IN-SITU ANALYSES OF BUILDINGS BY MEANS OF SMART DEVICES AND LOCATION BASED SERVICES

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Abstract. In this research we examined if it might be possible that a client accomplishes an ad-hoc analysis of an existing building with the intention of prospective revitalization. The aim is to give a client who incidentally faces a building the possibility to run an in situ usability simulation. To accomplish this we recommend Location Based Services that can be accessed by common remote sensing devices. These devices should automatically connect to server-based applications, which compare the requirements of the client with the existing building and run remote simulations on concrete further utilization. The newly generated information will then be passed back to the clients' device. In the paper we address a scenario of a prospective client who visits a city where he hits on an unused building he might be interest in. The client wishes to gain immediate and accurate information if the building is able to meet his demands regarding the space needed for his company. Different techniques investigated, their assets and drawbacks will be described that could accomplish suchlike tasks.

Keywords. Location Based Services, Smart Environments, Ubiquitous Computing, Optimization

1. Introduction

The existence of unused buildings in many parts of the world is increasing dramatically. In our country the amount of unused spaces in existing buildings already equals the total amount of new buildings per annum. A further usage of the existing building stock is desperately necessary due to a multitude of ecological, economical and social reasons. One of the most important reasons is however, that these buildings already used an enormous amount of energy and that they will continue to use energy if we would demolish them and decide to build new ones. It is quite obvious that we are in charge to counter this development and that we need to develop strategies for reasonable further usage of these spaces. In our investigations we arrived at the conclusion that many of these buildings feature a quality that is comparable to those of new buildings. Both the positive energy balance and esthetic requirements that would be made to new buildings can be discovered in many old buildings in remarkable quality. The reasons why we do not often make use of these buildings are manifold. Unfortunately they often come along with the architects desire to eternalize himself with the design of a new building. To hit the jackpot with a revitalization project is difficult if not impossible. However, to spread out the idea of revitalization we developed a concept that allows participation of potential clients already in the early phases of a redevelopment. On the basis of previous research which demonstrates that it is possible to objectively measure the performance of a revitalization action to be undertaken with standard Personal Computers, our new approach involves the integration of clients through the use of standard mobile communication devices.

Previous research that was conducted within the past few years demonstrated that it is possible to answer revitalization requests with the aid of methods taken from Operations Research, esp. Optimization Techniques (Loemker 2006). These requests were made on an

"as easy as possible" basis, due to the fact that their sole intention was to gain an immediate answer to a buildings general potential of further usage. Typically a prospective client has a clear vision of the future usage of a building. He develops a first and simple room program that describes his needs and demands in a simple manner. Thus, a characteristic inquiry made to an architect would imply the following questions:

- Is it possible to realize a specific usage within the existing building?
- Does the building provide enough space for this usage?
- Is it possible to rent a certain amount of rooms with a given size of floor space?
- Can the total space be divided into smaller ones to establish workgroups within which rooms are interconnected?

It is pretty obvious that the answers to these questions do not conclusively give information if a building is actually well suited for revitalization. Many other questions have to be answered with the aid of a professional architect. Our system however answers these first and fundamental questions automatically, without the necessity to employ a professional. Furthermore it is possible to send various requests to the system that can be related to a multitude of buildings. It would as well be possible to define a universal enquiry and to let the system propose buildings that fulfill the demands made. Both variants can be accomplished through the use of Push-/ Pull Technologies. In our opinion the possibility to let the system automatically answer a revitalization request increases the chance for actual further usage of the building stock. Precisely the fact that suchlike enquiries are usually dealt with great effort by architects or real estate agents and entail costs, leads to the situation that prospective clients do not take a revitalization action in to account. The possibility to automate this process as well as the necessary techniques for client participation is described in the following chapter.

2. Process Automation and Client Participation

Let us consider a scenario of a prospective client who visits a city where he incidentally faces an unused building he might be interest in. The client has no idea if the building is able to meet his demands regarding the space needed for his company. To obtain more information about the building he should either contact the real owner or an estate agent. Both are unknown to him and difficult to find without substantial effort. To get reliable information about potential future uses he might as well involve an architect which would entail to invest money. In any case the client has to gain access to any kind of inventory listing that specifies the building data needed. In our approach we refer to the utilization of remote sensing information technology, the Internet and Location Based Services to accomplish this demand. Most problematic in this context is the question which data is stored in the inventory listings, i.e. for what aim they were compiled, where they are stored and how they are organized. Generally spoken the content of inventory listings might be extremely diverse and closely related to the question of who is using them primarily. In our scenario it is sufficient to use listings that first and foremost specify basic data about the buildings dimensions, organization, classification and prior utilization. The whole purpose here is to make use of the existing building stock due to ecological reasons, i.e. the dissipation of energy through the erection of new buildings. Therefore we prefer a quantitative approach which lists many buildings with fundamental properties instead of a smaller amount of buildings which are precisely specified in every nut, bolt and screw. More specific the aim of these inventory listings merely is to publicize the existence of buildings that might be suitable for new uses with the goal to sell or rent them. Therefore it is necessary to use filters that compile only the data needed from the whole range of diverse listings. Through the use of these filters in conjunction with Location Based Services a first stone can be laid for further thorough discussion of the subject. Once a request to the LBS is successful many other parties have to be involved, i.e. real owners, estate agents, architects, town planners, municipalities, planning offices. In our scenario it is important to notice that the client cannot gather information about the building in-situ without asking

