Flexible Access to Services in Smart Cities: Let SHERLOCK Advise Modern Citizens

by Roberto Yus, Eduardo Mena, Sergio Ilarri and Arantza Illarramendi

Citizens can access a variety of computing services to get information, but it is often difficult to know which service will offer the best information. Researchers in the SHERLOCK (System for Heterogeneous mobilE Requests by Leveraging Ontological and Contextual Knowledge) project, from the University of Zaragoza and the Basque Country University, address this by providing mobile users with interesting Location-Based Services (LBSs).

As Smart Cities become a reality, citizens are starting to be overwhelmed with the amount of data they receive from different sources. This is partly caused by the sheer number of apps they can download to obtain information: most apps are designed for specific scenarios and goals and are embedded with implicit knowledge about the application context. They also receive data almost continuously (e.g., information about pollution, traffic, parking spots, lighting, etc.), which makes it difficult to distinguish which information is valuable. In this scenario, the use of semantic techniques becomes particularly relevant: a system that uses semantic information can help users select the most appropriate and relevant apps to the user's interests and transform the raw received data into smart data that represents actionable information.

Mobile devices (e.g., smartphones and tablets) have become a fundamental part of our everyday lives. According to a report by BI (Business Intelligence), one in five people worldwide owns a smartphone and one in 17 owns a tablet. These devices not only consume information but also create huge volumes of data (e.g., geo-tagged images, videos, text, etc.). In addition, sensors are ubiquitous and a common feature on smart and wearable devices (e.g., activity trackers, smart glasses and watches) as well as city-based sensors (e.g., sensors that measure air pollution, noise and traffic levels). These city-based sensors are useful in the context of Smart Cities. New management approaches are required for all this information to ensure users do not become overwhelmed. The semantic management of data in wireless environments can help users in a variety of ways including assisting with the process of determining what information a user really needs to finding the most appropriate information from a range of different sources and presenting it in an integrated way. For example, imagine tourists who arrive on an evening flight and need to reach their city hotel. At first, it would be useful to infer what kind of information the tourists might need, for example, with regards to transport information they might need to know the different options (e.g., buses, metros, taxis or car rental options), traffic conditions and perhaps even where available parking spaces are located. This information comes from a variety of heterogeneous sources (e.g., websites, city-based sensors, other users and vehicles) and it is difficult to reconcile and present these data as they are needed.

In developing the SHERLOCK [1] system, we sought to provide mobile users with interesting Location-Based Services (LBSs). Begun in 2011, this collaborative project brings together the Distributed Information Systems (SID) group at the University of Zaragoza (Spain) and the Interoperable Database Group (BDI) group at the Basque Country University (Spain). Since we started, we have developed an Android prototype [2] that can be downloaded from the website of the project (see Figure 2 for a screenshot of the app).

Our main focus is to develop a general and flexible system that is able to respond to the information needs of mobile users. We met a number of challenges in this project, but there were three main problems. Firstly, the system has to be able to understand the information needs of the user. For this task, SHERLOCK leverages the user's context (e.g., location, activity, etc.) that can be extracted for a range of sources, for example, from sensors in his/her mobile device. A personal agent guides the user in the process of selecting an interesting LBS. This agent uses context information along with

