Semantic Web Services for Integrated Tourism in the Apulia Region

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Abstract. In this paper we report our ongoing work on *Puglia@Service*, a PON Research & Competitivity project aimed at creating an innovative service infrastructure for the Apulia Region, Italy. A sector of interest to the project for the application of the infrastructure is Integrated Tourism. In this sector, we have defined Semantic Web Services following the OWL-S approach. The services have been based on OWL ontologies in the domain of travel and tourism, which have been populated with data of Apulia. This will enable users and software agents to automatically discover, invoke, compose, and monitor Web resources offering services, under specified constraints, for Integrated Tourism in Apulia.

1 Introduction

Tourism activity is becoming more competitive, more extensive, more complicated, and more demanding of host communities and their culture and environment. Tourism planning has been beset by a number of new challenges such as the ones posed by the principles of sustainable development. In order for the tourism enterprise in any destination area to respond positively to these challenges, it is necessary for tourism planning to be practised in a fashion commensurate with the needs of the destination area and the nation. Many reasons are offered for tourism planning, not least the advocacy that planning is the best way of extending the vital life-cycle of a destination by providing a means of anticipating changes, adjusting to the demands of change, and exploring new opportunities. However, integrating tourism planning into official planning - whether economic, social, welfare, environmental, infrastructure, or cultural - has been slow, and remains unusual. The ideal model would be a national/regional/local comprehensive planning system in which tourism is an integral component. This model is rare, which is not surprising, as the various component strategies within tourism are seldom integrated. The goal of *Integrated Tourism* is twofold. For the various interests, requirements and needs the aim is to be fused together into a composite, integrated strategic tourism plan. For tourism the aim is to be planned with the intention of being fused into the social and economic life of a region and its communities. Although there is evidence that some tourism destinations have developed without conscious strategic and integrated planning, many of them have experienced unforeseen consequences (either physical, or human, or marketing or organizational impacts) which have led to their deterioration. Integrated

Tourism has turned out be crucial in the sustainable development of rural areas (so-called Integrated Rural Tourism) [14]. However, the integrated approach can be beneficial also to urban areas as testified by recent progress in *Urban Tourism* research [1]. Indeed, tourism is being seen as a cornerstone of a policy of urban development that combines a competitive supply able to meet visitors' expectations with a positive contribution to the development of towns and cities and the well-being of their residents. Urban Tourism is complex, difficult to pin down and define, and depends on many factors such as the size of the town, its history and heritage, its morphology and its environment, its location, its image, etc.

Contribution of the paper. The application of Information and Communication Technology (ICT) to the tourism industry has been considered challenging since the very beginning due to the technical issues raised by interoperability. However, most research on so-called eTourism has been conducted by specializing technologies originally conceived for eCommerce (see [3] for a comprehensive yet not very recent review). We claim that ICTs for Integrated Tourism should go beyond the mere technological support for tourism marketing. For instance, identifying the most appropriate institutional structures and strategies to integrate the views and coordinate the actions of diverse tourism stakeholders is a key stage in the development of Integrated Tourism in rural and lagging areas. Bousset *et al.* [2] present a Decision Support System (DSS) which combines tools to assist in the analysis of the views, concerns and planned strategies of a wide range of tourism stakeholders in the face of given trends in tourists' expectations. In this paper, we report our experience in supporting Integrated Tourism services with semantic technologies. The work has been conducted within *Puglia@Service*[1], an Italian PON Research & Competitivity project aimed at creating an innovative service infrastructure for the Apulia Region, Italy[2]. As for the application to Integrated Tourism, the project addresses some of the issues analyzed in a report entitled "Sustainable Tourism and Local Development in Apulia Region" (2010)[3] and prepared by the Local Economic and Employment Development (LEED) Programme and the Tourism Committee of the Organisation for Economic Co-operation and Development (OECD) in collaboration with Apulia Region. The region as a touristic destination needs a better management in spite of the recent growth of visitors and the high potential. In particular, the report emphasizes the lack of an adequate ICT infrastructure and little use of new technologies.

Semantic Web Services are among the semantic technologies which are going to be applied in *Puglia@Service*. Just like conventional web services, Semantic Web Services are the server end of a client-server system for machine-to-machine interaction via the World Wide Web (or simply, the Web) [7]. As a component of the Semantic Web, they are defined with mark-up languages which make data machine-readable in a detailed and sophisticated way. In particular, *OWL-S*[4] is an ontology which provides a standard vocabulary that can be used together

[1] http://www.ponrec.it/open-data/progetti/scheda-progetto?ProgettoID=5807
[2] http://en.wikipedia.org/wiki/Apulia
[3] http://www.oecd.org/cfe/leed/46160531.pdf
[4] http://www.w3.org/Submission/OWL-S/

with the other aspects of the *Ontology Web Language* (OWL)[5] to create service descriptions. The use of OWL-S makes it easy for programmers to combine data from different sources and services without losing meaning. Web services can be activated "behind the scenes" when a web browser makes a request to a web server, which then uses various web services to construct a more sophisticated reply than it would have been able to do on its own. Semantic Web Services can also be used by automatic programs that run without any connection to a web browser. Overall, the interchange of semantic data allows to overcome some of the limits of conventional web services. Indeed, the mainstream XML standards for interoperation of web services specify only syntactic interoperability, not the semantic meaning of messages. For example, *Web Services Description Language* (WSDL)[6] can specify the operations available through a web service and the structure of data sent and received but cannot specify semantic meaning of the data or semantic constraints on the data. This requires programmers to reach specific agreements on the interaction of web services and makes automatic web service composition difficult.