someone passing by or without using technology he usually does not have at hand. However, the idea of LBS is that through the use of commonly available mobile communication devices and with the aid of data relating to the position, time and individual user, information or services could be made available by a service provider. In any case the only valuable information the client needs to provide is the location of the building. Due to the fact that this position in terms of georeferenced data is not known to the client, the Location Based Service automatically employs this position by the clients' mobile devices. In this respect LBS can be described as follows:

"LBS are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device." (Virrantaus et al. 2001) referred to by (Steiniger et al. 2006).

3. Location Based Services

To establish communication with the LBS various components are needed which are described in brief in the following section.

3.1. SERVICE USER (LBS USER)

The LBS User makes a request to the LBS Provider and calls for a specific service. These services can be distinguished into two different kinds: Pull Services (reactive services) and Push Services (proactive services). Reactive services are directly inquired by the user, whereas proactive services are either indirectly or not inquired by the user. They can be activated trough specific events. An indirectly inquired service could be a subscription to a service which would only be activated if a pre-defined condition arises (i.e. the user is situated at a specific location). Not inquired services can be advertisement massages, which are as well activated by entering a specific location.

3.2 MOBILE DEVICES

These devices assure communication between the client and the provider of Location Based Services. Mobile devices can be cellular phones, smartphones, PDA's, PNA's or notebooks. It is important that they have the capability to communicate via any kind of communication network. Communication can be established through various techniques, among which GSM, GPRS and UMTS prove to be most successful.

3.3 COMMUNICATION NETWORKS

The mobile network transfers data from the users' mobile device to the provider of the Location Based Service. This communication is bi-directional so that interaction between the parties is possible. The simplest possibility to set up a communication network would be a Wireless LAN, due to the fact that access to this service is more or less area-wide available. It is however wise to consider Wide Area Networks due to their better tracking mechanisms and wider range of devices to be supported.

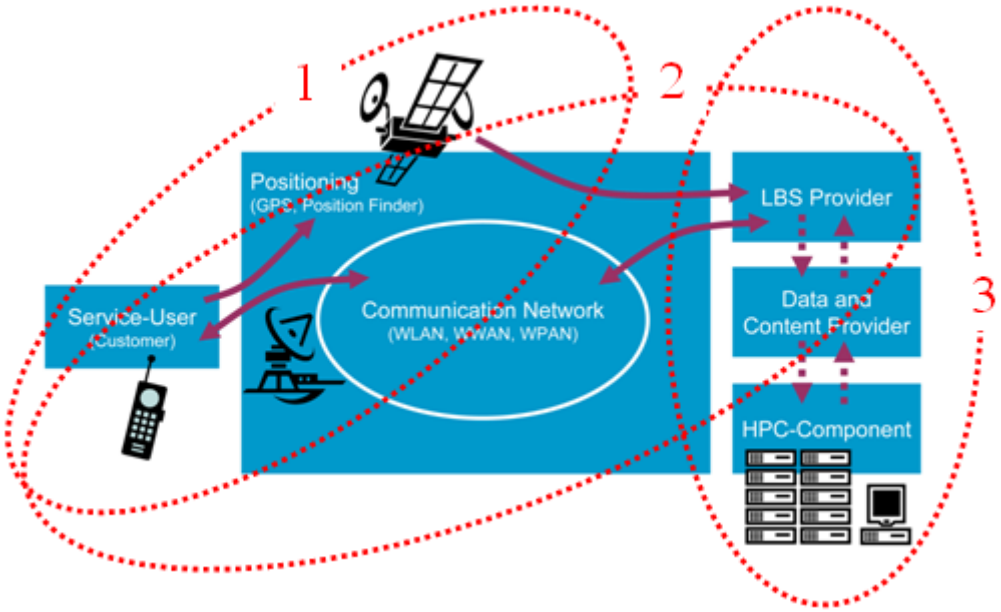

Figure 1. LBS communication. Positioning (1), Communication (2), Content Provision (3).

