YPOP Indoor Navigation and Service Information System for Public Environments

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Abstract: - A reliable indoor navigation and information system can offer assistance and make the every-day life of many specific user groups, such as the elderly and the visually impaired, easier. However, the same system, if designed well, can also be used by a wide range of new applications and serve as a enabling technology for future ubiquitous mobile applications. This paper describes the ongoing real-life project YPOP, which is an indoor navigation and guidance system designed to be easily and cost-effectively recreated.

Key-Words: - Indoor navigation, indoor positioning, Wi-Fi positioning, ubiquitous mobile applications

1 Introduction

An indoor or local area navigation and information system designed to serve specific user groups that have high expectations for its functionality, e.g the visually impaired, can also be used as a basis for a range of other applications aimed at various different functions. This paper talks about the YPOP system, which is aimed at augmenting the personal navigation and information system for users of the public transport outdoor navigation system for blind pedestrians [1] with an indoor positioning, guidance and information system aimed at offering high precision, location dependant, personalized indoor navigation. At the same time, the system's main component the data model of the building or local area, coupled with integrated navigation functions and reliable positioning make the development of future mobile ubiquitous applications a possible.

In an indoor environment, traveling is made more difficult by small spaces, narrow hallways, stairs, doors, pieces of furniture and other objects. In closed spaces people often encounter more and closer obstacles. For certain specific user groups, such as the visually impaired, potentially dangerous situations can occur when walking without guidance in environments unknown to them. A navigation and guidance system conveying the layout of an indoor facility through a either a verbal or visual interface can give its user a broader sense of what the environment is like. Other specific user groups such as the elderly and building maintenance workers can similarly benefit from the information the system conveys them. An indoor navigation system answering contextual awareness questions and communicating cues that include distance, navigation and Area of Interest (AOI) information can empower its users to arrive at their intended destination faster and make more independent decisions without the need for extra guidance. If the environment has been modeled to a sufficient degree, the system can also increase the level of traveling safety, especially for specific user groups, by employing timely obstacle prompting. However, it is important to take into account, that a guidance system based on Wi-Fi location estimation techniques cannot, without extra measures such as taken in [2], account for changes in environmental dynamics such as moving people inside the premises.

As GPS is largely not available indoors and because the requirements for measurement error change in closed or confined spaces, a system that is able to switch from a location tracking technology to another without significant delay or, when possible, fuse positioning data and measurement error information from two or more complementary technologies, is ideal. Our system, YPOP, is a Wi-Fi and sensor positioning service, which provides a high precision measurement scale for indoor use and prompts the user with the indoor room layout. YPOP is designed to enhance the user's real world navigation experience by augmenting their reality through verbal or visual interfaces that give contextual information about the surrounding environment. Advances in wearable computing, voice recognition, wireless communication (e.g. VoIP over WLAN), and Wi-Fi positioning techniques have made systems such as YPOP possible.

2 Related work

Many research projects have aimed to create electronic travel aids. Most projects have concentrated on solving one specific problem, thus resulting in a technically simple device which is difficult to use or just unwieldy for the user. Various technologies devised determine the location and/or orientation and provide routes to users. The development of traveling aids based on positioning has a relatively long history. Since the late 80's, the utilization of GPS has been researched and many research projects were carried out; MoBIC [3], Drishti [4], Brunel Navigation System for The Blind [5], and the work done by Bruce Thomas, etc [6]. Also commercial products such as Sendero Groups BrailleNote GPS [7] and HumanWare's Trekker 3.0 [8] are available addressing GPS based electronic travel aids for the visually impaired.

The research project NOPPA (personal navigation and information system for users of public transport) [1], carried out 2002-2004 with a budget about 0.5 M€, was a part of Finland's Passenger Information Program (HEILI) funded by the Ministry of Transport and Communications. NOPPA was a pioneer system in its use of real time public transport information made available on the Internet for the general public and it has gained considerable publicity internationally.