Structure of the paper. The paper is structured as follows. Section 2 summarizes the goals of the *Puglia@Service* project as for the application to Integrated Tourism. Section 3 shortly describes a domain ontology for Integrated Tourism, named *OnTourism*, which has been modeled for being used within *Puglia@Service*. Section 4 briefly presents a Web Information Extraction tool, named WIE-OnTour, which has been developed for populating *OnTourism* with data automatically retrieved from the Web. Section 5 illustrates some of the Semantic Web Services which have been defined on top of *OnTourism* for supporting Integrated Tourism in Apulia. Section 6 provides an overview of related work. Section 7 concludes the paper with final remarks and directions of future work. Appendix A provides further details of the OWL-S approach.

2 Integrated Tourism Services in Apulia

The research conducted in the *Puglia@Service* project falls within the area of *Internet-based Service Engineering*, *i.e.* it investigates methodologies for the design, development and deployment of innovative services. Concerning this area, the project will have an impact on the Apulia regional system at a strategic, organizational and technological level, with actions oriented to service innovation for the "sustainable knowledge society". The reference market of *Puglia@Service* is represented by the so-called *Knowledge Intensive Services* (KIS), an emerging category of the advanced tertiary sector, and transversal to the other economic sectors, that is supposed to play a prominent role within the restructuring process which will follow the world economic crisis.

Objective of the project is to promote a new service culture over the Apulia region, marking a discontinuity point in the local development model, and guiding the transition of the region towards the "smart territory" paradigm where the

[5] http://www.w3.org/TR/owl2-overview/

[6] http://www.w3.org/TR/2007/REC-wsdl20-primer-20070626/

territory is intended to be a multiplayer system able to improve, by means of an adequate technological and digital infrastructure, its attitude to innovation as well as its skills in managing the knowledge assets of the regional stakeholders.

The project will pursue this goal through process and product innovations. In particular, it proposes to radically innovate the processes of service conceptualization, design, development and deployment, by assigning to the user a central role that anticipates his involvement. This will be obtained by applying a *user-driven open innovation* methodology, created at the US MIT Laboratories and adopted by the European countries, known as "Living-Lab". The project also defines a set of methodologies and technologies for Internet-based Service Engineering starting from a next generation service model conceived to satisfy the needs for inclusion, participation and personalization. Finally, it is expected to produce not only a pervasive technological infrastructure (like a nervous system for the "smart territory") but also:

- a qualified personnel, educated according to the *Innovator and Entrepreneur Engineer* profile, *i.e.* able to catch the opportunities offered by the new technologies and to transfer them into new business models in order to create economic and social value (Technological Entrepreneurship);
- a start-up company operating in the Service Engineering area and addressing the European Commission request for "service innovation leaders".

The arrangement of the new service model into the regional context will regard the new generation services of the Public Administration and the Integrated Tourism. In particular, the application of *Puglia@Service* to Integrated Tourism (*Puglia@Service.Tourism*) encompasses an intervention on the Apulia tourism system, based on the definition of an Internet-based service model which increases the capability of KIS to create value for the region and for the tourist. Here, the tourist is not only "service user" but also "information supplier". In particular, the application will require the development of methods and technologies enabling an interaction model between the tourist and the territory with the ultimate goal of local development along three directions: Culture, Environment and Economy. For the purposes of this paper, we shall focus only on the Environment dimension.

Puglia@Service.Tourism aims at promoting forms of tourism with a low environmental impact centered around the notion of eco-compatible mobility. This will contribute to the achievement of a twofold goal. On one side, the tourist will benefit from decision support facilities during his/her tours, *e.g.* he/she will receive suggestions about sites of interest and public transportation means suitable to reach a certain destination. On the other side, the territory will benefit from the environmental sustainability of local tourism. The reduced environmental impact of eco-mobility together with the need for a more efficent transportation system in touristic places can be obtained by combining sensoring tools and applications with rewarding mechanisms that encourage tourists and citizens to make eco-compatible choices. A possible scenario is described in the following. Once arrived in a touristic destination, the tourist could use his/her smartphone/PDA in order to obtain a suggestion about specific itineraries compliant with his/her profile and the information about the context. The tourist will be informed about the availabiliy of alternative transportation means and will be offered some credits for the green options (biking, trekking, car pooling, car sharing, etc.). In order to support this scenario, the *Puglia@Service.Tourism* infrastructure should deal with multi-dimensional information useful to suggest a touristic strategy which should meet users' expectations and preferences (in culture, enogastronomy, shopping, relax, etc.); environmental conditions, both meteorological and natural; multi-modal transportation means; availability of car pooling and car sharing services; transfer time between sites of interest. The "fingerprint" of tourists visiting an area in a given time span can be anonymized and employed to improve continuously the user profiling with the choices made by tourists with the same profile. To this aim it is necessary to track the trajectories of citizens and tourists by means of localization and wireless communication technologies (traces from mobile phones, PDA, vehicles with GPS, etc.).