WLAN (Wireless Local Area Networks)

The easiest and cheapest possibility to setup LBS in revitalization would be through the use of an open WLAN. In this case charges for the service do not necessarily have to accrue for the client. It entails however that the client has a wireless mobile device such as a PDA or a notebook at his disposal. It also entails that the WLAN access-point is fixed to the building and that the client is within the reach covered by the network. If the WLAN would be accessed it would re-direct the client to a website where he could retrieve information about the building. Through this website he could also access a web-based front-end to enter data about his specific needs. This data would be passed by the web server to a high-performance computing center where a simulation of the request is processed with the aid of optimization engines. The results would be retransferred to the web server and displayed on the website, i.e. on the clients' notebook or PDA. There are several bottlenecks in this approach referring to the WLAN, the mobiles devices and security. In the first instance it cannot be guaranteed that each and every building can be equipped with a WLAN. It is also questionable how to deal with a situation where different buildings from different owners are situated at almost the same location.

WPAN (Wireless Personal Area Networks)

These networks cover ranges between 0,2m and 50m. Their data transfer rate reaches up to 2,1 Mbit/s (Buetooth 2.0) and 16 Mbit/s (IrDA (Infrared Data Association)). Most disadvantages that apply to a WLAN apply to a WPAN as well.

WWAN (Wireless Wide Area Networks)

The most common WWAN communication technologies are GSM (Global System for Mobile Communications) and GPRS (General Packet Radio Service). Both Services belong to the second generation of mobile communication standards. Due to the fact that both services

originate from voice communication requests, their data transfer rates are quite low and not sufficient for extensive multimedia applications. Other than these two services the roots of the third generation UMTS (Universal Mobile Telecommunications System) lies in multimedia communication. Thus, it provides much higher data transfer rates but is due to its high costs still not widely-used. WWANs cover ranges between 100m and 35km, which means that the distance of the mobile device, which is usually a cellular phone, from the base station is within that range. While communication through a WLAN entails that the position of the client and the building is known through the fixed position of the access-point, communication over WWANs comprises two kinds of position tracking. On the one hand the client could call upon specific services that would track his position. This could be achieved with the aid of a position finder who would make use of the clients' devices own mobile communication network within which his position is known. On the other hand the client could make use of GPS data received from his GPS-compliant phone. In either case the biggest advantage of WWAN-technology is that it is not necessary to affix any devices to the buildings themselves. This is an invaluable factor to foster the willingness of building owners to participate in Location Based Services. Even though Wireless Wide Area Networks provide the lowest data transfer rate and are more cost-intensive than other technologies we recommend their use in Location Based Services for Revitalization. The essential reason is that services can be provided device-independent. Thus the building owners do not need to install any hardware within the building. The only need is to make data about the building available to the Service- or Content Provider. The client however needs only a common portable device such as a cellular phone or a smartphone.

3.4 POSITIONING COMPONENT

To deliver a service to a client's mobile device, its position has to be determined. This is either possible through the use of the devices' own mobile communication network or by the use of the Global Positioning System (GPS). In the later case the mobile device has to have a GPS component attached to or build into it (e.g. PNA's). Generally spoken a position of a target device can be determined by the target device itself (GPS) or by a Position Finder which could be the provider of the phone service. This provider detects the position of the mobile device according to information from his base stations tracking the position of mobile devices in radio cells. These tracking positions usually need to be converted (by a Location Finder) into a format that can be used by the Service and Application Provider. It is also possible to determine the position through Wireless Local Area Networks (WLAN).

3.5 Service and Application Provider (LBS Provider)

This provider makes use of the position data generated by the position finder and integrates them into his applications, i.e. the service requested by the client. Communication between the Service User (Customer) and the Service Provider is displayed on the customers device using WAP or i-mode technology.

3.6 Data and Content Provider

Sometimes the LBS Provider does not maintain specific data that is needed to provide a service (e.g. maps for route finding). In this case Data and Content Providers deliver missing data. The basic idea underlying the approach presented herein is to use an optimization engine to execute a client request. The engine itself is not available on the clients own device. This is due to the fact that no mobile device would be capable to provide enough compute power to solve complex requests. In addition the client has no information about the buildings structure, i.e. inventory listings of the building do not exist on his device. Hence, the idea is to provide access to all necessary components via the use of communication devices, whereas the focus

lies on the condition that the least demands have to be made to the clients' devices. In our approach we used an optimization engine that is build into ILOG OPL Dev Studio. Access to this engine is made possible through the Content Provider who maintains it on an HPC-Component (High Performance Computing). Accessing the engine can be accomplished using a sophisticated programming language (OPL – Optimization Programming Language) as well as several script-languages such as OPL-script or JavaScript.

Figure 2. Cellular phone with LBS-request and -answer.

