Towards a Semantic City Service Ecosystem

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Abstract. We introduce the concept of City Service Ecosystem (CSE) as digital environment for the governance of urban services. We trace the research challenges and opportunities of adding semantics to improve the management of such ecosystems, especially in relation to description and retrieval of urban-related Web services. We explain the peculiarities and distinct characteristics of CSEs resulting from their relation to the city space and we introduce our current work to enhance with semantics an existing CSE in the city of Milano, in relation to the forthcoming World Exposition (EXPO 2015).

1 Introduction

Our daily lives and activities take place in the physical space but more and more often our actions have "reflections" in the digital space. Cities share the same fate: especially in the context of the so-called Smart Cities, digital representations of physical objects are becoming pervasive. Those digital images, in turn, share specific commonalities due to their relation to a spatio-temporal context; as such, (semantic) representations of geographic and temporal characteristics are essential for a meaningful management of those digital reflections.

In this paper, we focus our attention to Web services regarding urban environments. We introduce the concept of City Service Ecosystem and we outline how semantics can support the description of such city services. In particular, we delineate the main challenges of including city semantics (in terms of spatial characteristics for example) in the description of such services, in order to enable the accomplishment of a better retrieval and usage by the city stakeholders.

2 City Service Ecosystems

Cities are complex environments in which multiple heterogeneous stakeholders produce, consume and exchange digital information. Public utilities monitor their goods consumption (water, electricity, waste, etc.) and gather information from complementary sources to improve their business and service performance; public bodies provide information and services to their citizens with the aim to satisfy people needs and with the mandate to govern and coordinate the actions on the territory; citizens request and provide information about what happens in their cities during their everyday activities as part of their lives.

It is thus clear that in every city a diverse and intertwined ecosystem of services exists and that multiple and independent information systems are put in place to manage the digital representation of those services. We name *City Service Ecosystem* (CSE) the digital environment in which those services live, according to the principles and guidelines of the so-called API economy [1]. Such a CSE should allow for the coordinated and independent governance of the services provided and consumed by the different stakeholders, respecting the legal and business rules that apply, following the concept of *coopetition* (cooperation and competition [2]).

The peculiarity of a CSE with regards to other digital environments (e.g. any other B2B system) lies in the strong connection with a *spatio-temporal context*: those services are related and insist on a physical area and are widely dependent on the timing and possible co-occurrences of events happening in the city.

Taking the example of city mobility, multiple actors offer information services: local transportation utilities (timetables of buses and subways, availability of taxis), long-range transport companies (train and flights arrivals and departures), environmental-friendly or sustainable mobility means (availability of bike sharing or car sharing) and of course private transportation (GPS traces of vehicles, traffic sensors in the streets). The mobility providers are in a business competition, but, if they cooperate by exchanging their information (passenger flows, availability of services, congestion and delays), the whole city ecosystem benefits and the quality of life of citizens improves.

Our investigation questions are therefore: how should such a CSE be shaped and organized? How can semantics support the life-cycle of city services? This short paper is aimed at exploring (a part of) such a research space and at providing preliminary answers to those questions.

3 City Services

Managing city services within a CSE means managing their descriptions in the first place. In this section, we address the issue of using semantics to make explicit and machine-readable their specifications. Beyond the general considerations applicable to the semantic description of any Web service, we focus on the specificity of urban services.

3.1 Describing City Services

There is a large literature about ontological models and semantic enrichment of SOAP-based Web services [3–6]. However, those proposals have shown limited adoption outside the research community; one of the reasons is probably the high cost of producing such descriptions, making it an entry barrier that discouraged a real uptake.

Another reason is the rising popularity of Web APIs and REST services [7] which represent a more “developer-friendly” paradigm for Web services. Also in this space several proposals have been formulated for enhancing their descriptions with semantics [8, 9]. It is undoubted that APIs and especially REST interfaces are "closer" to the structure of the data they exchange. For this reason, their description is more strictly bound to the description of their data semantics.

Since cities are complex environments, their services span a large set of different domains, covering the heterogeneous aspects of citizens' lives. Nonetheless, they all share the city context from both a spatial and temporal point of view [10, 11]. As such, city services' data exchanges very likely share at least a part of their "semantics" in relation to the physical space and to the timing[1]. This fact must be taken into account when semantically annotating city services: describing a service, indeed, is not only a matter of explaining its *behaviour* in terms of functionalities, but it is also related to the specification of the service *context*, to allow on the one hand the discovery of the service (see next section), but foremost its comprehension and use.

Adopting common models to describe geographic and temporal features, as well as building and re-using identifiers for relevant points of interest (POI) in a city becomes therefore of utmost importance to add the relevant semantics to urban services. The question arises whether spatio-temporal semantics should be used to annotate the description of a *service interface* rather than to "shape" the *data exchanged* through the services, so to enable the interoperability of services' requests and responses. We think that both those conditions apply: in the former case, semantics supports the selection of the relevant service on the basis of the requester's needs (e.g., choosing the best transportation service for a specific geographical area); in the latter case, semantics allows an easier mash-up of different services in the same context (e.g., combining two different transportation services on the basis of the proximity between the stops/stations of the different providers so to enable a multi-modal journey planning).

