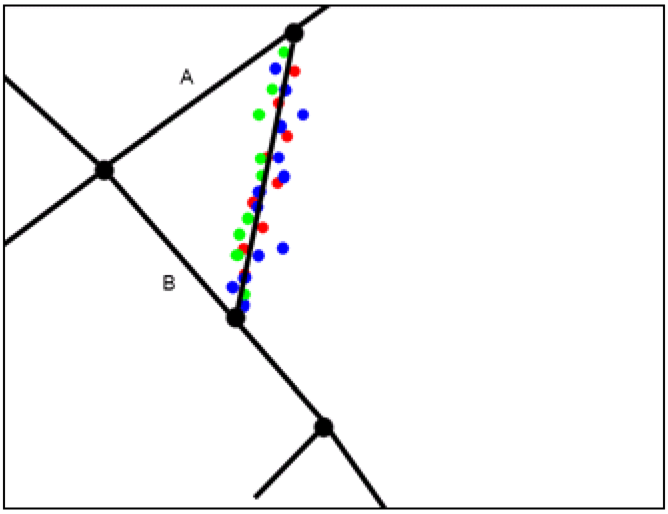
3.2 Trail Detection

The detection of barrier free ways, we call them trails, for people with physical disabilities is the crucial backend functionality of Trailblazers. Although the key requirement was to make a Navigation System, the lack of suitable data forced us to develop a convenient way to enter data into the system. The amount of work to be done by the user had to be kept as low as possible. The users should benefit from the system by getting barrier free ways and should not work for the system by feeding it with data manually. We propose a way to feed the system with new trails based on the position of the users. While using the system it continuously determines its GPS position. For achieving a greater accuracy of the position we use differential GPS (D-GPS). If the client device currently has a connection to the server e.g. via UMTS (online - scenario) the data is send immediately. In case of an offline scenario the



positions are buffered on the client device and transmitted later when a new connection could be established.

Figure 2 shows a graphical representation of the data which is provided to the server in such a scenario. Imagine a user of Trailblazers in a wheelchairs comes down road “A” and finds a new barrier free way which is not yet discovered by Trailblazers. The red dots are the recorded GPS positions of the user while taking the barrier free way. Out of these dots the backend of Trailblazers is able to detect a new trail and enter it into the database automatically. All this is done by certain pattern recognition techniques. Figure 3 shows a new detected trail. You can see that there are different kind of dots (here the green, red and blue ones) which are used the detect the new trail. The different coloured dots are the positions of different users moving through the area at different times. This is why we call the new detected ways trails. In real life a trail is created by having many people moving over the same location many times. After a while the grass is pushed away and a new trail is born. This analogy to the real world is implemented in the backend functionality of Trailblazers. We used this approach because of two reasons. Firstly to correct erroneous data created due to imprecise measurements in a statistical way. This means we allow some dots to be incorrect by having a large number of dots in a way that the average is always correct. Secondly to correct incorrect values coming from special circumstances in a statistical way. A special situation is for example if a skilled wheelchair user is able to take some steps this should not mean that the way is barrier free. Another situation could be that a wheelchair user is carried down steps by some pedestrians. This should also not be recorded as a barrier free way. These situations should be seldom enough to be solved by the threshold we use. The pattern detection is only applied after a certain number of users moved through the area.



3.2.1 Challenges

The detection of trails out of the provided user data is not always possible. The GPS signal is not accurate enough to allow the above algorithm to work correctly. Sources of the imprecise measurements are e.g. reflections of the GPS signal on large buildings. Another problem is that trees block the signals completely so that gaps arise in the data provided to the server. We have two solutions for these problems. The first one is to use the dead reckoning [2] technique to make the measurements more accurate. While being a successfully technique for automobiles this does not work properly for pedestrians right now. Until dead reckoning is researched enough for pedestrians we mainly rely on our second solution which is the trail editor described in the next section.

3.2.2 Trail Editor

The Trail Editor is a tool for the community to enable the users to help each other by correcting erroneous data by hand. If the data is wrong or could even not be detected, some users in the area are notified by the system. These users can use their local knowledge of the region and correct the trails by hand. Figure 2 shows the graphical user interface of the Trail Editor. The user can select trails and use a context menu to delete them or create new ones. All changed data is saved in the database and can be seen immediately by the community. An analogy to a wiki system [3] is visible. If a user enters an article which is not correct another user will recognize this and correct the information on behalf of the whole community. With the Trail Editor users can correct wrong data which was recorded by other users. In this way the system keeps itself correct with the power of the community.

