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Towards online position information integration in a location based services gateway

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Abstract—**Assistance Systems employing for example interactive control of building environments and indoor localization services are topics of growing relevance for ambient systems. Today there exist already a variety of indoor localization approaches and systems as well as universal remote control systems. In recent works we reported on our research on lightweight middleware offering a position related smart building services gateway. Such a system allows clients to receive visual- and contextual information about the environment and allows performing control of systems within this environment. The gateway middleware eases abstraction and integration of underlying systems and information, for example indoor localization technology, the original 3D building model data format, or existing control applications into client applications. In the current work we investigate the integration of dynamic position information using the iLoc indoor localization system and a mobile position visualization application.**

Indoor Localization; Position Information Gateway; Building Automation

I. INTRODUCTION

Building automation has been employed successful for decades now, for example for heating- and air conditioning control including blinds and illumination control. The main advantages of these systems are energy-efficiency and comfort. Today the systems are able to cover much more functionality for example monitoring for safety applications in the area of AAL (ambient assisted living). There exist a variety of automation standards and technologies [1], long established ones like KNX/EIB [2] and LON [3], mainly deployed in commercial buildings and newer technologies like for example ZigBee, EnOcean, Z-Wave etc., which are more tailored for installing in existing private environments, and IP-based UPnP (Universal Plug & Play) [4,5] networks which are typically employed for multimedia devices.

There exist gateways (see for example [6,7]) to couple these technologies and access them by user applications like behavioral monitoring for AAL purposes, remote control or whatever. Such systems allow access to the underlying networks and functionality with standard internet technologies and allow for example control via web browsers or other user friendly GUI applications. Control may be performed wireless with mobile devices like smartphones (for example [8] and references therein). Even more sophisticated application scenarios arise if the position of a user or a device is known. In this paper we summarize the concept of a location based smart building services gateway, report on the integration of indoor localization into such a system, and present early results of the integrated system.

II. LOCATION BASED BUILDING SERVICES GATEWAY

A. Overview

In recent works, we introduced the concept of a location based building services gateway for visual- and contextual information exchange and for control [9,10]. The concept circumvents the disadvantages of monolithic applications which typically include a dedicated localization system, some automation systems, sensors, analysis applications, presentation etc. in a hard-wired way and do not easily allow use cases like inclusion of new types of sensors or integration of new applications.

The approach of a location based building services gateway (LBG) allows access to functionality and services not only by means of address information but also based on position information and visual navigation in a 2D/3D building model. Devices, services, people, map information, region information etc, are all accessed via one meta-interface using the abstraction of “visual objects" (VO). The structure, requirements and design considerations for such a system are discussed in earlier work [9,10].

The LBG is a first access point for applications aiming to interact with one or more of the systems available in a building. The LBG will provide general data which is independent and universal to the installed systems, like 2D and 3D building maps. For application specific communication, depending on the architecture of the underlying systems, the LBG can act as a proxy and forward the communication for example between users and the system. In contrast to more comprehensive frameworks like universaAAL [11], the lightweight LBG approach does not itself allow the implementation of complex use cases but acts more as a broker between the user and existing use case implementations.

The aim of the LBG approach is that existing applications of the building, like different classical automation and control systems, possibly an indoor localization system, an existing remote control system etc. will not need to be touched and still are operational without the gateway. But they can be coupled to the gateway in variable depth.