Different Wi-Fi positioning techniques have been studied in cases such as [9, 10]. So far, one widely adopted technique has been WLAN received signal strength based probabilistic location estimation, such as [11]. Other techniques, such as relative positioning, utilizing infrared transceivers, active badges, or accelerometers, have been exploited [6, 12-14]. Currently projects such as RELATE are pioneering the use of mobile ad-hoc networks for relative positioning [15]. Except [6] and [15], one major limitation of these systems is that they merely deal with a locating or navigation service in outdoors or indoors, but not in actual combined traveling environments. In reality, for a personal positioning system to become more than the novelty it is today, a single system or a combination of systems working seamlessly together through standards, guiding the user all the way to their destination, will be required.

For these reasons, a modular system architecture able to fuse positioning information coming from two or more source technologies, depending on its availability, is more adaptable and less location or technology dependant. E.g. the MiddleWhere project [16] studies fusing positioning information originated through several different technologies.

3 Design criteria

The type of guidance the system offers to the user – whether being information on a very precise, or a more general scale – changes in accordance to the client's preferences, attained positioning and known or estimated measurement error. For example, giving guidance to a target 10 meters away is not possible for a system that has a positioning accuracy of only the same 10 meters. In the case of a low positioning accuracy, guidance is about forming a big picture of the route and closely resembles asking another person for guidance.

Generally, no or very limited maps that include information about large public premises are available, or the map data is in a form that makes it unavailable for use with an electronic guidance system. Furthermore, the lack of a single prevalent standard for indoor map data in use today makes each indoor positioning and guidance system – at least partly – a unique solution. Maps themselves are not a problem, however, as often a suitable guide map already exists for the area or building in question. To be useful for services such as YPOP, these maps need to be modified into a form where it is possible to plan simple routes and search location based data. Place-to-place guidance requires map data including entrances (transition points) and continuous guidance requires good quality indoor maps and precise indoor positioning.

The right side of Fig.1 represents a concept for an indoor data model, first proposed in [1], where basic geometry information is obtained from CAD drawings. Other information is then linked to this geometry model to create a model of the building that includes information on routes, services and Area of Interest (AOI) information available. Together with reliable positioning this information enables a host of new applications, such as those presented in this paper.

YPOP is designed to use existing software and hardware already available on the market, however, the coding of some specific parts, or modules, and the integration of the complete system remains the main aim for our research team of teachers, students and partner entities. Because of some memory and battery limitations in today's mobile terminals, most of the processor and memory intensive work is performed on the YPOP server.