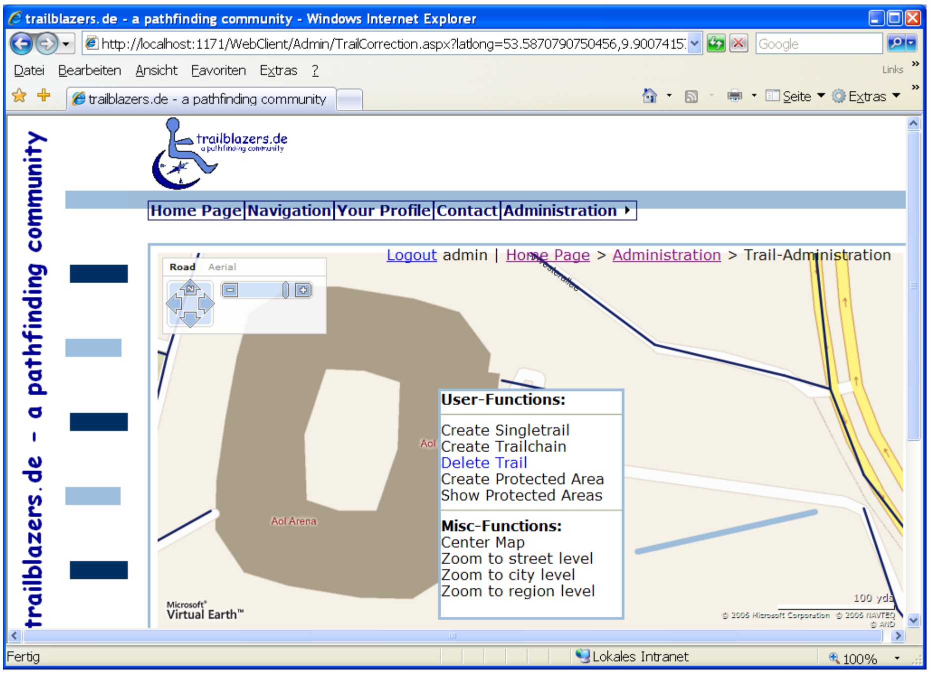


Figure 3 – Trail Editor

3.3 Point of Interest Detection

Because of different disease patterns for mobility impaired people there are paths which are barrier free for one person but not for the other. To solve this problem the system needs more information about the user and about the trails. The user provides a profile which includes information about his disease. Further the trails are annotated by what we call point of interests. These are detailed descriptions and photos about certain barriers which also includes a type. The system can use the profile information in conjunction with the type of point of interest to make the decision whether the trail is barrier free or not. The user can enter a point of interest if he encounters one. E.g. if he encounters a cobbled street he can take a photo of it, enter a textual description for the other community users and selects the type. After that all the information is uploaded to the server and provided to the whole community.

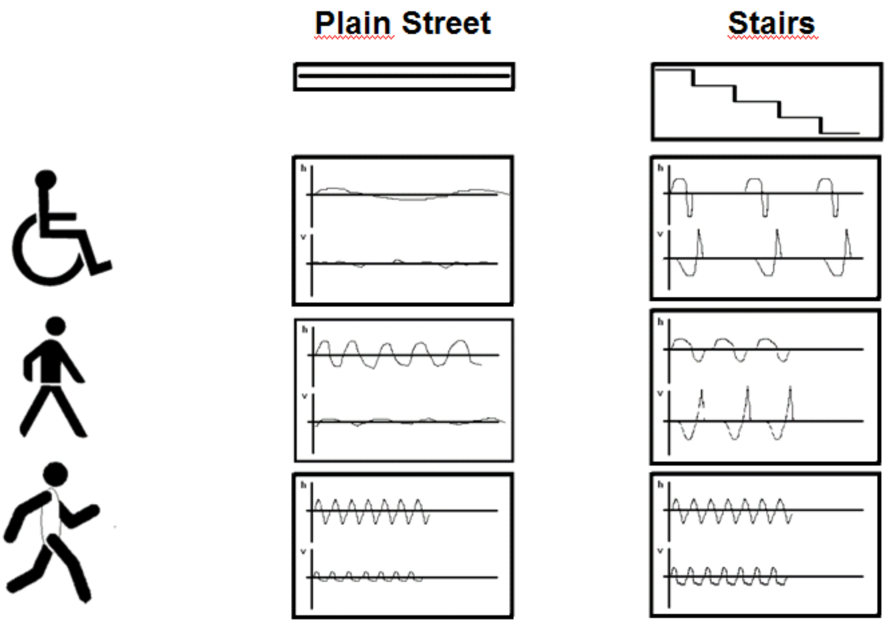


Figure 4 – Context Detection

To reduce the amount of work to be done the system also supports a semi-automatic detection of point of interests and also user profiles. This is achieved by a combination of 3-axis-accelormeters and an artificial neuronal network. During a trip the accelerometers provide the system with data about the motion of the wheelchair. This data is analyzed by the neuronal network. Because different environments provide distinct motion profiles (see figure 3) the system is able to detect if the user moves e.g. over cobbled streets. In result the smart client application will show a predefined dialog which can be edited by the user and then submitted to the server.

