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A context-aware web-mapping system for group-targeted offers using semantic technologies

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ABSTRACT

Existing location based systems that propose offers to their users do not provide points of interest (POIs) owners with the capability to flexibly customize their target groups of people/customers based on their context but they simply rely on the pre-determined application's methods to approach them. These systems also suffer from information overload, often providing offers to a user that are neither valid nor interesting because they do not match his/her context. Moreover, these offering strategies are not interoperable among different systems. In this paper, we present the design and implementation of an innovative web-mapping context-aware system called "SPLIS" (Semantic Personalized Location Information System) that utilizes Semantic Web technologies for delivering group-targeted offers from POI owners to users/potential customers. The presented system (a) adopts the schema.org ontology, (b) uses RuleML-compatible rules to represent group-targeted POI offers, (c) combines at run-time the above to match user context with suitable offers, and finally, (d) visualizes offers in an intuitive way. The paper also reports on a user evaluation of the system.

1. Introduction

Nowadays, mobile commerce applications play an important role in everyday life for millions of people and they have changed the way we do things in many sectors such as financial transactions, navigation, marketing, entertainment, etc. (Baldauf, Frohlich, Masuch, & Grechenig, 2011). A popular subsector of m-commerce is Location Based Services (LBS), which are services that utilize user location (Michael & Michael, 2011). LBSs should offer rich and personalized content to users and provide efficient answers tailored to their needs and preferences (Hand, Cardiff, Magee, & Doody, 2006). If we take as examples (a) a LBS user who is driving and looks for a coffee shop close to him, or (b) a user who is looking for transport, presumably the first user requires promotions or offers provided by cafes while the second requires very different kind of information such as suggestions for the nearest taxi stand, transport office, or car rental promotions. These examples make clear that successful LBSs should be capable of offering emerging information retrieval and direct information to users, relevant to their situation. Every piece of information which is used to characterize the respective situation (known as context) leads to this direction because user requirements are closely related to the user profile (e.g. preferences, social state, etc.) and the environment (place, time, weather, etc.) (Dey & Abowd, 2000; Emmanouilidis, Koutsiamanis, & Tasidou, 2012; Kwon & Kim, 2012; Kwon, Yoo, & Suh, 2006). Context-awareness has been associated with LBSs and the scientific community and the industry focus on collecting, utilizing and interpreting contextual knowledge by developing relevant hardware technologies (e.g. GPS) and software such as semantic technologies (e.g. ontologies, rules).

Concerning the second domain referred above, semantic web standards such as RDF/S and OWL, usually referred as ontologies, enhanced contextual knowledge collection and perception process because (Bizer, Tom, & Tim, 2009; Eberhart, 2003; Her et al., 2010; Ilarri, Llarramendi, Mena, & Sheth, 2011; Kim & Jin, 2010; Kim, Suh, & Yoo, 2007; Lee et al., 2005):

(a) They offer the ability to represent the structure of physical entities and the associations between them (e.g. representing concepts such as user profiles, places, etc.).
(b) They enable knowledge sharing, semantic interoperability, through reasoning, and seamless communication between heterogeneous systems, by providing a formal and general knowledge representation and reasoning standard.
(c) They can be reused and extended easily, saving a lot of time and effort for developers.

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Flexible context adaptation needed in LBSs can be effectively represented and enforced by combining ontologies with rules. Such examples are OWL 2 RL (Motik et al., 2012) and SRWL (Horrocks et al., 2004). Rule-based systems are more autonomous due to the following reasons (Lassila, 2005; Patkos, Bikakis, Antoniou, Plexousakis, & Papadopouli, 2007; Wu, Chang, Ho, & Chao, 2008):

(a) They are capable of conceiving context changes and respond accordingly without user intervention.
(b) They are more proactive and have the capability to offer services in advance.

The aim of our work is to combine semantics with location information services to deliver contextualized offers to users. The majority of LBSs that propose offers to their users, do not give POI owners, who are also offer providers, the opportunity to flexibly customize their target group of potential customers and its context. POI owners place their offers, and after that, the recommendation system that each developer has implemented handles them in a way determined only by the system itself. Even when the advertiser is able to customize some demographic parameters of the targeted potential customers, as in e.g. Facebook, the customization is limited to few pre-defined profile attributes, such as age, gender, etc. As a result, POI owners rely on application developers and the personalization system they have implemented and, consequently, their marketing strategy is not as effective as it could be. Besides, customers often get irritated by information overload (e.g. offers that exist but do not apply to them). Therefore, real-time contextualization of both content and offers is necessary and prevents from degrading user experience.

