All You Need Is Content — Create Sophisticated Mobile Location-Based Service Applications Without Programming

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Abstract. Programming of sophisticated location-based service applications (LBS apps) for smartphones and tablets still requires knowledge in computer science and a lot of practical experience in the application of existing programming tools for the different operating systems. This means that only a fraction of possible LBS applications has been realized until today. In particular, smaller companies and organizers of one-time events cannot afford to buy custom developed apps; especially if one takes data-quality and maintenance cost of varying app content into account.

The presented AIONAV®-LBS app technology allows for creating offline-focused (but also online-capable) LBS applications without any programming skills and to publish them immediately. This is accomplished by a strict separation of content and user interface on the mobile device. The graphical user interface contains all the functions needed for general LBS applications, i.e. search functions, different graphical content presentation, but also highly advanced algorithms which are required for indoor and outdoor positioning, navigation, image recognition, communication, etc.

The multimedia content is stored within a database on the mobile device. This allows for an autonomous usage in case a connection to the web is not available. The creation of the database contents is done with the so-called LBS Manager PC-software, which provides the maps and allows for an arbitrary structuring of the data. Filling the database is simple by just using drag & drop, allowing everyone knowing how to use office software to create an own interest-specific, feature rich, offline-capable smartphone LBS app.

Keywords: LBS applications, LBS app generator, indoor positioning

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1. Introduction

Programming of sophisticated LBS apps is still a field for specialists. This has manifold reasons, which can be summarized, in two problem areas. First you have to master the basic technologies of LBS itself. These cover a wide field of theoretical knowledge, from cartography to navigation, from image recognition and processing to sensor technology up to the usability of mobile devices. Second, programming of mobile devices, despite extensive software libraries and development tools are available, is still very demanding and thus subject to computer scientists. In addition, sophisticated applications for various operating systems cannot be completely developed on a neutral platform yet, since the different operating systems do not support the same functions and level of access to internal resources.

This paper presents the AIONAV®-LBS app technology platform, which is designed to allow anyone to create an interactive, sophisticated LBS smartphone app of his theme of interest by just entering the appropriate content. The resulting user-customized app provides a rich, LBS-focused feature-set playing seamlessly together with the individual content.

Section 2 gives an overview about the characteristics of location-based service applications followed by an abstracted feature-description drawn from available LBS smartphone apps. In Section 3 the basics of the AIONAV®-LBS app technology are presented. In the following the smartphone app itself as well as the LBS Manager tool to model the app's content are discussed in detail. At the end a practical example shows the ease of use and the quality of the app for one typical LBS use case.

2. Location-Based Service Applications

Today using information concerning the domain of 'location' is a popular approach of applications to ease the daily life of consumers and professionals with modern technology. Such applications fall into the category of location-based services (LBS). These LBS applications are already an important part of the electronically augmented life of many people. As most people have already experienced, even "only" knowing one's own position is very helpful for various leisure and business use cases (e.g. car navigation).

To use a smartphone software application (app) as a personal access-point for LBS is an obvious choice, because it is the device a user naturally always carries around without having to think about an additional "LBS device"; this fact should increase the acceptance and usage of provided LBS. Additionally a smartphone has a serious amount of computing power and built-in

sensors that are very favourable for the realization of desireable and user-assisting LBS.

2.1. Characteristics of LBS Applications

A reasonable usage application of an LBS smartphone app is for areas with a high density of different possible user-actions and/or -interest located within limited space next to each other. Typical areas are shopping malls, museums and alike.

LBS apps have to inform their users about things worth noting around the area they are located. Ideally, they help easen already present (location based) needs of users e.g. finding products, rooms etc. Therefore, one base functionality of LBS apps is a visualization of the location context around the user i.e. the map. That clearly helps a user at least in the way a paper map of that location would do.

Additionally to paper maps, an LBS app can improve the orientation purpose by marking the users position within the map; but doing that automatically and accurately is challenging within cost and convenience constraints of common consumer scenarios described in this paper. The reliability of accuracy is very important since a too (depends on the context) “wrong” indication of the user’s position is worse than no position regarding the given orientation purpose.

