Towards Personalized Smart City Guide Services in Future Internet Environments

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ABSTRACT
The FI-CONTENT project aims at establishing the foundation of a European infrastructure for developing and testing novel smart city services. The Smart City Services Platform will develop enabling technology for SMEs and developer to create services offering residents and visitors to cities smart services that enhance their city visit or daily life. We have made use of generic, specific and common enablers to develop a reference implementation, the Smart City Guide web app. The basic information is provided by the Open City Database, an open source specific enabler that can be used for any city in Europe. Recommendation as a Service is an enabler that can be applied to lots use cases, here we describe how we integrated it into the Smart City Guide. The uses cases will be iteratively improved and upgraded during regular iterative cycles based on feedback gained in lab and field trials at the experimentation sites. As the app is transferable to any city, it will be tested at a number of experimentation sites.

Categories and Subject Descriptors: H.3.3 [Information Search and Retrieval]: Information filtering

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I. INTRODUCTION

The Smart City Services platform will make use of a mix of professional and user-generated content while exploring the future of mobile Internet services. Location and context-sensitive content is likely to embrace and demand user-generated content, as all-encompassing useful outputs cannot possibly be achieved by employing professional staff alone, at the very least due to expense and logistics. We believe that through active participation residents and visitors can add value to information about the areas they know well, or are visiting.

With the support of information and communication technologies (ICT), new technical solutions are being developed and perhaps most importantly, existing infrastructures can be utilized more efficiently. For industrial nations, this implies an expansion of what is already there but for emerging and developing countries it often means the most basic construction of their infrastructure. Intelligent cities aim for a sustainable utilization of scarce resources. Energy, space, money and time are used dynamically – in a way that the current demands require at any given moment. Therefore, ICT infrastructure of the smart city is logically connected to each other in order to exchange and use data about status, demands and capacities. Information is available wherever it is needed, to whoever needs it and the modern city thus makes itself transparent and smarter. The technology itself takes a backseat because the control concepts fit seamlessly into the everyday life and customs of the people in the city.

Information is the key to the intelligent city of tomorrow. Communication in smart cities makes it easier for everyone to have access to information and eliminates time-consuming processes through electronic data transfer. The city provides a public communication platform that is meant to make everyday life easier by offering geo-localized, context sensitive information and communication possibilities, using open data and allowing a rich combination of professionally generated content with user generated content and experiences.

Section 2 introduces the FIcontent-initiative and Section 3 explains the Smart City Services Platform as well as its architecture and specific technologies, called enablers. Section 4 addresses innovative use cases, opportunities and services resulting from the combination of these enablers. Section 5 explains the field trials for the validation of the developed services and enablers. Finally, the last section considers a conclusion and outlook.

II. The FI-CONTENT initiative within FI-PPP

The Future Internet Public Private Partnership (FI-PPP) [1] was developed in the context of the European Union's FP7 research-funding program and is spread over a period of five years, starting in 2011 and is due to end in 2015. Its overall goal is to advance Europe's competitiveness in Future Internet technologies and support the emergence of Future Internet-enhanced applications of public and social relevance. The FI-PPP follows an industry-driven, user-oriented approach that combines R&D on network and communication technologies, devices, software, service and

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media technologies and their experimentation and validation in real application contexts. Major European and global companies and leading research centers have joined their skills in the FI-CONTENT 2 [2] initiative to drive innovation at the crossroads of content, media, networks and creativity. This initiative aims at developing and experimenting cutting-edge ICT platforms devoted to applications and services in the areas of Social Connected TV, Smart City Services, and Pervasive Games across Europe. Any European stakeholders, particularly developers and SMEs, willing to innovate and boost their business can access and use these open platforms. The core activity related to the solution proposed here is to deliver a common technical platform that application developers and service providers can use to build, host and operate applications for smart city services. The Smart City Service Platform [3] is a catalogue of homogeneous technology components and APIs that use server-side enablers, services developed for smart cities as well as tools and services to simplify the process of building, deploying, monitoring and managing content-related applications on top of open infrastructures.

