

# OPEN ISSUES IN BRINGING 3D TO LOCATION BASED SERVICES (LBS) - A REVIEW FOCUSING ON 3D DATA STREAMING AND 3D INDOOR NAVIGATION

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## ABSTRACT:

As the mobile Internet becomes ubiquitous with increasing bandwidth and as a broad range of always more powerful mobile devices appear Location Based Services (LBS) finally have become commonplace ten years after the first LBS hype. On the other hand 3D city models are being introduced to mobile navigation systems and scientist investigated that three-dimensional perspectives are likely to increase the orientation and self-localization of the user. However, unfortunately there is still a big gap between developments on the mobile platforms, LBS and the state of art in 3D GIS and 3D Spatial Data Infrastructures (3D-SDI). Transferring huge data volumes from 3D city models to mobile devices is required, but specific streaming solutions for those are not available and existing approaches often lack in performance. By introducing prioritization methodologies considering relevance for the application, an advanced streaming method could be invented. Current navigation solutions focus on outdoor environments and proper indoor solutions are scarcely available. Reasons for this are missing standards for indoor addressing schemata and difficulties in modelling indoor environments. Different approaches for indoor models are currently available, but they either do not provide optimal routes or they lack in semantic and topological information. Furthermore problems related to proper visualization of route instructions are still not solved satisfyingly.

## 1. INTRODUCTION

As the mobile Internet becomes ubiquitous with increasing bandwidth and as a broad range of always more powerful mobile devices appear it is possible to consume information and services on the internet and the mobile web. Location Based Services (LBS) bring in the first notion of context thus trying to improve the usability and "location awareness". LBS can be defined as "services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device" (Virtanen et. al. 2001). Today it seems as if they have finally become commonplace ten years after the first hype.

On the other hand 3D city models are being introduced to mobile navigation systems. By adding 3D visualizations it is possible to better support the consumer and add value. Typical examples include navigation systems that try to include 3D more and more. But up to now most available products and services still only offer a perceptively deformed map instead of a real 3D model (Neis et. al. 2007). Moreover there is still a big gap between developments on the mobile platforms, LBS and the state of art in 3D GIS and 3D Spatial Data Infrastructures (3D-SDI). Within this paper we present a short review of two related issues that we see as relevant for future research in merging LBS and 3D. The one is the issue of missing standards in 3D data streaming and the other is the need to enhance typical routing and navigations services towards 3D indoor environments. We have chosen these, because we think that these are important for future developments, but available research results are still limited, though.

The remainder of this paper is organized as follows: First, there is a brief overview about methodologies and approaches for 3D data streaming to mobile clients. Afterwards there is an overview about existing indoor routing approaches and solutions. For both topics, we furthermore describe which problems are currently occurring and we also provide some first thought-provoking impulses.

## 2. STREAMING 3D DATA TO THE MOBILE CLIENT

One research topic we would like to investigate more detailed is the area of data streaming. According to (Bauer et. al. 2008) processing units and storage capacity of currently available mobile devices are still limited and therefore are not sufficient for executing complex and advanced computations and analysis directly on the device. Furthermore the speed and overall performance of mobile networks is still not that fast (Schmidt 2009) so that transferring huge amounts of data still often takes too much time and furthermore lacks in performance.

In contrast to that, researchers figured out that people can localize and orientate themselves better when provided with a 3D model of the surroundings, thus orientation appears to be more intuitive with life-like three-dimensional visualization (Rakkolainen et. al. 2000). Considering these three facts and having the goal of providing advanced three-dimensional indoor location based services, leads us to the cognition that there is a strong need for efficient and advanced streaming possibilities for 3D (city) models.

Fractional, there do already exist solutions for minimizing the size of transferred data for a faster provision via mobile networks. According to (Eppinger & Coors 2005) general compression tools such as Win-zip or Gzip are useful for an average compression rate for 3D models, but specialized algorithms that consider the 3D model structure could additionally achieve a compression rate of up to 95%. One possibility is to develop and provide different Level of Details (LODs) of city models and maps which can be utilized for offering different detailed perspectives (Coors & Flick 1998). That is, a user who is interested in a brief overview about a city can request a model in LoD 1 (i.e. a model with blocks representing buildings) and a user who is interested in a detailed perspective on her surroundings can request a model in LoD 3 (i.e. concrete architecture with texture) or for indoor purposes even LoD 4 (i.e. concrete architecture including details of the inner building). Another possibility is the new version of the

Web3DService (W3DS) specification which supports a sophisticated tiling scheme for interactive 3D scenes (Schilling & Kolbe 2010). Moreover, (Bodgan & Coors 2009) also focuses on the reduction of data size. They proposed a procedural façade texturing for three-dimensional city models. Thereby they assume that the façade does not need to be photo-realistic, but a mixture between realism and fiction is desirable and functional. The approach is mainly based on (Coors 2008) by creating a pulse-function which places features (e.g. windows or doors) on an existing background texture, resulting in a synthetic texture. Further reductions can be achieved by using text library elements, so that less image data needs to be stored and processed. An example of such a synthetic texture and three-dimensional perspective is depicted in figure 1 on the right-hand side, with the corresponding user interface of the pulse function on the left-hand side.