Further functionalities of LBS apps deal with enriching the location context with useful information. These classic location-based services are basically searching for and suggesting points of information (POI) for the user and visualizing a route to such POI.

It depends on the specific user how or why a POI is “interesting” and there will always be only an overlap of interest in a POI when talking to different stakeholders or users; so some kind of customization of information presentation has to be possible.

Stakeholders on one hand are users which consume or experience “products”. On the other hand, suppliers or creators try to improve the user experience of their offerings by using LBS. All parties have their own – often divisive – goals which however depend on the other party’s cooperation. So every LBS has to create a win-win situation somehow to be provided at first and also to be consumed at last – or in other words – to be successful at all.

POI in general are locations that someone could want to visit. An LBS app provides further information to the user regarding that POI (text, picture, video, sound, hyperlink etc.) and allows actions to be taken on that POI (routing to, communicate with, buy it etc.).

2.2. Feature Abstraction Drawn From Evaluated LBS Applications

There exist several LBS apps for indoor and outdoor usage. In principle they serve analog purposes but in different scope and application. So following stated examples could easily be translated to other use cases as well.

Most of the apps are focused on finding POI in the context of operation. One category of POI in that context always deals with user needs like finding restaurants, rest rooms or convenience like finding public transport, the parked car and leisure areas. These POI are not the reason one visits a location for, but for a person they are necessary and assumed or at least appreciated to be offered as sure infrastructure in such facilities/areas.

Another POI category deals with things, that users already wanted to find/buy before they came to that location or that are a reason for their visit. This category is the main topic for shopping malls or touristic regions and consists of consumer products or sightseeing hotspots. Additionally to known and wanted products/spots, a user could develop an interest in products/spots just while being around the initial location of interest. This behaviour could be triggered or influenced by sensing (seeing, smelling, tasting, hearing) products in a store, advertisement or tourist information boards. Available apps always consist of these POI.

Based on the creator and the app's purpose, the POI is structured into subcategories in a natural way. Translated to indoor-LBS, if one wants to find a certain product, he chooses the right store (thematically or by user preference), therein the right product category, down to specific product; this is the real-life shopping behaviour translated to a software app with the advantage over real-life of not having to walk during the (maybe only informative) search process.

Another real-life product/spot finding behaviour would be by asking shop staff or locals. This behaviour is ideally suited to be adopted/supported by a software-application because of obvious product database search functionalities. Both ways of finding something are implemented into these apps, reasonable and helpful to the user. Some apps extend these natural ways to look for products and present them as necessary goods for a specific context; especially meal suggestions and recipies lead to corresponding products (plus amount).

In most apps another key feature is "lists of POI". Such lists could be assembled by the LBS provider and could contain products currently on sale/discount, newly available products, best selling products, best italian restaurants etc. For convenience, a user can compose own lists of POI at home for a fast(er) access when needed while shopping/sightseeing; these

lists collect needed products to buy (i.e. shopping lists), favorite products and shops as well as touristic hotspots to visit on a tour.

All these app-actions finally lead to one or more specific POI the user actually wants to walk to. All evaluated apps show the user a route to POI in the manner of a map/track representation or purely textual. These indoor LBS apps ask for manual user-input of the track start point or use some means of positioning technology.

3. The AIONAV®-LBS App Technology

All the typical features and characteristics of LBS applications are common, wanted and needed by users for useful LBS. But as mentioned before, it is not cheap to create sophisticated, full featured LBS applications from ground up as different expert knowledge is needed. A common and easy strategy to create an LBS smartphone application is to integrate popular web-based mapping services. These provide a programming framework and automatically fill-in the external map and context information. One's own information can be augmented on top of the provided layers of information in different ways. The easiest usage would be to just „pin" a wanted location to mark special interest. A more complex usage would be to draw additional polygons etc.

But with this approach one always needs a smartphone software developer who creates the overall business-relevant, functional smartphone app which also works soundly together with the mapping framework. Following this approach also includes the usual software development project risk, reasonable content quality concerns and difficulties with maintenance responsibility/cost as well as other imaginable factors. Further it is questionable if a user wants the LBS application to be always online as required by most web-based mapping frameworks. If online-restraints are not wanted (e.g. because of roaming charges for tourists), the question arises if a chosen software developer is able to produce an offline-capable LBS app, which in fact is considerable harder to do and therefore also more expensive.