III. The Smart City Services Platform

The Smart City Services Platform (SCSP) is one of three Future Internet Platforms that are part of the FI-PPP program. The platform aims to foster the development and uptake of smart city applications using technical components, so called enablers, provided by FI-CONTENT. This platform offers various specific and generic enablers focusing on innovative and open smart city functions as open data databases, point-of-interest (POI) handlers, social network and community sharing as well as recommendation services and interactive user-generated content.

Figure 1 summarizes the SCSP core components and identified scenarios. It shows different components and relations between the components. The Smart City Services Platform high level architecture includes the main scenarios (at the top of figure 1) and their necessary enablers (generic and specific ones). Generic enablers (in blue) are provided by FI-Ware [4] and Specific Enablers (in green) are provided by the different FI-CONTENT 2 partners. Public available enablers are shown in figure 2.

The identified scenarios are the basis for the large-scale user experimentations conducted within FI-CONTENT 2, each uses a subset of the functionalities developed and provided by the Smart City Service Platform. The scenarios represent main functionalities identified for the first release of the Smart City Guide (SCG) application and builds the basis for development of reference applications that will be used for testing at the experimentation sites.

The smart city scenarios cover the full range activities related to visiting a city including functions to prepare the trip, assist the visitor during his visit, as well as share the impressions after the trip with friends. The following list of scenarios has been identified:

- **On-site visit**
  Creating interactive content while on a SCG tour
- **Local content and recommendation**
  Accessing local content aggregated from multiple sources (open data, websites, etc.), enriched with UGC and recommendations
- **Virtual/mixed reality**
  Mixing virtual and real objects in a same hybrid reality