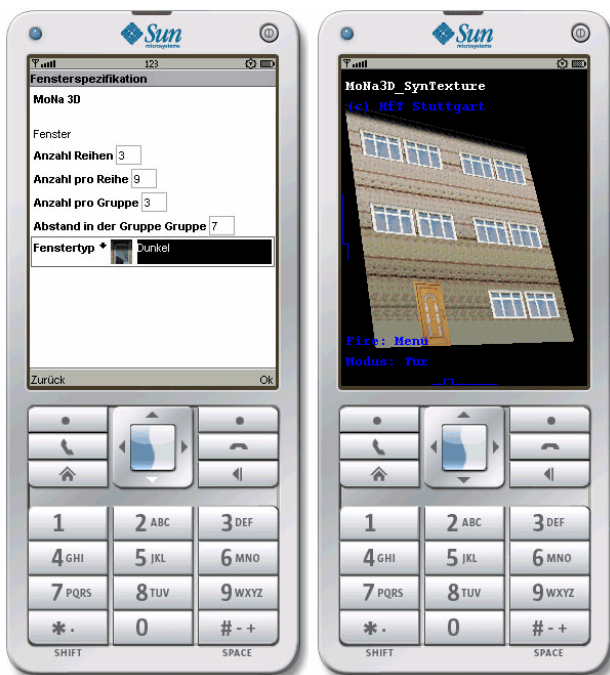


Figure 1: user interface of the pulse function (left-hand side) and corresponding synthetic textured façade (right-hand side) on a mobile phone device (Coors 2008)

However from our perspective the data size is still too big for a proper mobile usage, thus further work is required. One might argue that the performance of mobile devices and networks will increase in the next couple of years, but on the other hand the huge amounts of 3D data will still be a problem and furthermore data size will also increase due to higher resolute and more detailed models. Until now there exist some streaming algorithms for media files, e.g. MPEG or Flash Video Streaming which can be (mis)used for LBS (Zlatanova & Verbree 2005). However we are not aware of any special solution for 3D (city) models, which are capable for streaming 3D (city) model data such as VRML, X3D, KML or CityGML. Therefore we propose the development of a streaming protocol for 3D models tailored to the special requirements of LBS and mobile applications. In doing so, we assume it will possible to increase overall performance, thus it is possible to increase the quality of the application. We propose that such a streaming concept should contain some kind of priorities for objects

according to their relevance for the application, so that sophisticated prioritization methodologies can be implemented. That is, objects with a high priority can be transferred faster and illustrated more quickly on the mobile device and relevant information can be consumed faster by the user. Altogether the overall performance of the mobile application can be improved. First work has shown how to focus and prioritize specific objects in a mobile 3D environment using open standards (Neis & Zipf 2008), but the question on how to identify and parameterize the objects is still open as well as the question on how to improve performance through intelligent streaming.

### 3. INDOOR ROUTING

Another research topic is the area of indoor routing. Not only for private purpose such as navigation through a shopping mall, but also for rescue forces, it is important to get detailed routing instructions inside a building. There are many different fields of application for indoor routing and extending research on indoor routing is beneficial for all of them. In table 1 there is a short overview about some use cases, whereby they are grouped into the three different categories authority (i.e. for official use), personal (i.e. for private use) and commercial (i.e. solutions to be bought by commercial facilities)

Category	Use Case
Authority	- routing of rescue forces - routing of staff in public buildings - ...
Personal	- routing in a shopping mall - routing in a museum - interactive real-world games - routing at the airport - routing in hotels - routing at conferences - routing at exhibitions - ...
Commercial	- routing of autonomous robots - routing for customers in a supermarket - surveillance and optimization of logistic processes in indoor environments - ...

Table 1: Possible fields of application for indoor routing

Unfortunately, information about indoor spaces is currently still rare (Kolbe et. al. 2008) and existing routing solutions primarily focus on outdoor and city or urban regions. Moreover, due to the fact that GPS is hardly available in indoor environments (Zeimpekis et. al. 2002), that is concrete positioning is hard, most research in the area of indoor routing is done on indoor positioning and indoor localization systems. e.g. RFID localization (Renaudin et. al. 2007)), usage of sensors (Zheng et. al. 2009) and (Grejner-Brzezinska et. al. 2009) or the usage of WLAN (Ohlbach et. al. 2006). But as far to our knowledge sophisticated indoor routing solutions do hardly exist. A first prototype using OpenGIS standards (such as W3DS and OpenLS) has been showcased in the OWS6 testbed by members of our group, but lacks more specialized support for Indoor environments. Further prototypical applications are the so called Cyberguide system (Abowd et. al. 1997), a nomadic exhibition guide for trade fair visitors (Schmidt-Belz & Hermann 2004) or the indoor navigation system INav (Kargl et. al. 2007) which

allows routing and real-time navigation. However we think that all existing solutions are very specific according to distinct requirements (e.g. emergency) and therefore are not universally applicable or adaptable to other requirements.