It is straightforward to notice that Internet-based Service Engineering for KIS in Integrated Tourism should strongly rely on Web technologies - such as Semantic Web Services - enabling an automated service composition. As shown in the rest of the paper, Web services in *Puglia@Service.Tourism* are enriched with semantic annotations starting from domain ontologies.

3 A Domain Ontology for Integrated Tourism

Domain ontologies for tourism are already available, *e.g.* the *travel*[7] ontology is centered around the concept of *Destination*. However, it is not fully satisfactory from the viewpoint of Integrated Tourism. For instance, it lacks concepts modeling the reachability of places. In *Puglia@Service.Tourism*, we have decided to build a domain ontology, named *OnTourism*,[8] more suitable for the project objectives and compliant with the OWL2 standard.It consists of 359 axioms, 196 logical axioms, 113 classes, 9 object properties, and 14 data properties, and has the expressivity of the DL $\mathcal{ALCHOIF}(\mathbf{D})$.

The main concepts forming the terminology of *OnTourism* model the sites (class *Site*), the places (class *Place*), and the distances between sites (class *Distance*). Sites of interest include accommodations (class *Accommodation*), attractions (class *Attraction*), stations (class *Station*), and civic facilities (class *Civic*) as shown in Figure 1. The terminology encompasses the amenities (class *Amenity* with subclasses reported in Figure 2) and the services (class *Service* with subclasses reported in Figure 3) offered by hotels. Also, it models the official 5-star classification system for hotel ranking (class *Rank* with instances *1_star*, *2_stars*, and so on) as well as a user classification system for accommodation rating (class *Rate* with instances *Excellent*, *Very_Good*, *Average*, *Poor*, *Terrible*). Finally, the terminology includes landscape varieties (class *Landscape* with instances *City*, *Country*, *Lake*, *Mountain*, *River*, and *Sea*) and transportation means (class *Transportation_Mean* with instances *Bike*, *Car*, *Foot*, and *Public_transit*). Distances are further classified into *Distance_by_car* and *Distance_on_foot* according to the transportation means used.

[7] `http://www.protege.cim3.net/file/pub/ontologies/travel/travel.owl`
[8] It significantly extends the *Hotel* ontology described in [10].

The object properties in *OnTourism* model the relationship between a site and a distance (*hasDistance*), the relationship between a distance and the two sites (*isDistanceFor*), and the relationship between a site and the place where the site is located at (*isLocatedAt*). Also, for each accommodation, it is possible to specify the amenities available (*hasAmenity*) and the services provided (*provides*). The user rating allows to classify accommodations into five categories (from *Excellent_Accommodation* to *Terrible_Accommodation*). In the case of hotels, the ranking (*hasRank*) is the starting point for the definition of five categories (from *Hotel_1_Star* to *Hotel_5_Stars*).

The data properties in *OnTourism* allow to refer to sites by *name* and to places by *address*, *zipcode*, *city*, and *country*. Details about accommodations are the number of rooms (*numberOfRooms*) and the average price of a room (*hasPrice*). Distances between sites have a numerical value in either length or time units (*hasLengthValue*/*hasTimeValue*). Note that each of these numerical values would be better modeled as attribute of a ternary relation. However, only binary relations can be represented in OWL. The concept *Distance* and the properties *hasDistance*, *isDistanceFor* and *hasLengthValue*/*hasTimeValue* are necessary to simulate a ternary relation by means of binary relations.

4 Extraction of Touristic Information from the Web

Information extraction (IE) is the task of automatically extracting structured information from unstructured and/or semi-structured machine-readable documents. In most of the cases this activity concerns processing human language texts by means of natural language processing (NLP). The proliferation of the Web has intensified the need for developing IE systems that help people to cope with the enormous amount of data that is available online, thus giving raise to Web Information Extraction (WIE) [4]. WIE tools typically exploit the HTML/XML tags and layout format that are available in online text. As a result, less linguistically intensive approaches have been developed for IE on the Web using wrappers, which are sets of highly accurate rules that extract a particular page's content. Wrappers typically handle highly structured collections of web pages, such as product catalogues and telephone directories. They fail, however, when the text type is less structured, which is also common on the Web.

WIE-OnTour is a wrapper-based WIE tool implemented in Java and conceived for the population of *OnTourism* with data concerning accommodations (in particular, those in the categories "hotel" and "bed&breakfast") available in the web site of TripAdvisor[9]. The tool is also able to compute distances of the extracted accommodations from sites of interest (*e.g.*, touristic attractions) by means of Google Maps[10] API. Finally, the tool supports the user in the specification of sites of interest.