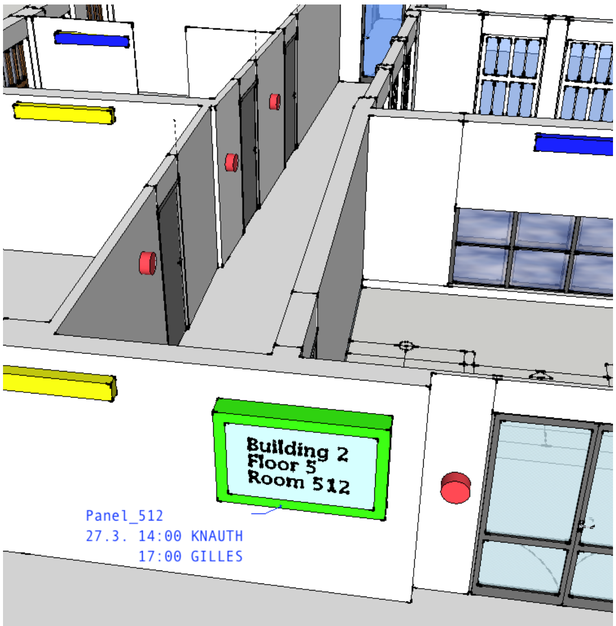


Figure 1. Client visualisation of LBG object shapes. Informal and controllable objects (coloured) are embedded in the 3D map visualisation. Lighting state is indicated by green/blue colour. Currently the room info panel is activated and the room schedule information is displayed.

For example, the LBG may just announce entry points to other systems. It can also allow identification of managed objects like blinds, lightning, access control, etc. If supported by the underlying application, the gateway offers a complete control interface.

In order to take advantage of the LBG, dedicated client applications are needed. The basic application task is the visual services navigation. In Fig. 1, a screenshot a navigation interface is shown. The user sees a 3D building visualization and specific objects which indicate system information and control. In the figure some objects are visible: a room information panel is selected by the user. The client includes current information from the room information system, here a schedule of the room usage. Stretched rectangles at the top of some walls indicate lighting control. The state of the room illumination is indicated by the color of the rectangles. By selecting these objects, the user may control the items, i. e. switch the lamps in the corresponding room/area. Red cylinders close to room doors indicate electronic access systems. Doors can be opened by clicking on these items. Access control is provided by the user authentication against the LGB.

B. *LGB Architecture and Visual Objects*

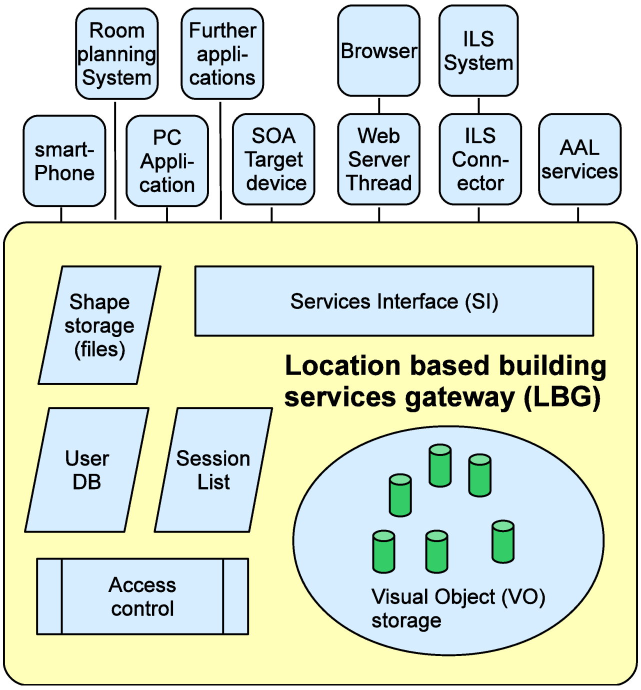


Figure 2. Location based building service gateway (LBG) architectural overview.