The AIONAV®-LBS app technology aims to circumvent the outlined risk, cost, uncertainty and quality issues of a custom software development. This is accomplished by putting the focus onto the content during the app creation process, which is separated from the already done, generic, LBS-feature-rich, offline-focused app software development, which finally just „uses" the individual content. The app software development risks for a new app based on the AIONAV®-LBS app technology are not present anymore,

because the app is finished and can be evaluated before a specific usage investment.[1]

The used generic LBS software and tools emerged from a location-provisioning framework developed during the last ten years and numerous research projects at the Institute for Building Informatics, Graz University of Technology, Austria. The research projects dealt with various aspects of the development of a disaster management system with a focus to build a usable mobile positioning system around a developed, patented inertial positioning algorithm for deployed forces (Walder et al. 2009, Walder and Bernoulli 2010). This has lead to demonstrator systems with mobile positioning and stationary control/command software components.

So this background formed a very solidly designed software framework which was extended to a complete LBS software framework in recent years (Krammer et al. 2013), assuring further, high quality, stable software applications. The developed software suite was partly commercialized under the common label AIONAV (*A*utonomous *I*ndoor *O*utdoor *Nav*igation). According to the intention of the paper the following sections focus on a description of the „LBS app generating" aspects of the AIONAV system.

3.1. The AIONAV®-LBS App GUI

The AIONAV®-LBS app technology is characterized by the fact that the content of the app is strictly separated from the graphic user interface (GUI) with its functions for content manipulation and presentation. LBS app GUI as presented as the top layer in *Figure 1* is an operating system-specific mobile application that enables the interaction with the user on one hand and contains the algorithms to solve the typical LBS tasks on the other hand. These include information search and filtering, displaying maps and multi-storey floor plans, presenting and recording multimedia content, but also positioning and navigation according to different methods, either with the device-internal or external Bluetooth-connected sensors.

A concrete LBS app GUI has been implemented as an Android smartphone app directly using the Java-based LBS software framework. To be deployed to Apple devices, the Android app code has been ported to iOS in Objective C. The advantage of this approach is obvious. The platform-specific app development has to be done only once, regardless of the various LBS applications beyond. The porting of the extensive code base, whose development previously required several man-years, was carried out in a few weeks

[1] Several different apps based on the AIONAV®-LBS app technology are publicly available:
https://play.google.com/store/apps/developer?id=AIONAV+Systems+AG
https://itunes.apple.com/ch/artist/aionav-systems-ag/id917348430?l=en

thanks to the clear structure of the LBS framework. Porting to Windows Mobile and other operating systems is still waiting. However, the effort will be of the same order.

Special attention was paid to ergonomics and user friendliness of the app's GUI. Extensive usability testing for development projects and demo apps in various fields of application (shopping (Krammer et al. 2013), museums, didactics, etc.) yielded iteratively to a user interface, which can be operated intuitively, despite its powerful functionality.

Parameterization of the GUI

The need for a unified and easy operation of the app conflicts with the requirement of potential providers of LBS apps to give their apps an individual appearance and features. This concern is met by the fact that the generic app is highly parameterized and automatically adjusts appearance and capabilities according to the used and defined LBS content (see Figure 2). The hierarchical structure of the individual app provider's content may be defined arbitrarily as wanted.