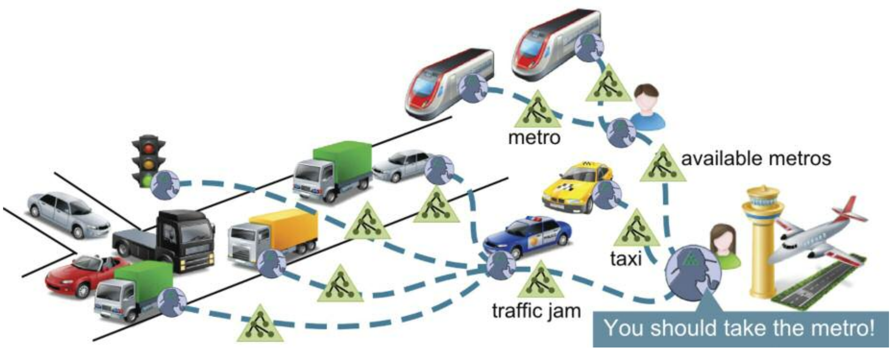

Figure 1: SHERLOCK finding appropriate transport in a city

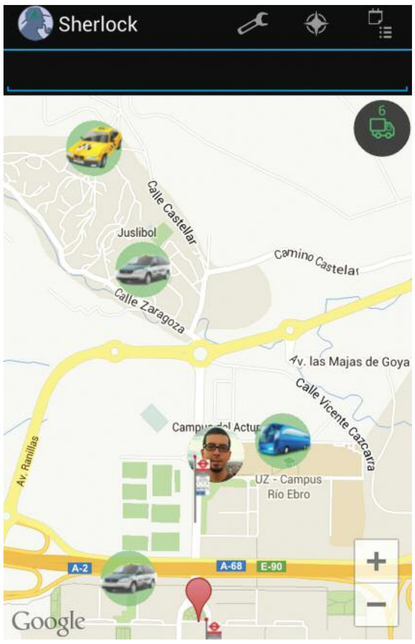

Figure 2: SHERLOCK app for the transports scenario

information about the services, encoded in ontologies (i.e., a formal representation of knowledge) and a semantic reasoner (i.e., a software to infer logical consequences), to deduce which LBSs would be useful for the user. Secondly, the system has to be able to find the information the user needs. For this task, SHERLOCK deploys a network of mobile agents (i.e., software that is able to move from one device to another autonomously) to search all available information among the distributed data sources and bring back the results to his/her device. Finally, the system has to be able to present the results to the user and keep this information updated for as long as the user requires.

We believe that a system such as SHERLOCK is very useful in the context of Smart Cities, as it can support citizens and visitors in achieving their tasks more efficiently and effectively. Any developed city services could easily be made available to SHERLOCK, simply by defining it in the form of an ontology.

Links:
SHERLOCK: http://sid.cps.unizar.es/SHERLOCK
Smartphone and tablet penetration in 2013: http://www.businessinsider.com/smartphone-and-tablet-penetration-2013-10

References:
[1] R. Yus, et al.: "SHERLOCK: Semantic Management of Location-Based Services in Wireless Environments", Pervasive and Mobile Computing, 2013.
[2] R. Yus, et al.: "SHERLOCK: A System for Location-Based Services in Wireless Environments Using Semantics", WWW 2013

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Quantifying the Benefits of Taxi Trips in New York through Shareability Networks

by Paolo Santi, Giovanni Resta and Carlo Ratti

Shareability networks demonstrate that more than 95% of taxi trips taken in New York can be shared with minimal passenger discomfort.

The increasing pervasiveness of digitalized information has unleashed unprecedented opportunities for understanding aspects of human behaviours and social lives, including individual mobility. An enormous amount of digital traces are now obtainable from a range of sources (e.g., cell phone records, taxi GPS traces, etc.) which allows human mobility to be analyzed to an extent that would have been inconceivable several years ago [1]. Although this raises privacy concerns, this "big data" era offers unique opportunities to improve understanding around human mobility needs and, hence, improve transportation system efficiencies.

The goal of this project, performed in cooperation with a team from the MIT Senseable City Lab (Michael Szell, Stan Sobolevsky and coordinated by Carlo Ratti), is to quantify the benefits of taxi sharing in New York City (NYC). Our analysis was based on a dataset which captured all the taxi trips taken in NYC in 2011 (over 150 million trips). For each trip, the dataset captures the pick-up time and location and drop-off time and location.

In this project, we posed the fundamental question, "How many taxi trips can be shared in NYC?". To answer this question, the intrinsic trade-off between shareability opportunities and passenger discomfort must be considered: the longer a passenger is willing to wait for a shared trip, the higher the sharing opportunities. This tradeoff is made explicit by the novel notion of a shareability network in which we have defined the model sharing opportunities: each network node represent a separate trip and links between two nodes represents a sharing opportunity between those trips. The criterion used to determine whether two trips can be shared is based on spatial and temporal constraints. For two trips, T_1 and T_2, a sharing opportunity only exists if a route connects the respective pick-up and drop-off points such that both passenger groups can be picked up and delivered to their destinations with a

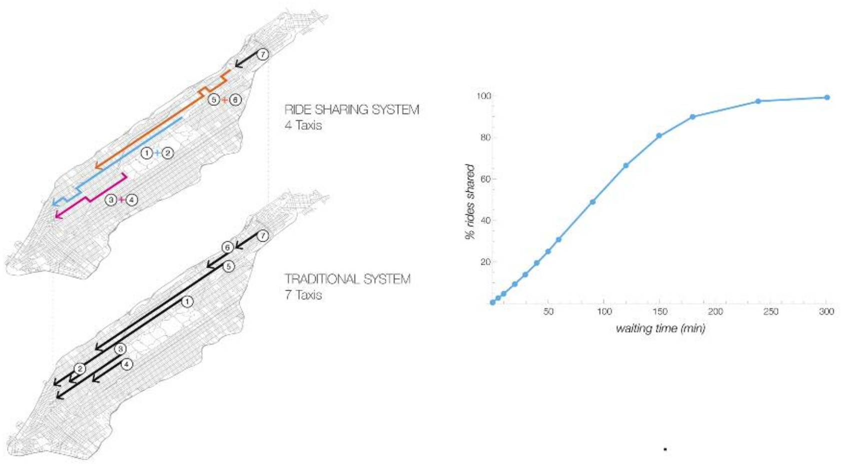

Figure 1: The shareability of taxi rides taken in New York City is constrained by the length of time customers are willing to be delayed. As the delay time lengthens, trip sharing opportunities increase. Results indicated that a delay of 5 min meant more than 95% of the taxi rides could be shared.