WIE-OnTour has been tested on several cities in the world. However, the main destinations of Urban Tourism in the Apulia Region are of interest to

[9] `http://www.tripadvisor.com/`
[10] `http://maps.google.com/`

the project. Therefore, as case studies, we have restricted our attention to capital towns of Apulia provinces (Andria, Bari, Barletta, Brindisi, Lecce, Taranto, Trani). A snapshot of WIE-OnTour performing the information extraction process for Bari, the capital city of Apulia Region, is shown in Figure 4. In this session (performed on May 13, 2014), the tool has extracted 46 hotels (instances of *Hotel*), 151 bed&breakfast (instances of *Bed_and_Breakfast*), 205 places (instances of *Place*), 1996 distances (instances of *Distance*) for a total of 2406 individuals. The distances have been computed with respect to the following sites of interest: *Basilica di San Nicola*[11] and *Cattedrale di San Sabino*[12] (both instances of *Church*), *Museo Nicolaiano* (instance of *Museum*), *Porto di Bari* (instance of *Port*), *Aeroporto Karol Wojtyla* (instance of *Airport*), and *FS Bari Centrale* (instance of *Train_Station*). The computation for this session has been completed in about 33 minutes.

5 Adding Semantics to Integrated Tourism Services

In *Puglia@Service.Tourism*, we have defined several services on top of two domain ontologies: *travel* and *OnTourism*. For example, *destination_attractions_service* is a service that returns the attractions located in a given destination. The semantic description of this service in OWL-S (shown in Figure 5) specifies that it is an atomic service with only one input and only one output where the parameter types for the input and the output are the classes *Destination* (belonging to *travel*) and *Attraction* (occurring in *OnTourism*) respectively. Several specializations of *destination_attractions_service* have been considered, one for each subclass of the parameter types. For example, *city_churches_service* is a service that returns the churches (output parameter of type *Church*) located in a given city (input parameter of type *City*). When executed for the city of, *e.g.*, Bari, the service will query the underlying domain ontologies (more precisely, their instance level) to retrieve each *Church* that *isLocatedAt* some *Place* in Bari, *e.g. Basilica di San Nicola* and *Cattedrale di San Sabino*. Note that these instances will be returned also by *destination_attractions_service* because they are inferred to be instances of *Attraction*. As a further case, *near_attraction_accomodations_service* is a service that returns all the accommodations (output parameter of type *Accommodation*) near a given attraction (input parameter of type *Attraction*). Note that closeness can be defined on the basis of the distance between sites (class *Distance*) either in a crisp way (*i.e.*, when the distance value is under a fixed threshold) or in a fuzzy way (*i.e.*, through grades of closeness). In both ways, however, the computation should consider the transportation means used (*Distance_by_car* vs. *Distance_on_foot*) as well as the measure units adopted (*hasLengthValue* vs. *hasTimeValue*).

In *Puglia@Service.Tourism*, we have chosen to define only OWL-S atomic services in order to exploit the aforementioned advantages of the WSDL grounding. As an illustration, the WSDL grounding of *destination_attractions_service* is reported in Figure 6. Composite services can be automatically obtained by applying

[11] Basilica of St. Nicholas: `http://en.wikipedia.org/wiki/Basilica_di_San_Nicola`
[12] Cathedral of St. Sabinus: `http://en.wikipedia.org/wiki/Bari_Cathedral`

service composition methods such as the one described in [15]. The simplest form of composite service is based on the control construct of *Sequence*. For example, the services *city_churches_service* and *near_attraction_accomodations_service* can be executed in sequence by having the output of the former as input to the latter. Note that the type mismatch is only apparent since *Church* is a subclass of *Attraction*. One such service composition satisfies, *e.g.*, the user request of knowing the accommodations around *Basilica di San Nicola* and *Cattedrale di San Sabino* in Bari. Considering that Bari is a major destination of religious tourism in Apulia, this composite service effectively supports the demand from pilgrims who prefer to find an accommodation in the neighborhood of places of worship so that they can practise their own religions at any hour of the day. Also, if the suggested accommodations are easy to reach (*i.e.*, at foot distance) from the site of interest, the service will bring benefit also to the city, by reducing the car traffic. In a more complex scenario, the pilgrim might need an accommodation accessible to disabled visitors. The service composition mechanism should then consider a further specialized service, say *disabledfacilities_hotels_service*, which returns the hotels (output parameter of type *Hotel*) with disabled facilities (input parameter of type *Disabled_Facilities*). Indeed, the resulting composite service can be considered compatible with the special needs of this user profile.