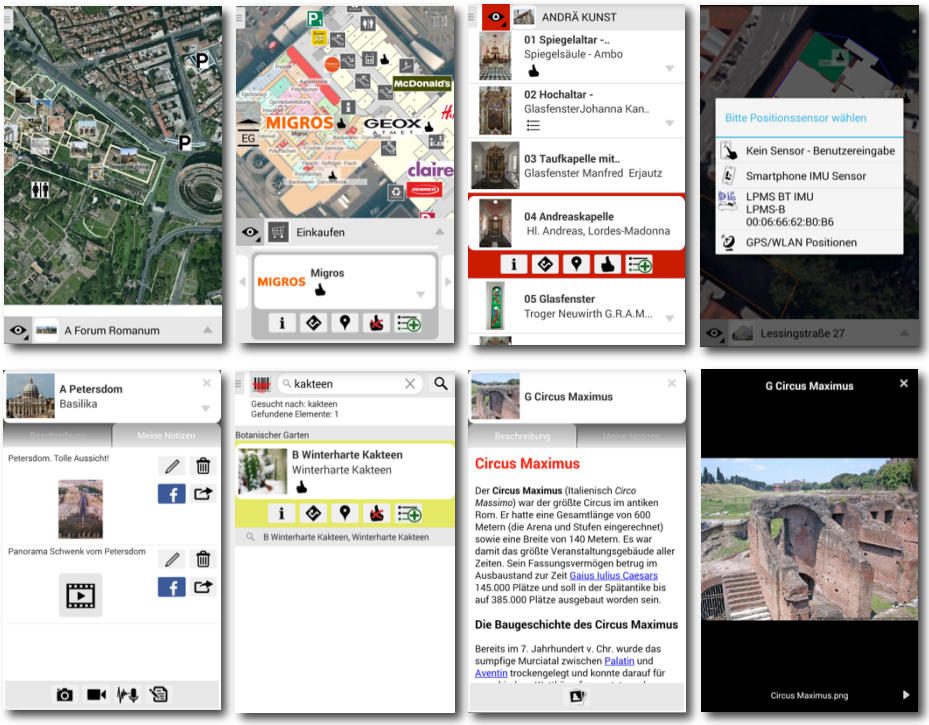


Figure 2. LBS app screenshots: Different applications and possible app features packed with one generic app.

Interactive Use

A particularly popular feature is the linking of the app content with user-created notes. This includes text, images, movies or sound recordings. Initially they are stored on the mobile device locally and can be integrated into the app with the LBS Manager later as well. These private notes can be shared on social networks or be sent by mail immediately as wanted by the user.

The practical applications of this are innumerable; from a travel diary to record keeping of a site visit, from the documentation of a design process to the observation of nature or complementing teaching contents with comments and observations of the student.

Positioning and Navigation

Since the LBS app emerged from a specialized research used in various navigation projects at Graz University of Technology, the LBS app contains all methods developed in this regard, particularly for autonomous indoor navigation. In addition to the usual positioning aids such as GPS and Wi-Fi, which achieve only a very limited accuracy, the patented algorithms for positioning with a foot-mounted inertial measurement unit (IMU) and positioning based on video content analysis (VCA) technology are available.

Positioning based on inertial navigation has been designed for professional first responders (fire fighters, police, etc.). In these applications it is important to determine and track positions in unknown or already heavily damaged environments without any external aid (Foxlin 2005, Walder

Figure 3. Navigation aid for blind and visually impaired people

2012). The method is suitable also in civilian environments, such as monitoring services or sensitive inspection missions.

The VCA method allows for a determination of the user's position along a route with the help of previously recorded images of the environment. The challenge was to code the complex algorithms in a way that they can run on a smartphone in real-time. It was mastered in collaboration with the University of Lucerne. The final goal of this feature is the navigation of blind and visually impaired people in urban areas. Thereby the navigation commands will be transmitted either via headphones or onto a bracelet with vibration sensors (Groves 2013, Bernoulli et al. 2011).

3.2. AIONAV®-LBS Manager

The LBS Manager is a PC-software used to structure/model an LBS app's content and to link multimedia content to a location. The latter is not compelling; often it is just a need to bring structured, multimedia content to a smartphone quickly (e.g. teaching content, procedure plans, manuals, etc.). All information is stored within a database; the hierarchical structure can be freely defined by the user. The LBS Manager runs on a PC locally or can be accessed via the Internet. Similar to the operation of the LBS smartphone app, the LBS Manager is self-explanatory and explicitly developed to be operated by laymen.

The app content is divided into information categories, which are structured hierarchically. The structure of the content can be freely defined. A new category may be defined at any point within the tree of categories. By creating this structure, the later appearance in the LBS app GUI is defined too.

The multimedia data itself is assigned to so-called points of information (POI). POI locations are represented by a polygon that is either filled or outlined on a geo-referenced pixel-based map or a picture and optional vector-based floor plans. A category can contain several POI, such as several sales areas of the same product in a shop or infrastructure facilities of the same type at different places.