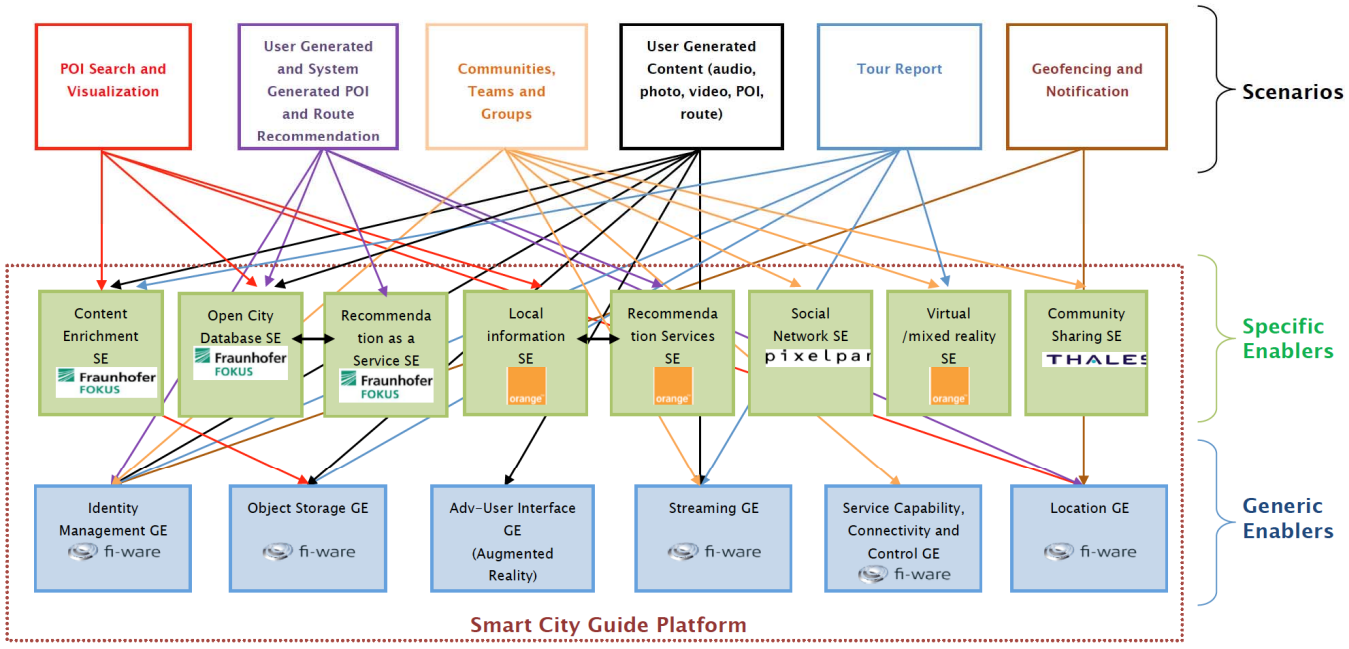

Figure 1: Architecture of the Smart City Platform

- **Device-to-device content sharing**
  Seamlessly share content between users when no infrastructure connectivity is available
- **Social network**
  Create a social network, either temporarily or permanently for a specific group of users.

We will present the on-site visit scenario as an exemplary service built on top of the SCSP.

The Smart City Guide (SCG) mobile web app (Figure 2) is designed to be used by visitors during their trip. Implemented as a HTML5 based real-time web application, the SCG is available on all major devices. The user can search for a point of interest (POI) on his smartphone or tablet, view these on a map, in a gallery view or as a list. For each POI there are details and related content is linked, events happening near the user are also displayed on the map. During the trip the user can use his smartphone to create and update POIs or route information. The user can also rate, check-in to and bookmark a POI. This information can be utilized by the recommendation service.

The trip preparation of a can be done on a smartphone, tablet or PC. Figure 4 illustrates an overview of the recommendation service. The user creates an SCG account in the app and then enters a set of criteria for an up-coming trip, for example, an area (a city or a specific section on the map), a budget, a time interval (specific dates or times), his interests and number of people. The recommendation enabler suggests suitable hotels and the user may choose one of them. Using this hotel as a starting point, different routes can be automatically generated showing all POIs, sights and events on a map. The user could, for example, receive three trip suggestions for three days. The first one being a walking route showing all important sights in the area near the hotel. The second one shows routes to a local event on the second day and the last route recommends renting a car in order to visit some districts at the other end of the city.

Users can record videos at a sight, create and display interactive videos with content enrichment, take pictures of events, comment on a POI or event, check in at hotspot, rate

Figure 2 - Smart City enablers

POIs and view related information while visiting. After the trip an automatic report is generated based on this user generated content.

IV. Enablers & Opportunities

This section describes two enablers, the Open City Database and the Recommendation as a Service Enabler, and illustrates a sample use case in terms of a reference service, the Smart City Guide Web App.

a. Open City Database Enabler

The Open City Database Enabler is an API to get and generate data for different European cities such as their points of interest or events. The OCDB is built as a NoSQL [5] mongoDB with REST-Endpoints. The data format used in this database is JSON [6]:

- OCDB includes European city objects with their name, country, latitude and longitude, description and an image
- POI objects contain name, latitude and longitude, description, images, videos, contact information, opening hours, fee, cityID, category, privacy and a userID

Every POI and event has an owner, identified by the userID/token. A token is required to integrate or send requests to the Open City Database to an app or service. In the Smart City Guide Web App, for example, a token is given while generating an account.

POIs and events can be public or private. Any user can modify and enrich public POIs and events, only the owner can delete them. To request a private POI or event, the API requires the suitable userID/token. In a city guide context, private POIs and events can be used for "real insider tips", places that only the user and his friends should know. With the token the user can share these secret places or events with friends and generate a tour for the POIs.