6 Related Work

The application of ICT to the tourism industry has been considered challenging since the very beginning due to the technical issues raised by interoperability. Werthner and Klein [18] defined interoperability as the provision of a well-defined and end-to-end service which is in a consistent and predictable way. This generally covers not merely technical features but also in the case of electronic market environments, contractual features and a set of institutional rules. Interoperability enables partners to interact electronically with each other by the most convenient method and to deliver the right information at the right time to the right user at the right cost. Using a domain ontology a mediator software system (such as HARMONISE [13,5]) effectively "'translates"' partners' data and allows them to communicate electronically. Maedche and Staab [11,12] showed that semantic web technologies can be used for tourism applications to provide useful information on text and graphics, as well as generating a semantic description that is interpretable by machines. Dogac *et al.* [6] describe how to deploy semantically enriched travel Web services and how to exploit semantics through Web service registries. We also address the need to use the semantics in discovering both Web services and Web service registries through peer-to-peer technology. Hepp *et al.* [8] investigate the use of ontological annotations in tourism applications. They show, based on a quantitative analysis of Web content about Austrian accommodations, that even a perfect annotation of existing Web content would not allow the vision of the Semantic Web to become a short-term reality for tourism-related eCommerce. Also, they discuss the implications of these findings for various types of eCommerce applications that rely on the extraction of information from existing Web resource, and stress the importance of Semantic Web Services technology for the Semantic Web. Within the scope of the OnTour[13] project, Siorpaes and Bachlechner [17] develop a system based on a fast and flexible Semantic Web backbone with a focus on e-tourism. The major benefits of the OnTour approach are its simplicity, modularity, and extensibility. In [9], Jakkilinki *et al.* describe the underlying structure and operation of a Semantic Web based intelligent tour planning tool. The proposed tour planner has inbuilt intelligence which allows it to generate travel plans by matching the traveller requirements and vendor offerings stored in conjunction with the travel ontology. Ricca *et al.* [16] present a successful application of logic programming for e-tourism: the iTravel system. The system exploits two technologies that are based on the state-of-the-art computational logic system DLV: (i) a system for ontology representation and reasoning, called OntoDLV; and, (ii) a semantic information-extraction tool. The core of iTravel is an ontology which models the domain of tourism offers. The ontology is automatically populated by extracting the information contained in the tourism leaflets produced by tour operators. A set of specifically devised logic programs is used to reason on the information contained in the ontology for selecting the holiday packages that best fit the customer needs. An intuitive web-based user interface eases the task of interacting with the system for both the customers and the operators of a travel agency.

7 Conclusions and Future Work

In this paper we have reported our ongoing work on the use of semantic technologies for supporting Integrated Tourism services in the Apulia region within the *Puglia@Service* project. More precisely, we have shortly described *OnTourism*, a domain ontology for Integrated Tourism. Also, we have briefly presented WIE-OnTour, a Web Information Extraction tool which has been developed for populating *OnTourism* with data automatically retrieved from the Web sites of TripAdvisor and Google Maps. Moreover, we have illustrated the semantic descriptions in OWL-S of some Integrated Tourism services built on top of *OnTourism*.

Though developed for the purposes of the project, the technical solutions here described are nevertheless general enough to be reusable for similar applications in other geographical contexts. Notably, they show the added value of having ontologies and ontology reasoning behind an Interned-based service infrastructure.

For the future we intend to apply Machine Learning tools such as Foil-$\mathcal{DL}$ [10] to enhance the automated composition of OWL-S services. Notably, we shall consider the problem of learning from the feedback provided by specific user profiles. The idea is to use the ontology axioms induced by Foil-$\mathcal{DL}$ in order to discard those compositions that do not reflect the preferences/expectations/needs of a certain user profile. Therefore, the axioms will act as composition rules to be integrated with other existing approaches to automated service composition.

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[13] The OnTour project should not be confused with our ontology *OnTourism*. The names are only accidentally very similar.

A The OWL-S approach

Besides being a service mark-up language, OWL-S is an upper ontology for services whose structuring is motivated by the need to provide three essential types of knowledge about a service (class *Service*): The service profile (class *ServiceProfile*), the service model (class *ServiceModel*), and the service grounding (class *ServiceGrounding*). Generally speaking, the service profile provides the information needed for an agent to discover a service, while the service model and the service grounding, taken together, provide enough information for an agent to make use of a service, once found. More specifically, the three components satisfy the following informative needs.

The *service profile* tells "what the service does", in a way that is suitable for a service-seeking agent (or matchmaking agent acting on behalf of a service-seeking agent) to determine whether the service meets its needs. This form of representation includes a description of what is accomplished by the service, limitations on service applicability and quality of service, and requirements that the service requester must satisfy to use the service successfully.

The *service model* tells a client how to use the service, by detailing the semantic content of requests, the conditions under which particular outcomes will occur, and, where necessary, the step by step processes leading to those outcomes. For services based on composite processes, this description may be used by a service-seeking agent in at least four different ways: (1) to perform a more in-depth analysis of whether the service meets its needs; (2) to compose service descriptions from multiple services to perform a specific task; (3) during the course of the service enactment, to coordinate the activities of the different participants; and (4) to monitor the execution of the service.