As can be seen in *Figure 4,* POI information can further consist of texts, images, movies, sounds or links to different on- and offline sources of information (other apps, web pages, etc.). The text is stored offline within the database in HTML format, but one can embed links to all other common information on the web as well, resulting in flexible on-/offline app content as desired. In addition direct access to the functions of the mobile device is available and as already mentioned, direct links to social networks are possible.

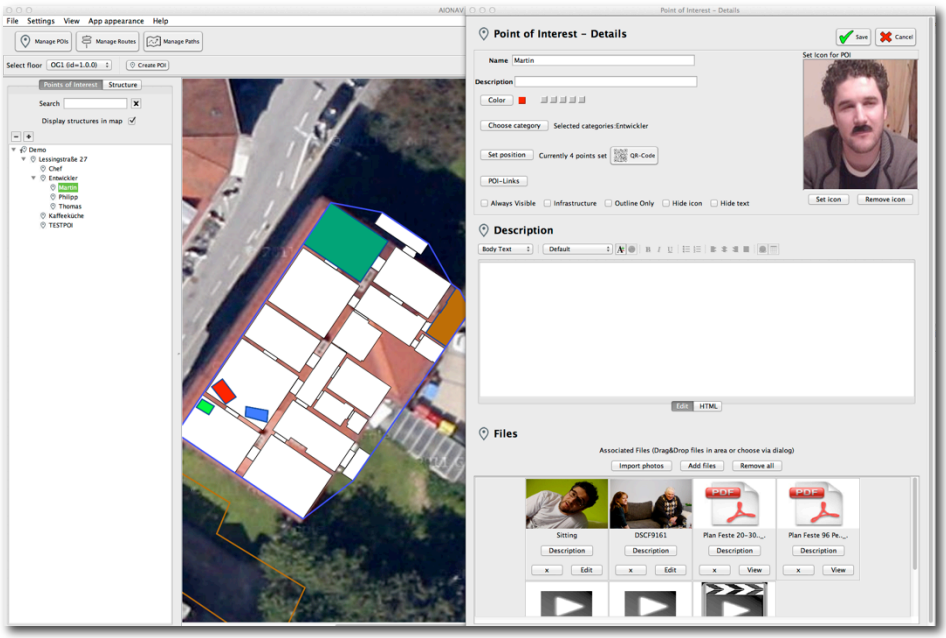


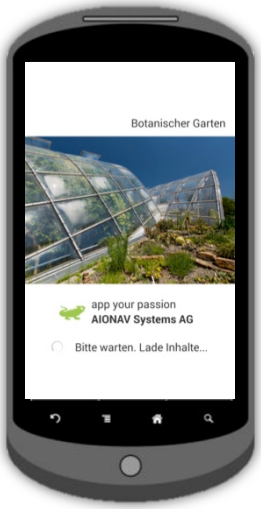
Figure 4. LBS Manager: POI as element for structure, spatial and multimedia information

Since pictures are often not available in the required size or format, the LBS manager provides a simple image editing tool. Entering styled text is facilitated by an integrated HTML-WhatYouSeeIsWhatYouGet editor. Additionally to the LBS Manager, simple tools are available to download maps from Open Street Maps, Google Maps or World Wind, as well as for the import and structuring of floor plans.

To publish the generated app in an app store, its database gets coupled with the generic LBS smartphone app to form a specific LBS app for that content; because of the automatically content-adjusted app features, icons, app name etc. an app user will not be able to tell that the final app was not specifically programmed for that use case e.g. a specific museum's information/guiding app.

So the content provider is able to generate an app by entering and maintaining the data solely via the LBS Manager. This approach reduces cost and development risk as well as enables self/expert-controlled content quality and flexible content management over the app's lifetime as wanted by the content provider, i.e. the app creator.

Starting from template databases for a variety of use cases can further accelerate the LBS app creation process. The possibility to directly import POI from existing databases, such as corporate or telephone directories is envisaged.