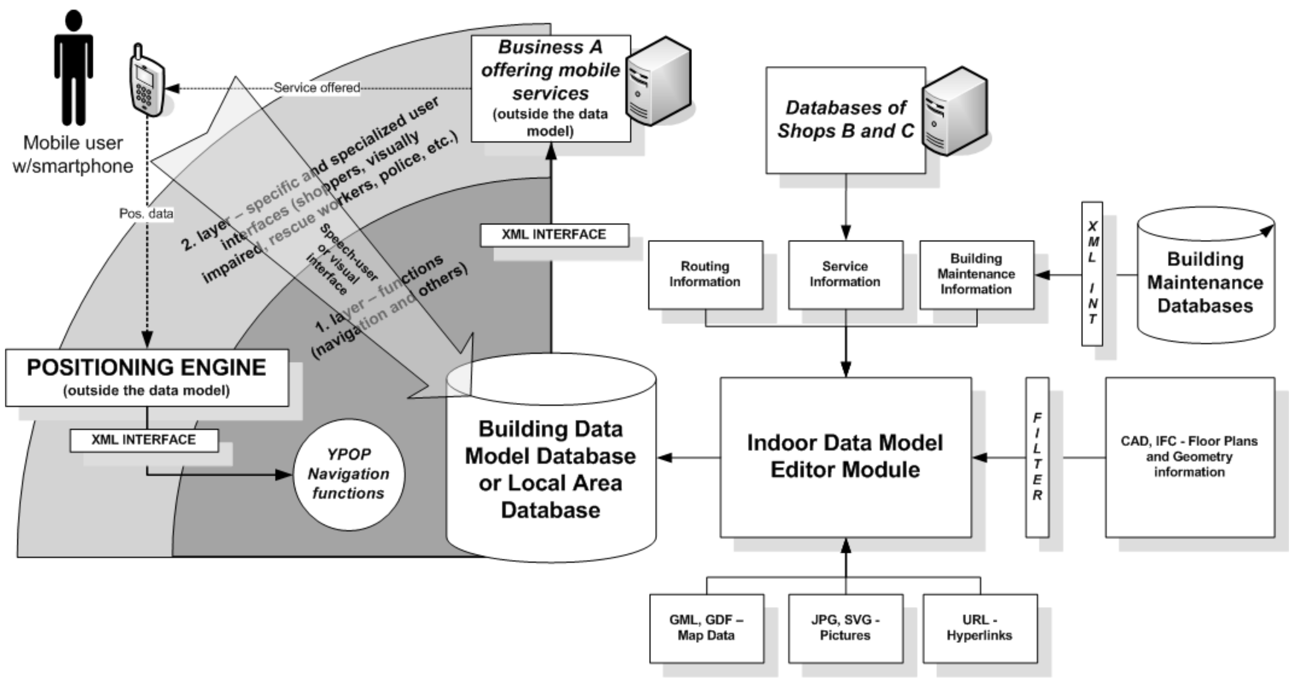

Fig.1 YPOP architecture

3.1 Positioning Data Fusing and Reasoning Module

There are several technologies available for indoor positioning, but none of these has yet acquired a position as a technological standard comparable to that which GPS has for outdoors. Moreover, for some applications, we must be able to utilize the positioning system through our chosen mobile terminal device. Cell-based positioning is too coarse for our purposes. Today, indoor positioning research and development is largely focused on WLAN and Bluetooth. Bluetooth positioning techniques are still not as widely adopted and Bluetooth positioning systems currently suffer from drawbacks such as the slowness of the electronic handshake between the Bluetooth enabled devices. Meanwhile, the currently predominant WLAN standards lack detailed definition of some features, such as the received signal strength indication, that are used in WLAN location estimation, resulting in measurement deviations between cards from different hardware manufacturers [17]. New wireless technologies such as Zigbee [18] and Wibree [19] are also emerging as possible candidates to be used in future indoor positioning techniques. The use of WLAN positioning systems can also set demands on network infrastructure and require investment. However, depending on the site, the building or upgrading of WLAN infrastructure can be further justified by other obtainable benefits, such as increased wireless network availability.

Although WLAN is used as the main resource for our system, current WLAN positioning methods cannot guarantee positioning in all environments and conditions, thus for our purposes, it is expanded by support for other more ranged technologies, such as Bluetooth and Zigbee. In our project, we are also experimenting with a simple reasoning logic that together with a short-term positioning memory can support the positioning engine and enhance the reliability of the system's position estimation by removing glitches such as floor jumping in large open spaces, typical to WLAN positioning methods based on RF fingerprinting.

In terms of the YPOP architecture, the Positioning Engine is situated outside of the actual data model in order to not limit the use of the data model in environments with different positioning technologies. This decision is further justified by the fact that largely only mobile applications have use for the positioning engine, where as positioning information for static terminals, such as building info screens, can be placed into the data model itself. After positioning data has been gathered from the mobile terminal and properly fused and reasoned over, the resulting information is passed on to the navigation function through XML interfaces.

3.2 Datamodel Database

The other main element, besides positioning, for creating a navigation system is the availability of maps and routing information of sufficient quality. The indoor data model is a coming together of things such as a building's CAD maps, routing, maintenance and service information, map data, pictures and hyperlinks. Equally important, however, is the creation of an editor that can be used to relatively easily create, update, fuse and integrate this information into a single database.