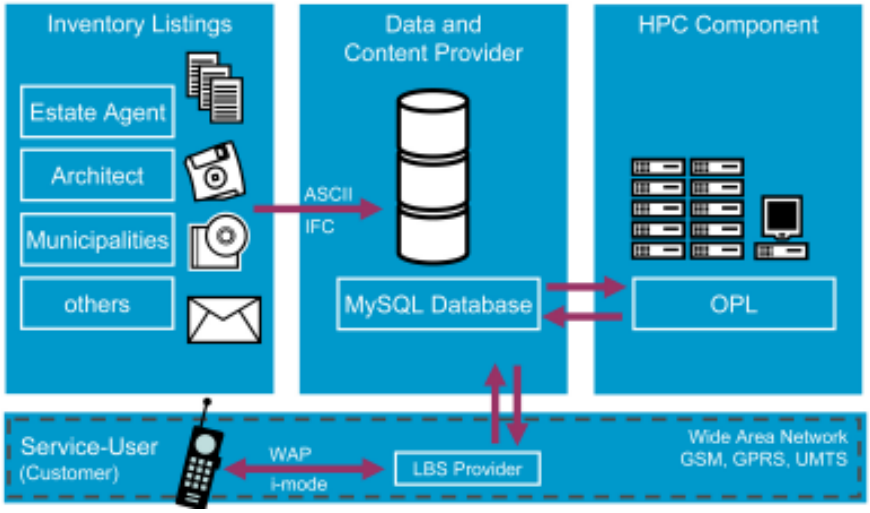

Figure 3. Data transfer and communication.

4. Push- and Pull-Services

In our scenario we were describing a client who traces an interesting building. In this specific situation the service was inquired directly by him (Pull Service). Position finding was then conducted automatically and the ascertained position data was transferred to the Service Provider to query the database in terms of the building which is closest to the clients' position. Alternatively the service could as well be inquired through a subscription that activates it once the client passes through an area within which buildings are located that match his predefined needs (Push Service). These services can specifically be helpful for those who are

professionally interested in the purchase or procurement of buildings. Push Services are usually internet-based services to deliver information, whereas the information is stored on a central server that distributes the data on the basis of a clients predefined parameters. In this case there is no further request from the client necessary to activate the enquiries. Predefinition of parameters is established through a web-based questionnaire whose structure matches the deliverable content of the database. This ensures that only requests that can actually be handled by the data- and content provider will be executed. Push Services are often used on BlackBerry s that make use of MDS (Mobile Data Service) to transfer other information than emails to the end device. For PDA s and Cellular Phones that are increasingly widespread the Wireless Application Protocol (WAP) or i-mode technology can be used to utilize these services.

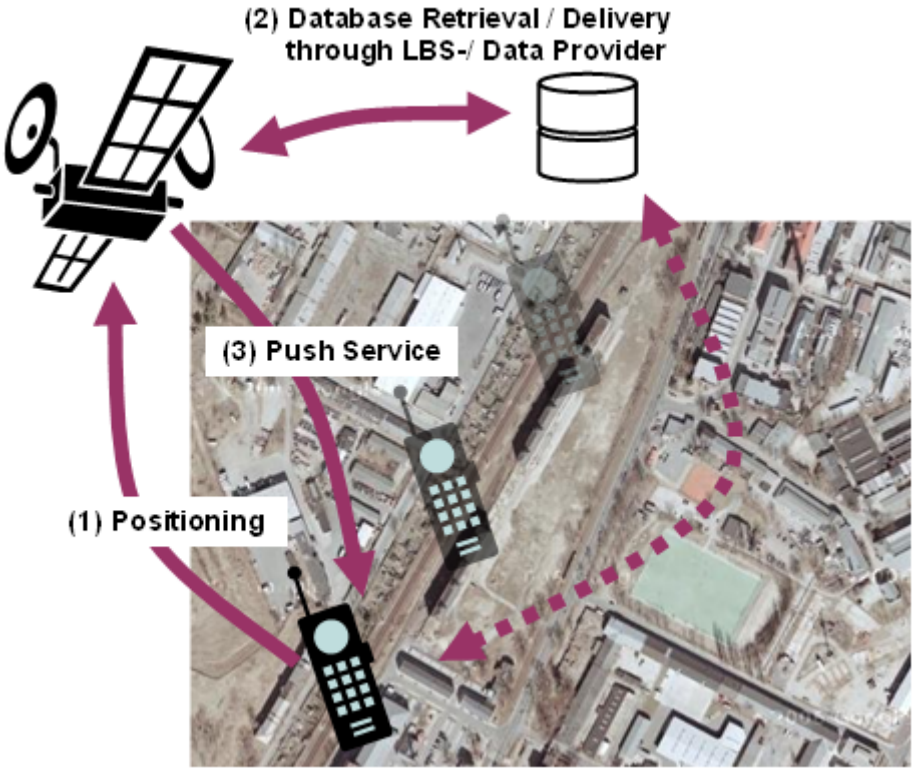

Figure 4. Schematic of Push Services.

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