One problem for a lack of indoor routing solutions is a missing standard for the addressing scheme of rooms inside a building, i.e. those vary quite often. Some rooms have a number for the floor level, others have a figure for the floor level, some have continuous numbers in the whole building and some do not even have any number or name. So a first step towards proper indoor routing is the development of a standardized indoor addressing schema. Thus, we expect a unique identification of each room and its location. This will allow querying routing services for the route from room A in building A to room B in building B. And extended review on address and address standards is provided in (Hong 2008). Moreover the paper investigates the concept of the new generation of geographic information (UBGI) and discusses a “possible mechanism to handle various address-related issues” (Hong 2008).

Furthermore, we think there is work on indoor models required. A first topological model, i.e. a model which relies on abstract description of spatial relations, is presented in (Raubal & Worboys 1999). It provides “a formal approach of the process of wayfinding in built environments” (Raubal & Worboys 1999). A second topological model is presented by (Brumitt & Shafer 2001). According to the authors, the model is very simple and provides information about existing relationships between different parts (e.g. room, corridor, hallway etc.) of a building. The approach in (Gilliéron & Merminod 2003) creates a very abstract model with no semantic or topological details. Important information such as solid obstacles or the concrete location of doors is also missing. In (Park et. al. 2009) a RFID-tag based model is proposed, however the quality strongly depends on the settlement of the tags. The model proposed in (Stoffel et. al. 2007) considers rooms with concave shape, but the constructed routes are not optimal and length-dependent. In (Yuan & Schneider 2010) a model for length-dependent routes is proposed. In figure 2 (a) an exemplary architectural map is shown with its corresponding route graph in figure 2 (b) for computing optimal length-dependent routes through the building. However this approach produces an overhead of graph elements, thus performance during computation of optimal routes is likely to be suboptimal. We see a trade-off between computation result and performance and we think that future studies are required to clarify whether optimal routes are really required or if differences of a couple of meters are acceptable for a human user.

Most former models have a lack of accuracy and furthermore semantic or topological information is often missing. Moreover most models do only showcase buildings with one or two levels. Additionally the concrete visualization of indoor objects is open for discussion. There is little experience available about how much details a user needs for proper orientation. We recommend a fair balance between too little information and information overload. Since mobile devices are furthermore limited regarding display size and colours (Bauer et. al. 2008), a clear visualization is required. Furthermore there are clear and easy to understand routing instructions required for different routes. In (Münzer & Stahl 2007) some visualization methodologies are introduced and furthermore evaluated according to user acceptance. Also questions related to linguistic natural language route instructions are relevant for indoor navigation as discussed in (Zhang 2008) or (Roth & Frank 2010).

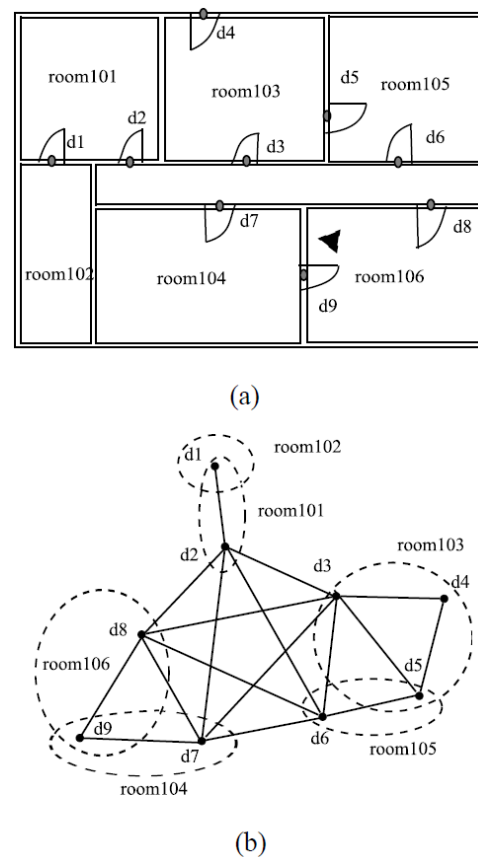


Figure 2: (a) Exemplary architectural map and (b) corresponding route graph (Yuan & Schneider 2010)

Though there are little prototypes available, evaluations and use case studies are crucial because results obtained from them can be utilized for the development of future concepts and solutions.

#### 4. CONCLUSION AND OUTLOOK

In this paper we have provided a very brief overview about LBS applications merged with 3D capabilities. Thereby we have focused on the two interesting topics 3D data streaming and indoor routing. We have provided a brief overview on existing related work in these two areas and additionally we have elaborated some open research questions in order to provide first thought-provoking impulses.

In the future we will work on improving the streaming of 3D data for mobile applications. Furthermore we will extend our previous work on 3D indoor routing. Thereby we want to focus on advanced indoor models and the automated extraction of routing graphs from city model and building data such as Computer Aided Design (CAD), Building Information Model (BIM), building images, CityGML etc. Open questions relate to use cases, address schemata, visualization and evaluation of those.

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