The Smart City Guide web app developed in FI-CONTENT aggregates all Open City Database data in one application and presents them to mobile users who are using different types of devices and platforms. In addition to the OCDB data, the Smart City Guide backend also collects other

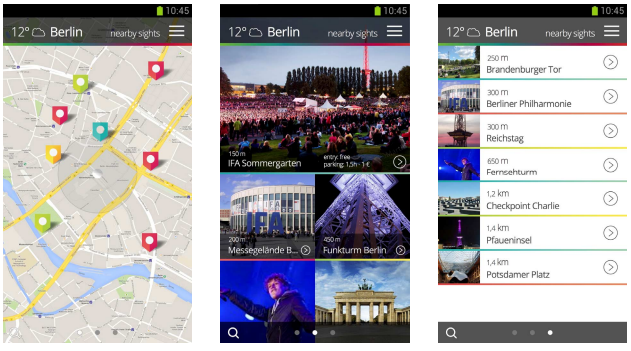

Figure 3 - Smart City Guide Web App views

information such as user generated data (generated in the app or with API calls) or data from DBpedia [7] and shows all POIs and events on a map-view, gallery-view or list-view. It is also possible to collect further information (pictures, videos, etc.) related to the OCDB data from 3rd party providers such Yelp [8], Facebook [9] and Flickr [10].

b. Recommendation as a Service Enabler

Recommendation engines usually provide a set of powerful algorithms to process a large amount of data. The result is a prediction of the users' behavior, preferences and needs. Taking this into account, buying or usage decisions of end customers become more effective and service providers benefit from maximizing the quantity of sales and winning over their customers.

On the other hand, a system of this nature needed to be developed, adjusted and hosted by technical experts due to its intricacy. The Recommendations as a Service (RaaS) platform assists service providers to start a professional server-side recommendation engine for a variety of use cases and without any programming skills. Costumers can easily use the benefits of this Recommendation Engine to optimize their service when they host a Smart City Service with lots of places and points of interests.

An example use case of the RaaS platform is a holiday trip planner. Tourists planning a trip to a new location can type in the place or area they want to visit, the time they want to spend and even their available budget as well as their preferred means of transportation. As a result, the engine suggests suitable hotels for the customer and as a core component, RaaS recommends personalized trips to different places and points of interest.

Recommendation as a Service Platform Engines have been successfully deployed in various websites and TV portals recommending live TV programs and VoD content, such as the TV Predictor [11]. The Platform offers a powerful set of highly developed algorithms – each can be used as stand-alone approach or in combination. Amongst others the RaaS platform offers a variety of content-based, collaborative and hybrid filtering approaches as well as machine learning algorithms in order to calculate:

- Similar Items: e.g. with algorithms using the Euclidean Distance, Cosine Similarity, Routing and Shortest Path Algorithms or Association Rules
- Nearest Neighbors: Pearson Correlation Coefficient and Data Segmentation with Cluster Analysis
- Rating Predictions: improved bi-polar Slope One and Matrix Factorization
- Automatically recognized behavior patterns: Neural Networks and Support Vector Machines

The usage of the Recommendations as a Service platform makes consumption and buying decisions more effective and the user experience more comfortable by recommending only relevant items. It allows service providers to predict the customer's usage behavior by reusing professional data mining services.