A *service grounding* specifies the details of how an agent can access a service. Typically a grounding will specify a communication protocol, message formats, and other service-specific details such as port numbers used in contacting the service. In addition, the grounding must specify, for each semantic type of input or output specified in the service model, the serialization techniques employed for exchanging data elements of that type with the service. The most commonly used grounding is WSDL due to the following reasons: (1) An OWL-S atomic process corresponds to a WSDL operation; (2) The inputs and outputs of an OWL-S atomic process correspond to WSDL messages; (3) The types of the inputs and outputs of an OWL-S atomic process correspond to WSDL abstract types.

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Fig. 1. Taxonomy of sites in the *OnTourism* ontology.

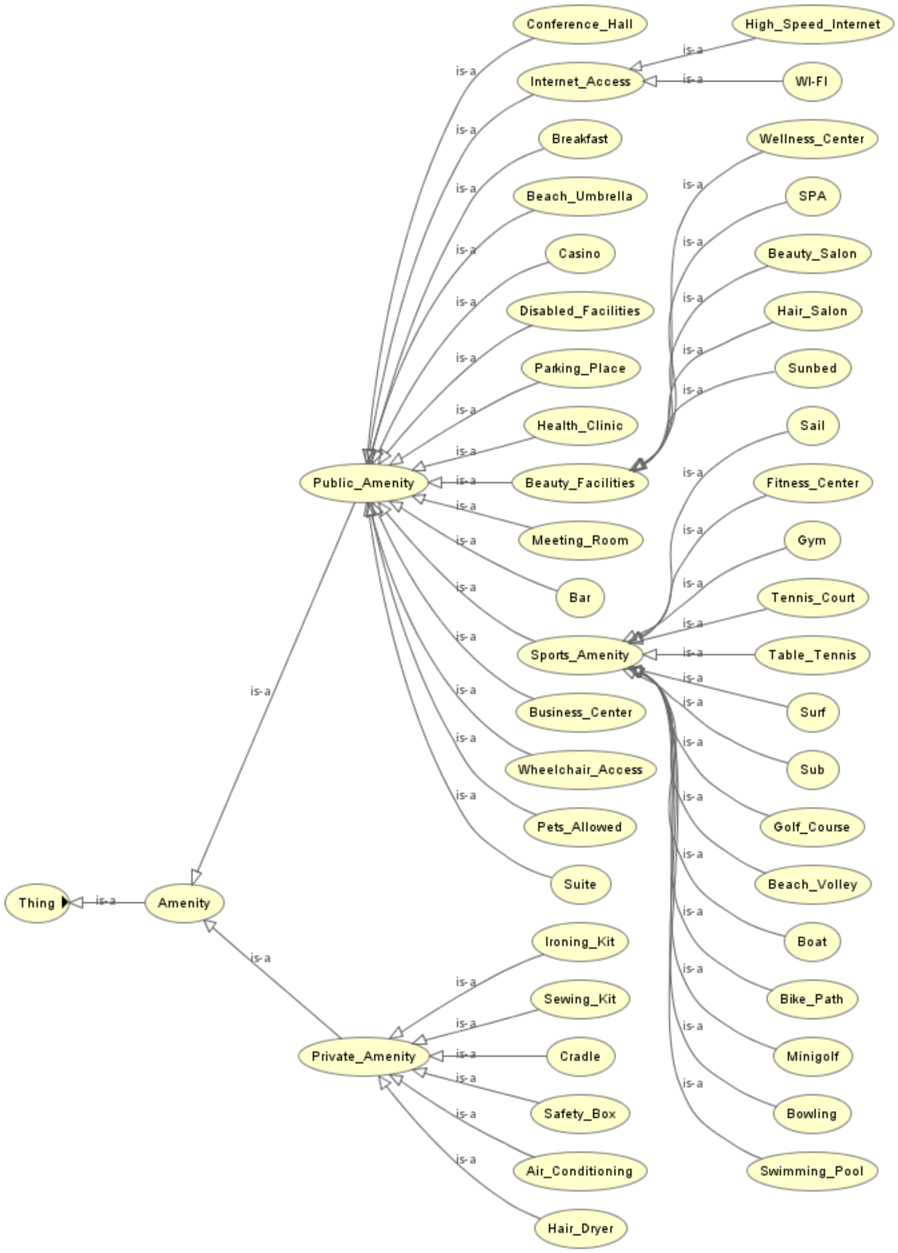

Fig. 2. Taxonomy of amenities in the *OnTourism* ontology.

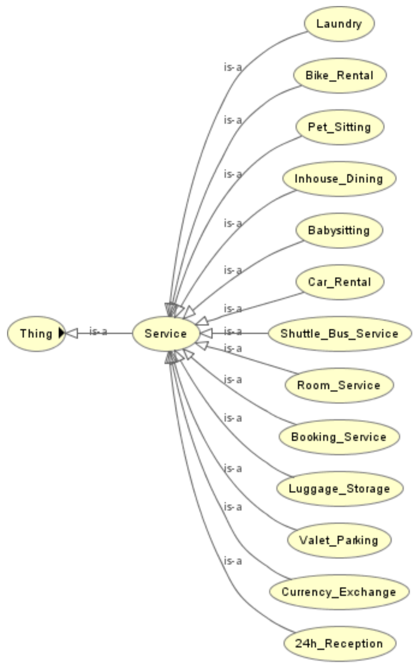

Fig. 3. Taxonomy of services in the *OnTourism* ontology.