For this purpose, we have implemented a system called "Semantic Personalized Location Information System – SPLIS[1]", which provides POI owners with the ability to build more accurate and more profitable relationships with their potential customers, as their offers will be much more specific and related to them (A preliminary implementation of the system has been presented by Viktoratos, Tsadiras, and Bassiliades (2012)). To achieve the above, SPLIS:

(a) Collects data concerning POIs from Google Places API.
(b) Adopts a widely used ontology (schema.org) to represent persons, POIs and their relations. POI owners can enrich the schema at run time by adding their own properties.
(c) Provides POI owners a form-based web interface to deploy their offers according to their policy, regarding the appropriate target group and the context of each user (user's profile, place, time, weather, etc.).
(d) Transforms these offers into machine understandable rules. RuleML format is used in order these rules to be shared with other systems in the web. Jess translation is employed to make them machine executable.
(e) Stores metadata and rules in the form of RDF triples (using Sesame) for knowledge sharing and reusability.
(f) Displays personalized information on Google Maps[2] to regular users/potential customers in order to quickly find a place or an offer matching their profile.

SPLIS not only possesses the advantages of ontologies and rules which are discussed above but it also overcomes some of the disadvantages of rule-based systems by adopting a dynamic knowledge-based approach (allowing POI owners to add data and rules at run time). This capability will be discussed in detail in Section 2, compared with other approaches. In Section 3, the design of SPLIS system is discussed, while Section 4 describes implementation details. In Section 5 the system operation process is illustrated. In Section 6 the functionality of the system is exhibited by the use of a number of examples. The results of the evaluation of the SPLIS system by end users are presented in Section 7. Finally, Section 8 presents the conclusions of our work and discusses future directions.

[1] Can be accessed at http://tinyurl.com/splis-login
[2] http://maps.google.com

2. Related work, motivation and contribution

Section 2.1 below presents (a) an overview of services that exploit semantic web technologies to provide high level personalization and inspired our work, and (b) an overview of services that provide personalized offers and promotions. Section 2.2 presents some drawbacks of the works that are discussed in Section 2.1 and explicates SPLIS overall contribution.

2.1. Personalization in LBSs and LBSs which provide nearby offers

Many researchers have been studying the provision of personalized POI's, services or tasks to users. Noguera, Barranco, Segura, and Luis (2012) used recommendation techniques such as collaborative and knowledge based filtering to propose a hybrid recommender system, which is combined with smartphones visualization capabilities (e.g. 3D) to achieve better presentation of information. Furthermore, Liu, Liu, Aberer, and Miao (2013) proposed a model for category-aware POI recommendation. They used Matrix factorization to predict a user's preference transitions over categories and after that his/her preference on locations in the corresponding categories. Liu and Aberer (2013) also in SoCo combined contextual information and social network information to improve the accuracy of recommendations. Yuan, Cong, Ma, Sun, and Thalmann (2013) defined a new problem of time-aware POI recommendation as an extension of the conventional POI recommendation problem by considering the temporal influence in user activities. In the same spirit, Cheng, Yang, Lyu, and King (2013) approach the problem of POI recommendation by proposing a novel matrix factorization method which includes personalized Markov chains and localized regions.

Liagouris et al. (2011) also implemented a mobile travel guide by referring to the concept of task computing. A general platform is supported, so that users can select tasks defined from a related ontology and access relevant content. Similarly, Ciaramella, Cimino, Lazzerini, and Marcelloni (2009) proposed a situation-aware service recommender. Rules in SWRL format are used to determine each condition and, after that, a set of related tasks is recommended. Another service designed for tourists is COMPASS (Van Setten, Pokraev, & Koolwaaij, 2004), which, through an interactive web interface, displays personalized information based on user preferences and contextual attributes (e.g. last time user visited a place). Hawalah and Fasli (2014) implemented a system that can track user interests and build contextual ontological profiles to provide personalized recommendations. In the same spirit, Guo and Lu (2014) proposed a novel contextual information recommendation model based on distributed cognition theory after modeling user interest information structure. Another interesting service is that implemented by Bozzon et al. (2011), which recommends to the users combinations of nearby POI's by ranking available results.

Additionally, Keßler, Raubal, and Wosniok (2009) combined data collected from sensors with ontologies and rules in SWRL format for utilizing complex context information and provide personalized recommendations for surf spots. Another application of this area is Sem-Fit (García-Crespo et al., 2011), which uses fuzzy rules