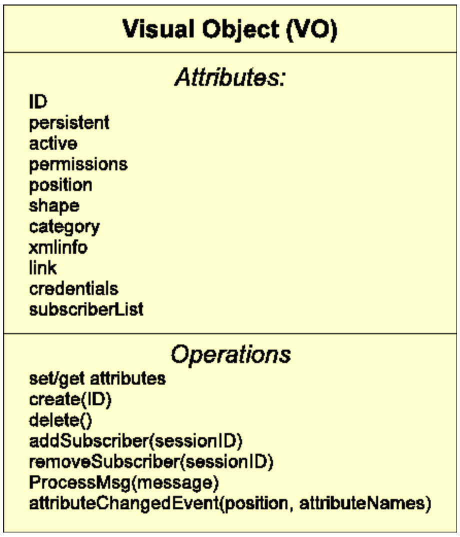
An overview of the LBG is sketched in fig. 2: The core components are: the Visual Object Storage, a general services interface (SI), a 3D shape storage including a format converter, a user database, and an access control component. The services interface offers web-services. A client keeps a connection this interface. Such a connection is called ”session". Authentication takes place during session initiating. When connected, a client session accesses visual objects. In order to access VOs, the client needs a list of objects he is interested in, provided by the SI object selection methods e.g. by name or ID, by context (Room, Floor, Type) or by proximity to a spatial coordinate.

C. *The Concept of Visual Objects in the LBG*

“Visual Objects" (VO) generally spoken represent entities of the building. This is principally anything in the building that may be of interest for a user or an application and can be associated with a spatial position. Typical VOs represent building maps, smaller visible objects like barriers etc, assets or persons, link/info objects, sensors and other automation system control objects. Link objects are objects which, besides their visualization, provide only an url, for example access to some control interface, and a textual information. The textual information may for example be a timetable at an university room or info from other technical equipment like a meter. This information may be updated by LBG clients. The automation objects currently represent SOAP or complete UPnP devices, and the device description XML is included in the object such that a client may interpret the information and control the device, for example lighting devices.

III. INTEGRATING ONLINE INDOOR POSITION INFORMATION

A. *General considerations*



Visual Object (VO)

Attributes:

ID
persistent
active
permissions
position
shape
category
xmlinfo
link
credentials
subscriberList

Operations

set/get attributes
create(ID)
delete()
addSubscriber(sessionID)
removeSubscriber(sessionID)
ProcessMsg(message)
attributeChangedEvent(position, attributeNames)

Figure 3. Visual Object Attributes and Methods.

Fig, 3 outlines the structure of a visual object. We regard the case where a visual object represents someone or something whose position is detected by an indoor localization system (ILS). From the point of view of an ILS, mainly the attributes ID, active, and position are of interest. We assume that the objects already have been created as VOs in the LBG, e. g, they are known, have an ID, and have associated shape, for example an icon.

The ILS shall update the VOs position attribute according to the detected position. A typical ILS could detect position estimates at a constant rate, for example twice per second. The easiest approach of integrating the online position information into the LBG is to send the position estimates to the LGB with the update rate. Therefore the ILS opens and keeps one session to the SI interface. The ILS itself hat the role of a “user” in the LBG. Via the session, the position attribute of the VOs covered by the ILS are repeatedly updated each time a position estimate is available. This is performed by calling the “set attributes” method of the VO via the web service interface.

The ILS itself does not care what user or application is using this information, and no synchronization between applications and the ILS is necessary. These issues are all handled by the LBG. An application, say a visualization client or a behavioral observation application subscribes to VOs where it is interested in. Attribute changes like change of position are notified to the application and corresponding actions like display update or path analysis can be triggered inside the application.

B. *Integration of the iLoc ILS*

As an example, we integrated the iLoc+ ILS [12,13]. iLoc+ is an ultrasound based system (see also [14]) which localizes up to 20 transmitters in indoor environments with a position update rate of about 2 estimations per second, when using 10 transmitters. The system uses wireless reference nodes. Persons or objects to be localized wear a small mobile transmitter. A system layout overview is sketched in fig. 4.