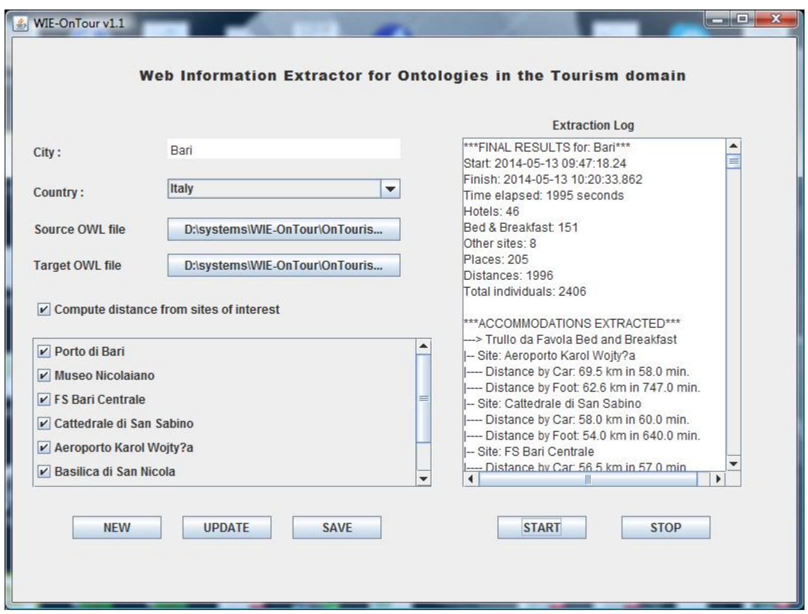

Fig. 4. Web Information Extraction for the city of Bari, Italy, with WIE-OnTour.

```
<rdf:RDF xmlns:owl="http://www.w3.org/2002/07/owl#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:service="http://www.daml.org/services/owl-s/1.1/Service.owl#"
 xmlns:process="http://www.daml.org/services/owl-s/1.1/Process.owl#"
 xmlns:profile="http://www.daml.org/services/owl-s/1.1/Profile.owl#"
 xmlns:grounding="http://www.daml.org/services/owl-s/1.1/Grounding.owl#"
 xml:base="http://127.0.0.1/services/1.1/destination_attractions_service.owls">

<owl:Ontology rdf:about="">
  <owl:imports rdf:resource="http://127.0.0.1/ontology/Service.owl"/>
  <owl:imports rdf:resource="http://127.0.0.1/ontology/Process.owl"/>
  <owl:imports rdf:resource="http://127.0.0.1/ontology/Profile.owl"/>
  <owl:imports rdf:resource="http://127.0.0.1/ontology/Grounding.owl"/>
  <owl:imports rdf:resource="http://127.0.0.1/ontology/travel.owl"/>
  <owl:imports rdf:resource="http://127.0.0.1/ontology/OnTourism.owl"/>
</owl:Ontology>

<service:Service rdf:ID="DESTINATION_ATTRACTIONS_SERVICE">
  <service:presents rdf:resource="#DESTINATION_ATTRACTIONS_PROFILE"/>
  <service:describedBy rdf:resource="#DESTINATION_ATTRACTIONS_PROCESS"/>
  <service:supports rdf:resource="#DESTINATION_ATTRACTIONS_GROUNDING"/>
</service:Service>

<profile:Profile rdf:ID="DESTINATION_ATTRACTIONS_PROFILE">
  <service:isPresentedBy rdf:resource="#DESTINATION_ATTRACTIONS_SERVICE"/>
  <profile:serviceName xml:lang="en">Destination Attractions Service</profile:serviceName>
  <profile:textDescription xml:lang="en">
    Service that returns attractions located in a given destination.
  </profile:textDescription>
  <profile:hasInput rdf:resource="#_DESTINATION"/>
  <profile:hasOutput rdf:resource="#_ATTRACTIONS"/>
  <profile:has_process rdf:resource="DESTINATION_ATTRACTIONS_PROCESS"/>
</profile:Profile>

<process:AtomicProcess rdf:ID="DESTINATION_ATTRACTIONS_PROCESS">
  <service:describes rdf:resource="#DESTINATION_ATTRACTIONS_SERVICE"/>
  <process:hasInput rdf:resource="#_DESTINATION"/>
  <process:hasOutput rdf:resource="#_ATTRACTIONS"/>
</process:AtomicProcess>
<process:Input rdf:ID="_DESTINATION">
  <process:parameterType rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
    http://127.0.0.1/ontology/travel.owl#Destination
  </process:parameterType>
  <rdfs:label/>
</process:Input>
<process:Output rdf:ID="_ATTRACTIONS">
  <process:parameterType rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
    http://127.0.0.1/ontology/OnTourism.owl#Attraction
  </process:parameterType>
  <rdfs:label/>
</process:Output>

<grounding:WsdlGrounding rdf:ID="DESTINATION_ATTRACTIONS_GROUNDING">...</grounding:WsdlGrounding>
<grounding:WsdlAtomicProcessGrounding rdf:about="#DESTINATION_ATTRACTIONS_AtomicProcessGrounding">
  ...
</grounding:WsdlAtomicProcessGrounding>

</rdf:RDF>
```