4. Architecture

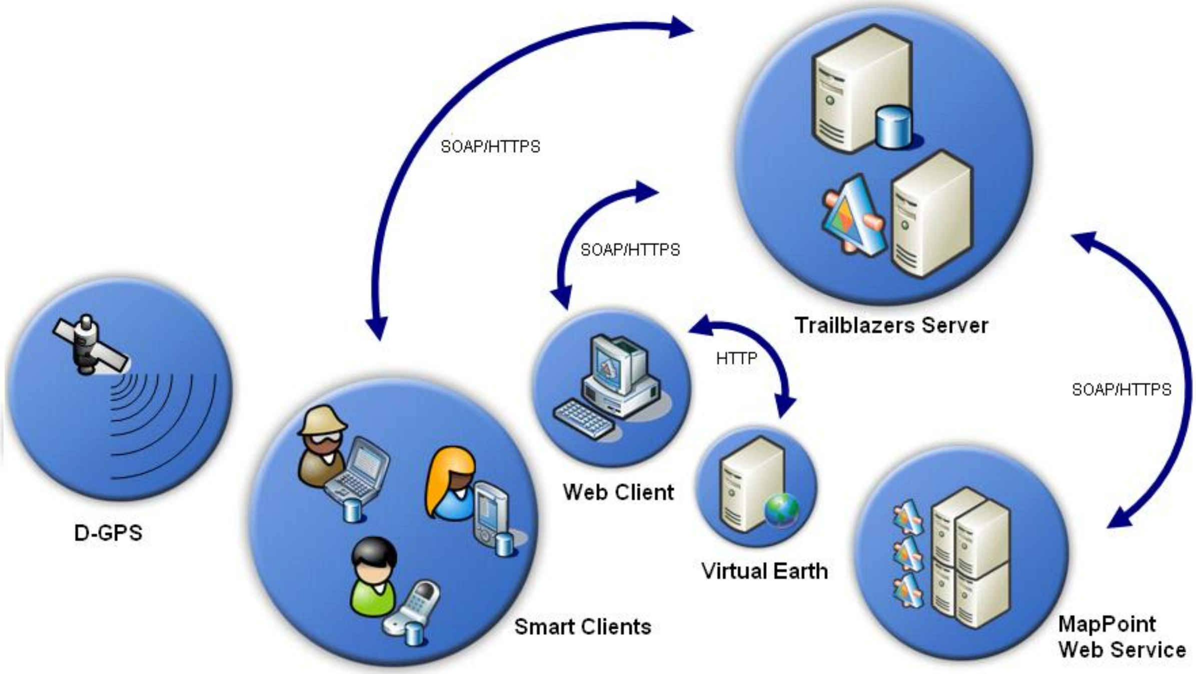


Figure 5 – Overall Architecture

Figure 4 shows an overview of the whole Trailblazers system. It is a modern client/server-architecture with a central server and smart clients on several mobile devices. Trailblazers currently runs on Personal Digital Assistants (PDA), mobile phones and Ultra Mobile Personal Computers (UMPC) all based on Microsoft .NET technology. Additionally there is a web client application which can be used for administration purposes and also for finding barrier free ways. The latter can be saved into a profile and then later be directly accessed from the smart clients. All clients consume the same web service provided from the server application. The server application is responsible for answering routing requests, detect new trails out of provided GPS data from the clients and share the points of interests with the community. For providing a better range of visual aspects to the user we use two mapping frameworks in the system. The server uses Microsoft MapPoint WebService and the web client uses Microsoft Virtual Earth.

5. Conclusion

In this paper we introduced a navigation system which helps mobility impaired people to move in a barrier free manner. The usage of the system should be as simple as possible for having a great acceptance. The user just needs to provide two locations and the system provides him with a barrier free way between those locations. This path includes not only the sidewalks of streets but also paths like footways and bicycle lanes making the system much more fine grained that common navigation systems. To solve the problem of data acquisition for barrier free ways we propose a community driven solution. The users improve the system while using it by detecting new barrier free ways in a transparent manner. To customize the functionality for different disease patterns the detection of points of interests have been introduced. These are detailed descriptions of barriers which also include a photo and are classified in types. The latter is used to show barrier free ways based on user profiles. The simple but effective system consists out of only three use cases which empower each other by having more people using the system. Trailblazers has a modern client- / server-architecture and runs on several mobile devices. In one sentence the idea behind the system can be described in the following way: activate a community and provide them with the right tools to help each other.

References

[1] http://en.wikipedia.org/wiki/Web_2

[2] http://www.deadreckoning.com/

[3] http://de.wikipedia.org/wiki/Wiki

[4] Microsoft European Innovation Centre, EMIC Location and Mapping Framework, http://www.microsoft.com/emea/emic/downloadcentre.mspx

[5] Microsoft msdn, Mobile Client Software Factory, http://www.microsoft.com/germany/msdn/library/mobility/windowsce/MobileClientSoftwareFactoryCommunityTechnicalPreviewRelease.mspx

[6] Microsoft, MapPoint Web Service