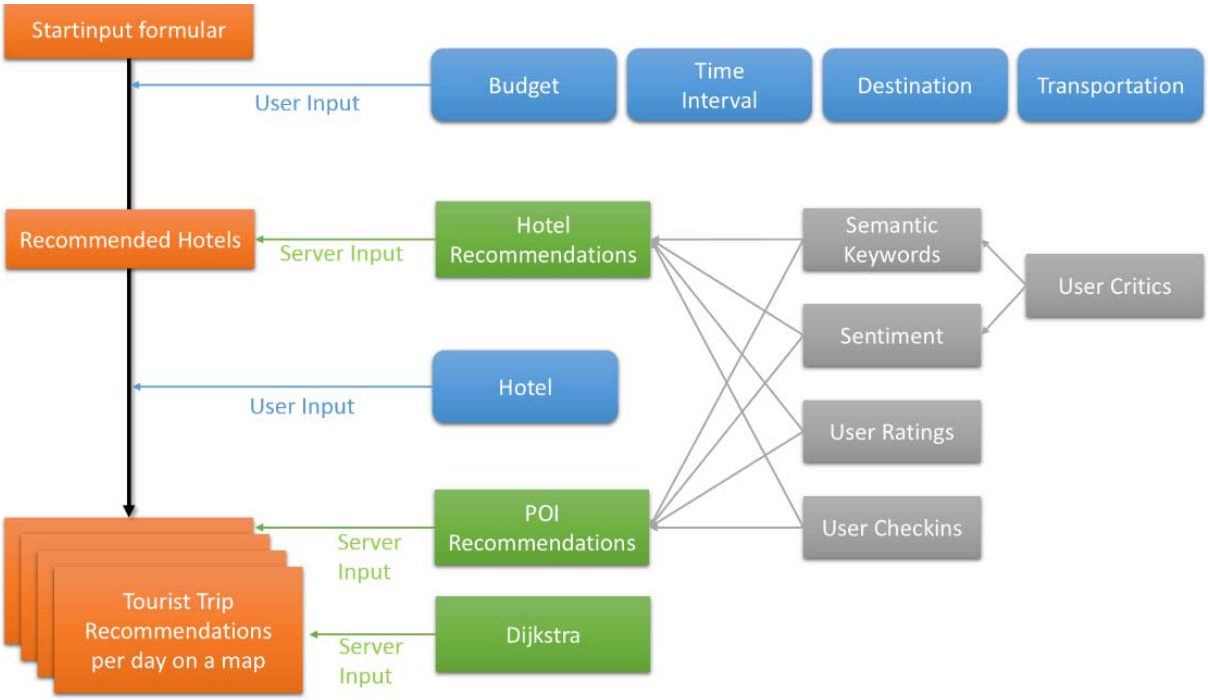

Figure 4 - SCG recommendation scenario

c. Smart City Guide Web App

FI-CONTENT partners developed a real-time Smart City Guide web app based on different future internet technologies that we want to introduce in this subsection. For planning a trip with the SCG the app uses two enablers:

- Open City Database SE to get POI and event information
- Recommendation as a Service SE to generate a personalized tour

The Recommendation as a Service SE creates up to three tours based on the information provided by the user, i.e. dates, budget and interests of the user, as stated in figure 4. The recommended POIs and events are retrieved from the Open City Database SE. The RaaS analyzes the user's ratings, check-ins and bookmarks and provides recommended POIs and events for his trip. The user can save this recommended tour.

While he is travelling the user's location is tracked by HTML5 geolocation [12]. POI and event data next to the user's current location will be displayed while the app is running. The user also has the opportunity to filter these POIs by their category, distance and rating or hide visited sights. This filtering is displayed in the header navigation of the app. This navigation is shown in figure 5. The header has three different sections to drop down and get related information:

- Weather: displays the weather forecast of the next 5 days (The weather information is provided by the Open WeatherMap API [13])
- Select City: It provides the list of each city in the Open City Database with the current city description
- Filter: the displaying of POIs and events can be filtered by category, already visited, distance and rating

An existing POI or event can be modified in the app. For a private POI/event, the owner can add missing data, for a public POI/event anyone with a valid userID/token can add information. Furthermore users can generate photos and videos in the app. These photos and videos will be uploaded and hosted at the Object Storage GE located at the Xifi Node [14] in Berlin.