3.2 Retrieving City Services

Web service descriptions are intended in the first place to be employed to discover – either at design time or at run-time – the best service to fulfil a specific need. Research focused also on semantically-enhanced Web service discovery (including our own results [12, 13]), especially foreseeing a global process of automatic discovery, selection, replacement and composition of Web services. However, as outlined above, those fully-automated methods rarely exited the labs.

We believe that a semi-automatic or only partially automated scenario is more likely to happen: a developer needs a service to complete a business process and would like to find it, exactly as he would do by searching the Web for information. As a consequence, in this paper we talk about *Web service retrieval* rather than discovery. A number of Web service catalogues and directories have

[1] A very interesting discussion about the interplay between spatial and temporal description is taking place within the W3C Locations and Addresses Community Group, cf. `http://www.w3.org/community/locadd/`.

emerged[2], both as pure editorial efforts or collaborative wiki-like initiatives; developers can look for services via traditional keyword-based search or category facets/filters. Along those lines, some proposals emerged within the Semantic Web community to build scalable "search engines" for Web services [14], by focusing on simple yet effective ontological models to enable service retrieval (like the minimal ontologies proposed by [15] and [16]).

In the context of cities, the same considerations are valid and it is clear that a city service description should include spatial information to allow for a geo-based retrieval (e.g. which public transportation services cover an area of x kilometre radius from this position?). Within a CSE, in which multiple actors cooperate and compete, other service details are very important, like usage terms and conditions: a semantic description of such non-functional properties of urban services should be mandatory for a semantic CSE.

It is worth noting that such non-functional description are not only limited to generic business rules (e.g., whether a service is available to everybody vs. limited to registered users, or provided for free vs. requiring a fee), but also to city-specific peculiarities and conditions related to the actual usage of such services (e.g. is a ticket from a transportation service valid to travel with another provider? will a shuttle bus connection service wait for the arrival of a specific train service in case of delay?): with the increasing blending of the physical and cyber systems, digital representations of such features becomes essential for an effective governance of a CSE.

4 The experience of EØ15 Digital Ecosystem

Milan will host the World Exposition in 2015 whose main theme is "Feeding the Planet, Energy for Life"[3]. This event is a major opportunity to introduce disruptive innovations in all aspects of the urban life: infrastructures, transportation, cultural and social life, accommodation, services and facilities.

EØ15 [17] is a CSE enabling and fostering interoperability between different organizations and companies, from both the private and public sector, that can join the digital ecosystem for free[4]. It is a business environment where the participants openly publish their Web services and APIs, described both in terms of functionalities and in terms of rules and usage policies (licenses, service level agreements and possible remuneration models are specified and made available). Interoperability is based on open standards: Web Service interoperability specifications (e.g., WS-I Basic Profile 1.1 [18]) and security standards (e.g., WS-I Basic Security Profile 1.1 [19]). Usage requests and access to services are regulated by common guidelines and processes.

While in its current realization, EØ15 does not make use of semantic technologies, all the issues related to an effective description of the offered services emerged during its design and development. In order to lower the entry barrier

[2] Like the very popular ProgrammableWeb, `http://www.programmableweb.com/`.
[3] Cf. `http://en.expo2015.org/`.
[4] Cf. `http://www.e015.expo2015.org/`.

for participants, EØ15 requires providers to compile a form to describe their services (besides producing the technical details, for example WSDL files): the completed forms can be the basis for a semantic description of EØ15 services. We are currently exploring and comparing the different existing ontologies to describe Web services, in order to come up with a simple but powerful model, able to cover both SOAP-based services and APIs and REST services; we are adopting a bottom-up approach, by starting from the concrete EØ15 services so to take into consideration all the concrete requirements coming from a real CSE. While EØ15 currently encompasses services mainly in the domains of transportation, accommodation and tourism, we believe it is an interesting test-bed to experiment with semantic technologies.

EØ15 also fosters interoperability at data level by promoting sharing and reuse of glossaries between different services; for example, the services providing real-time information about flight arrivals and departures of the three airports around Milano, even if operated by different stakeholders, adopted the same service interface and data structures[5]. Semantic technologies can for sure play an important role in defining common and shared vocabularies and ontologies and in paving the ground for an improved interoperability of city services.

5 Conclusions and Outlook

In this paper, we introduced the concept of a City Service Ecosystem and we explained the rational and the possible benefits of adopting "a little semantics"[6] to improve city service descriptions and enable an easier service retrieval and an improved interoperability at city level. We are currently applying the considerations expressed in this paper to enhance the EØ15 service ecosystem of Milano; our plan is to design and develop a semantic registry for city services (something like LOV[7] for services) and to enable a semantically-enhanced retrieval of those services.

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