3.3 Indoor Navigation and Guidance functions

The Indoor Navigation and Guidance Engine, by the using information coming from the positioning module and datamodel database, offers navigation and information services through verbal and visual interfaces. It can be augmented to offer the user access to other applications through its verbal or visual interfaces. Verbal user-interfaces can offer specific user groups some substantial benefits and in the same way a person guiding a car benefits from hands-free, a maintenance person being guided to the target can have both hands free for other purposes. The information that is given to the user can be altered by the preferences of the user and by information of their user-status, e.g. whether they are a guard or maintenance person on duty, or an impaired or unimpaired client just strolling through the shopping mall or museum.

3.4 Client terminals

In the first stage of the project, we use a WLAN tag together with a suitable mobile handheld device to simulate the end product and to test the navigation system. The prototype of the terminal is built to a commercial mobile phone with hands-free accessories and suitable wireless communications properties. For some alternative applications, such as interactive information screens providing environment information, we can use media-sharing hardware already available on the market today.

3.5 Speech-user interfaces

Verbal user-interfaces can offer specific user groups some substantial benefits and in the same way a person guiding a car benefits from hands-free, a maintenance person being guided to the target can have both hands free for other purposes.

3.6 VoIP over WLAN Call Manager

We use Linux Asterisk-based VoIP over WLAN manager for transferring spoken commands to the speech recognition module for translation into command language for YPOP server software.

4 Design Goals and Problem Areas

4.1 Design Goals

The design goals for our YPOP navigation and information system are largely the same that NOPPA [1] had. YPOP is designed for ease of use, flexibility, modularity, affordability, applicability – both indoor and specific outdoor areas, product and service integration, upgradeability, maintainability and has a speech user interface. Fig.2 presents some of the different user groups that can benefit and use the data model and the navigation functions it provides.

4.2 Problem areas

The YPOP prototype is being built in a large shopping mall that can be considered a challenging environment for modern Wi-Fi positioning due to its large open spaces and changes in environmental dynamics. However, by developing proper positioning data fusing mechanisms and reasoning logic YPOP hopes to overcome some of the shortfalls of current Wi-Fi positioning techniques. Other problem areas that need to be taken into consideration are the usability of a speech-user interface in a demanding environment, such as a shopping mall packed with people, and those of power consumption. The power requirements for continuous active use of both WLAN and Bluetooth, or some of the other Wi-Fi technologies on the market today, are known to be relatively demanding. Thus a risk remains that the end user will not be able to make use of the service for fears of mobile terminal battery discharge. However, new technologies, improving standards and optimized chip designs arriving on the consumer market are raising hopes that in the near future these factors will be less of a threat for the usability of projects such as YPOP.

5 System application environments

YPOP can be applied to any number of different environments from shopping malls, airports, office skyscrapers to large open sea cruisers. In any of these different environments, the potential user-groups and their expectations for services may vary, but the basic idea of maps with service information and a system with integrated navigation functions remain the same. In effect, only the applications change, but the body and the tools for creating and maintaining it remain the same. The data model editor module makes YPOP a special indoor navigation system in that compared to other similar prototype systems; it can be