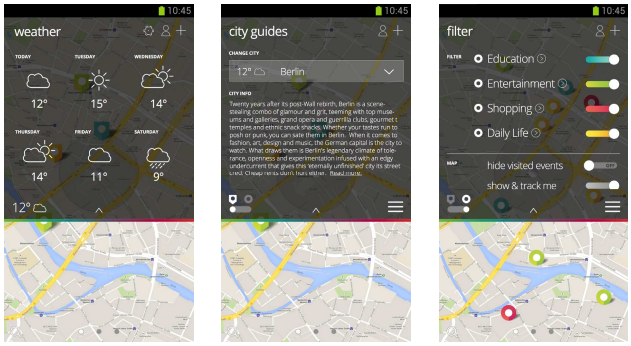

Figure 5 - SCG header navigation

Users can tag POIs in a video with the common specific enabler Content Enrichment, the app comes with its own tagging tool. The Content Enrichment scenario is divided into three steps:

1. Upload a video to an existing POI/event
2. Tag an object, give a name and description or add a photo to the object
3. Check and watch the video

After the video is generated and tagged, other users can watch the video or add some objects or comments to the existing objects.

The last phase of the Smart City Guide concept is the trip report. The Open City Database and Second Screen Framework enabler are integrated in the web app for the following scenario. A user has gone on a trip, taken pictures, generated enriched videos, checked in somewhere and left some comments. With this data an interactive photobook will be generated for the user to share with his friends and family. Imaging the user is sitting on the couch with his family and wants to tell them all about his trip, the sights he saw, the things her experienced and people her met. The Second Screen Framework SE that has been integrated into the SCG allows him to open his SCG on a mobile device and use his TV as a second screen. Photos and videos taken in the app can be displayed on the larger TV screen. The app helps put the images in context for the viewers by providing information on the POI/event. Enriched videos can also be viewed on the TV screen, the additional information and comments related to the tagged objects is displayed in the app on the mobile device.

The Smart City Guide web app was developed as reference implementation to demonstrate a smart city service based on open data and user generated content using technology developed as part of the FI-PPP program. The technology and concept has been and will continue to be tested in experiments throughout Europe, resulting in robust mature enablers that are available to SMEs and developers to use and develop their own smart city services.

V. Field Trials

FI-CONTENT aims to create working experimentation sites across Europe (Brittany, Berlin, Cologne, Barcelona, Zurich and Lancaster) driven by the project partners and their local communities to execute early trials of technical components developed and provided through the smart city services platform. The experiments prepare large scale trials planned for the second half of the project by organizing regional clusters around the different experimentation sites allowing especially SMEs and domain experts to test and deploy novel content applications for smart city services.

Figure 6 - Smart City experimentation sites

The aforementioned smart city guide app which fulfills the on site visit scenario has been trialed at the Berlin experimentation site in lab trials and a large scale experiments during the IFA trade fare. Feedback gathered from the tests has been evaluated and the results were integrated in the future development process.

VI. Outlook

The use cases have shown that city applications do play an important role in future smart city ICT infrastructures. The establishment of open platforms and device-independent city applications for administrative services, municipal service providers and even the people visiting a future city support the involvement of open data for future services. Citizens will benefit in their daily life and visitors will enjoy tailored services with up-to-date information about infrastructures and services. FI-CONTENT will support this idea with ongoing large-scale experiments and a cross-European open platform for smart city services. Trials started in Berlin will be conducted in Barcelona in April 2014 by integrating up to 10.000 data records provided by the Barcelona experimentation site and their partners. In Berlin we have planned the next large scale trial around the 25th anniversary of the "Fall of the Wall". Based on our open enablers, we will provide smart city apps around this event including recent technology as well as relevant media to provide Berlin tourists and citizens with the best experience and a comprehensive presentation of this historical cultural event.

Through its open platforms and enablers, FI-CONTENT offers opportunities for third party developers, SMEs and domain experts to get involved. Open APIs for components such as Content Enrichment and the open source Open City Database will enable the creation of further services and applications. This also applies to FI-PPP phase 3 [15] participants and beneficiaries selected through the FI-CONTENT Open Call [16].

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