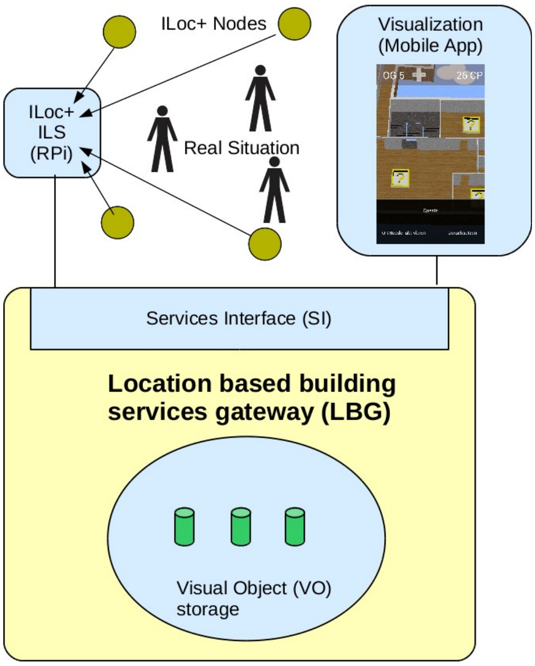


Figure 4. ILS integration Demonstrator System Overview (ILS tracking not fully implemented)

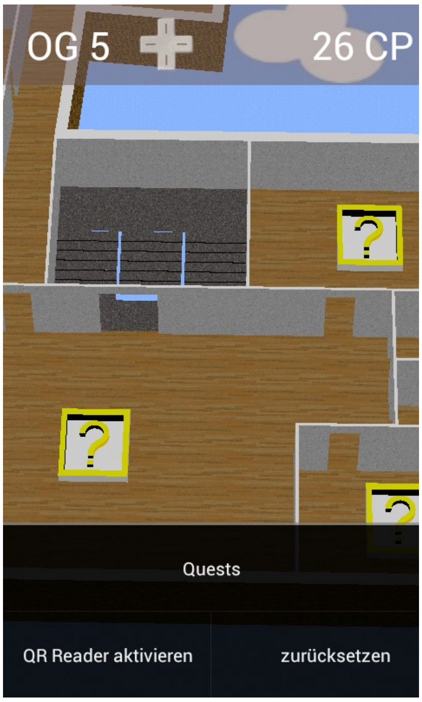


Figure 5. Android client map view

The iLoc+ system is installed in our lab environment at HFT Stuttgart. As this work is in early state, we did not really track people but generated “dummy” positions into the iLoc communication subsystem. The real tracking would not principally change the behavior of the communication between iLoc+ and LBG but further investigations will follow.

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Position estimates for three objects are sent to the LBG at a rate of 2 per second and object. The LBG updates its corresponding VOs accordingly.

An Android client application (Fig. 5) is also connected to the LBG. This client is not position aware. The viewport of the client is selected by its user by swiping in the 3D map, or by scanning QR codes located at the doors of the rooms. The 3D map is provided to the client by the LBG as compiled scene graph. Initially, the client requests a list of all VOs of category "ILS" and subscribes to notifications for attribute changes of these VOs. Each time an attribute is changed by some application (here the only connected application besides the client itself is iLoc+) the client updates its local VO storage and updates his view. The VOs whose positions are under control of the ILS are indicated with the question mark icons.

IV. RESULTS AND DISCUSSION

We used the LBG concept introduced in earlier work to set up a simple position monitoring system. LBG features like gateway for control of automation devices are not used in this setup but could of course be integrated. We learned that the connection of an ILS to the LBG can be performed with moderate effort by implementing the SI interface in the ILS. An already existing client is able to visualize the dynamic position information of a LBG visual object. The gateway abstracts the ILS and for the client, it is completely uninteresting what system provided the information. Such an abstraction is also delivered by much more comprehensive systems, but for limited scenarios, we like our lightweight approach due to ease of setup and reasonably low resource usage.

We realized one drawback which to some extend breaks this independence: Currently, each position update triggers the notification chain which could in extended scenarios produce a considerable communication and computing power issue. Of course, updates are only triggered on VOs to which the client has subscribed and not on all information like maps, "landmarks" and other VO categories. But the notification concept should allow the client to set a maximum update rate in cases where missing updates do not cause a problem. Also, the current Java LBG implementation uses hibernate and a MySQL database. For performance issues a variant using an in-memory database, for exapmle redis, could be considered.

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