4. Creating an LBS App for the Botanical Garden Graz

The Botanical Garden Graz[2] is one of the oldest botanical gardens in Austria; with around 14,000 plants it is one of the most renowned gardens in Europe. It is affiliated to the Institute of Plant Sciences at Karl-Franzens University Graz.

The garden is accessible to the public free of charge whereupon the spectacular architecture of the greenhouses is an attraction by itself.

The requirements of an app for the Botanical Garden Graz were widespread, but showed a clear need for an LBS focused app. Also easy maintenance of plant data within the app was a requirement, because entering plant information is an expert task and plant inventory changes are common. Further the app should serve three very different groups of users:

- Visitors to the Botanical Garden,
- Students at the Institute of Plant Sciences and other institutes of the university (e.g. pharmacy with the medicinal herb garden),
- The employees of the garden.

Creating an app should be as simple as possible; before starting the POI creation process within the LBS Manager software, it's important that some considerations are made: To whom the app is primarily addressed, how it will be structured and how its GUI should look like. Therefore it is necessary that the information contents, i.e. the texts and images, are previously procured in the right formats and made available digitally. At the Botanical Garden a printed guide for visitors exists, so the structure of the app has been modeled on that basis.

Figure 5 shows some features of the final app[3] of the Botanical Garden Graz. In the following it will be described how it was done to get that feature rich LBS app by just entering data into the LBS Manager.

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[2] For further information see http://garten.uni-graz.at

[3] App publicly available:
https://play.google.com/store/apps/details?id=com.aionav.lbs.spot.botanischerGartenGraz
https://itunes.apple.com/ch/app/botanischer-garten-graz/id921183231?l=en&mt=8

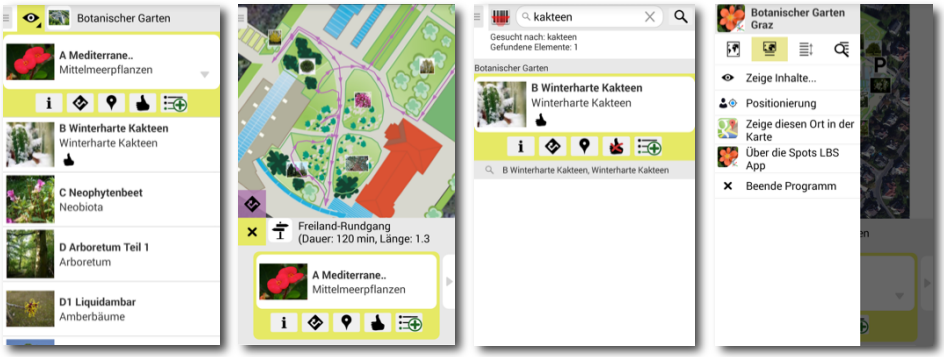

Figure 5. LBS app screenshots: Different features of the final Botanical Garden Graz LBS app

4.1. Structuring and Entering the Content

According to the printed guide the app was not structured by botanical order principles, but accordingly to the geographic occurrence of plants, i.e. by continents and regions, which in turn has its counterpart in the compound of the garden. As a basis for the local context representation served a painted plan, that was embedded in a geo-referenced satellite image of the environment.

The hierarchical structure of the app has been deliberately kept flat in order to enable the visitor a rapid overview of the whole garden:

Botanical Garden

- plant species by region of origin
  - sub region
    - plant
- greenhouse
  - climate zone (for example, tropical house)
    - plant species by region of origin
      - plant
- general information
  - Botanical Garden
    - activities
  - environment
    - parking
    - public transport
    - restaurants
    - etc.

Reordering an existing structure is very simple and possible at any time in the app creation and maintenance process. An element of the structure tree with all its sub-elements, can be easily inserted to any new location by drag and drop. (see *Figure 6)*

Figure 6. LBS Manager screenshot: POI structure tree of the Botanical Garden app's content

4.2. Routing

As the footpaths are not automatically recognized as such on a pixel image, the map is augmented with an invisible network of paths implemented as a 3D routing graph. The creation of the paths is done graphically and very simple within LBS Manager; it consists of a network of nodes and corresponding connections. Attributes, such as priorities or one-way directions, can be assigned. The created path network allows for an automatic point-to-point routing within the smartphone app. (see *Figure 7, left)*