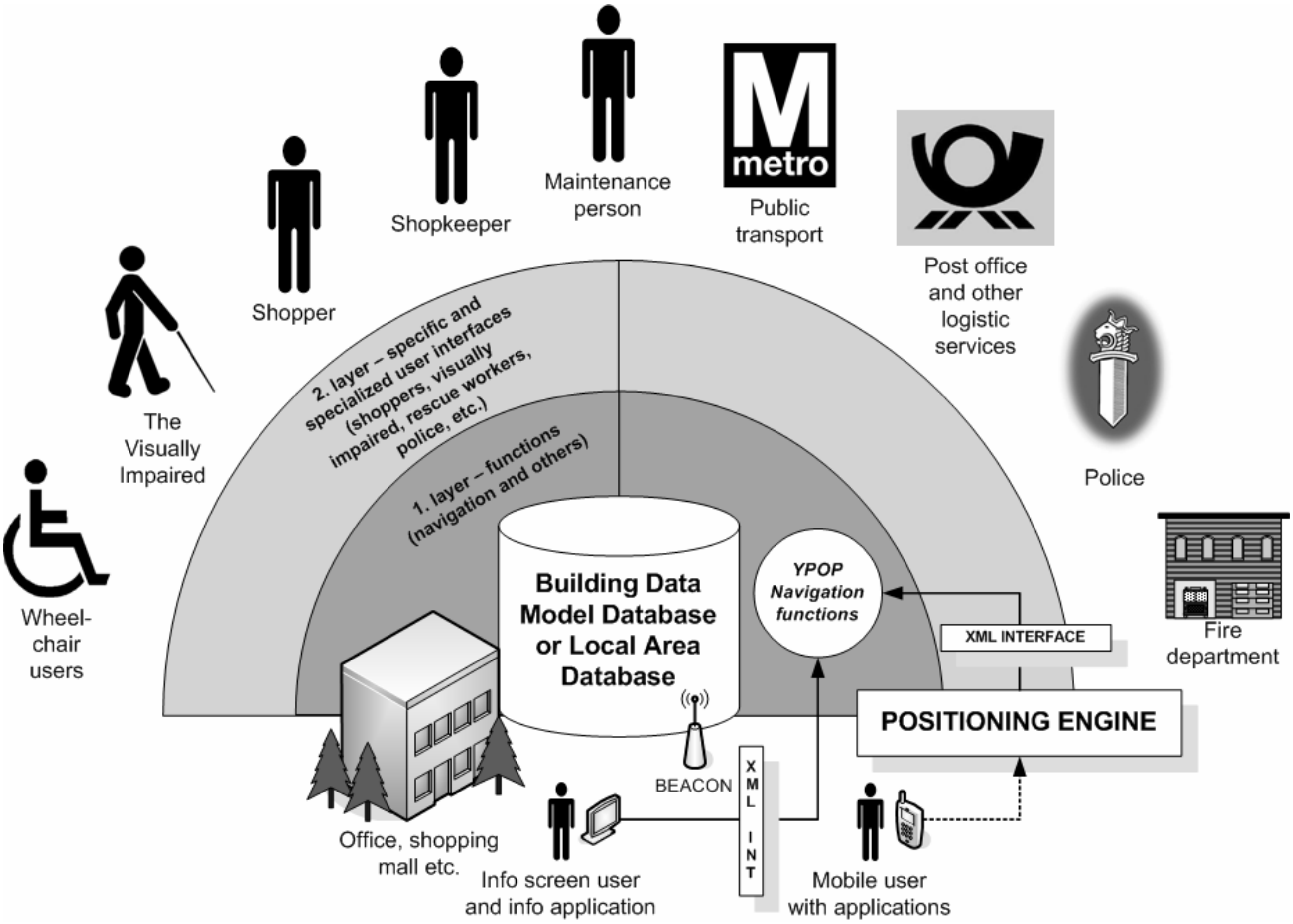

Fig.2 Some YPOP user groups

relatively easily recreated in different buildings or similar environments. The creation of tools to help keep the data model database up to date also makes maintaining the database considerably easier.

6 Summary and Future Work

The development of indoor navigation systems, if done correctly and by applying open interfaces, can create the base for the development of new indoor positioning related applications. These applications can share and utilize parts of each other, and base each other on top of the same architecture and infrastructure. Although Wi-Fi positioning itself has already matured to the point that a range of products are found on the market, and systems such as Ekahau EE [20] already support XML-interfaces for publishing positioning data, the distribution of these systems have been left marginalized because of lack of supporting applications. For this reason, the writers feel that in order to make them more interesting, effort should be put on generating applications for systems such as YPOP. The writers feel that this will stimulate interest for building necessary technological infrastructure and enable future ubiquitous mobile applications. Importantly, these systems or platforms should be designed to be open to third party applications to enable creative use of the available resources.

So far, efforts to generate local area routing and service information for projects similar to YPOP have been scattered and with little focus on developing tools for creating and maintaining the information necessary for such systems to become widely used. The development of the tools and the data model database can be seen as a step forward to this direction and are being continued within the project.

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