Fig. 5. Semantic description of *destination_attractions_service* with OWL-S.

```xml
<rdf:RDF xmlns:owl="http://www.w3.org/2002/07/owl#"
 xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
 xmlns:service="http://www.daml.org/services/owl-s/1.1/Service.owl#"
 xmlns:process="http://www.daml.org/services/owl-s/1.1/Process.owl#"
 xmlns:profile="http://www.daml.org/services/owl-s/1.1/Profile.owl#"
 xmlns:grounding="http://www.daml.org/services/owl-s/1.1/Grounding.owl#"
 xml:base="http://127.0.0.1/services/1.1/destination_attractions_service.owls">

<owl:Ontology rdf:about="">...</owl:Ontology>

<service:Service rdf:ID="DESTINATION_ATTRACTIONS_SERVICE">...</service:Service>

<profile:Profile rdf:ID="DESTINATION_ATTRACTIONS_PROFILE">...</profile:Profile>

<process:AtomicProcess rdf:ID="DESTINATION_ATTRACTIONS_PROCESS">...</process:AtomicProcess>
<process:Input rdf:ID="_DESTINATION">...</process:Input>
<process:Output rdf:ID="_ATTRACTIONS">...</process:Output>

<grounding:WsdlGrounding rdf:ID="DESTINATION_ATTRACTIONS_GROUNDING">
  <service:supportedBy rdf:resource="#DESTINATION_ATTRACTIONS_SERVICE"/>
  <grounding:hasAtomicProcessGrounding>
    <grounding:WsdlAtomicProcessGrounding rdf:ID="DESTINATION_ATTRACTIONS_AtomicProcessGrounding"/>
  </grounding:hasAtomicProcessGrounding>
</grounding:WsdlGrounding>

<grounding:WsdlAtomicProcessGrounding rdf:about="#DESTINATION_ATTRACTIONS_AtomicProcessGrounding">
  <grounding:wsdlDocument rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
    http://127.0.0.1/wsdl/DestinationAttractions.wsdl
  </grounding:wsdlDocument>
  <grounding:owlsProcess rdf:resource="#DESTINATION_ATTRACTIONS_PROCESS"/>
  <grounding:wsdlOperation>
    <grounding:WsdlOperationRef>
      <grounding:operation rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
        http://127.0.0.1/wsdl/DestinationAttractions#get_ATTRACTIONS
      </grounding:operation>
      <grounding:portType rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
        http://127.0.0.1/wsdl/DestinationAttractions#DestinationAttractionsSoap
      </grounding:portType>
    </grounding:WsdlOperationRef>
  </grounding:wsdlOperation>
  <grounding:wsdlInputMessage rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
    http://127.0.0.1/wsdl/DestinationAttractions#get_ATTRACTIONSRequest
  </grounding:wsdlInputMessage>
  <grounding:wsdlOutputMessage rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
    http://127.0.0.1/wsdl/DestinationAttractions#get_ATTRACTIONSResponse
  </grounding:wsdlOutputMessage>
  <grounding:wsdlInput>
    <grounding:WsdlInputMessageMap>
      <grounding:owlsParameter rdf:resource="#_DESTINATION"/>
      <grounding:wsdlMessagePart rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
        http://127.0.0.1/wsdl/DestinationAttractions#_DESTINATION
      </grounding:wsdlMessagePart>
      <grounding:xsltTransformationString>None (XSL)</grounding:xsltTransformationString>
    </grounding:WsdlInputMessageMap>
   </grounding:wsdlInput>
  <grounding:wsdlOutput>
   <grounding:WsdlOutputMessageMap>
     <grounding:owlsParameter rdf:resource="#_ATTRACTIONS"/>
     <grounding:wsdlMessagePart rdf:datatype="http://www.w3.org/2001/XMLSchema#anyURI">
       http://127.0.0.1/wsdl/DestinationAttractions#_ATTRACTIONS
     </grounding:wsdlMessagePart>
     <grounding:xsltTransformationString>None (XSL)</grounding:xsltTransformationString>
   </grounding:WsdlOutputMessageMap>
 </grounding:wsdlOutput>
</grounding:WsdlAtomicProcessGrounding>

</rdf:RDF>
```

Fig. 6. Semantic description of *destination_attractions_service* with OWL-S (cont.).