4.3. Guided Tours

If you want to guide visitors through the garden or, e.g. specify a thematically organized round trip for the students, the software allows the definition of tours. A tour basically consists of a subset of POIs, which can be ordered in a user-defined, tour-specific sequence following an arbitrary walk path. (see *Figure 7, right)*

4.4. Search and Navigation

Searching for information is done via alphanumeric input of a search term or, depending on the ability of the smartphone, also by voice input. All search results are listed subsequently. If you want to navigate to the desired

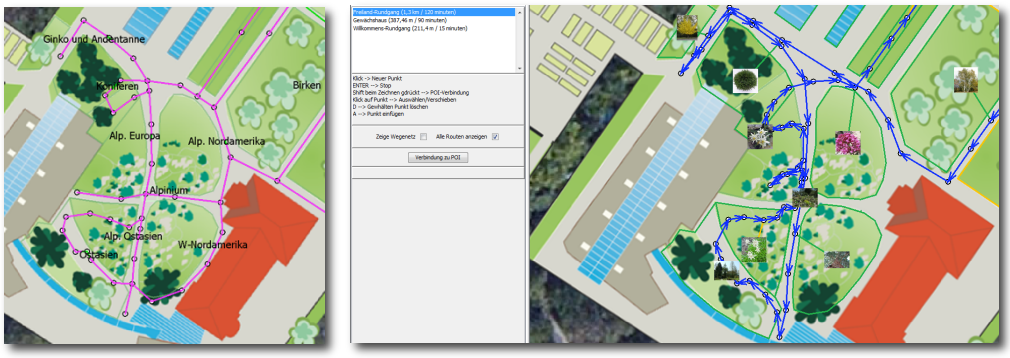

Figure 7. 3D routing graph (left); Definition of a specific tour with linked POI (right)

POI, the shortest route to the POI is displayed on the map. The own position can be the current GPS location or a manually entered point on the map, if no GPS is available. In addition, ad-hoc positioning by scanning of (LBS Manager generated) QR-codes on site is available and very suitable for museum-like use cases.

If you move to the intended POI, your position can be tracked continuously, if GPS or Wi-Fi positions are available. In environments without such positioning options AIONAV® inertial positioning and navigation can be used.

4.5. Linkage with External Sources

Undoubtedly it is a great advantage if all core functions of an app can be used without connection to the internet. It saves not only roaming charges, but is a must at many occasions when no network connection exists. In addition the LBS app can start other apps on the mobile device without leaving the context of the LBS operation at hand.

If an internet connection exists, it can be used in many ways, either through the imposition of hyperlinks in the texts of a POI or by calling web pages directly from the information window or scanned by appropriate QR-codes.

5. Conclusion and Future Development

Without a doubt the simple and rapid creation of sophisticated mobile applications with the tools mentioned above will increase the availability of LBS applications. In particular, applications only needed for a single event or dedicated to a very limited group of users are possible now.

In schools novel opportunities now exist to disseminate interesting and attractively presented course contents via the scholar's smartphones.

A further increase of acceptance of the new technology will be achieved, as soon as POI that are commonly used, such as the nearest restaurant, surrounding attractions, etc., can be downloaded directly from existing databases, such as telephone directories, websites and specialized information providers. A good example is Wikipedia, which allows for integrating their contents in various formats into other applications. A certain standardization of information formats will be necessary to get full access to a wide variety of sources.

Another major goal is to develop LBS solutions also for blind and visually impaired people. Here it is especially important to increase the safety of navigation and to define a 'language' for vibration-bracelets which goes beyond simple commands for directions.

Additionally to further increase the inherent possibilities with the AIONAV®-LBS app technology it is planned to define an easy-access LBS-service interface. This will allow third party software to access basic LBS functionality from information collection to arbitrary positioning services to use them within their context of application. This decoupling of expert tasks should enable arbitrary business applications to implement needed offline LBS functionality easily and future-proof, without loosing focus on their core business application. A first application regarding the development of an environmental context-service interface, which was evaluated within a construction workflow application, is presented in Krammer (2014). The envisioned easy-access location context provisioning strategy concept for third party applications is presented in Krammer et. al (2014).

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