Computers and Electrical Engineering 52 (2016) 49–64

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Mobile services discovery framework using DBpedia and non-monotonic rules☆

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ARTICLE INFO

Article history:
Received 15 May 2014
Revised 17 February 2016
Accepted 17 February 2016
Available online 9 March 2016

Keywords:
Mobile services discovery
Context information
QoS information
Semantic search
Non-monotonic rules
DBpedia
Multi-domain ontologies

ABSTRACT

Mobile services are constantly evolving, thanks to improvements in performance of mobile devices and wireless networks. As a result, there is a need for and efficient supply of discovery processes that will even allow non-technical users and developers to publish, discover and access services in a mobile environment where non-functional properties (context and quality of service information) play an important role in the discovery process in conjunction to functional properties. In this paper, we propose a user-centric mobile services discovery framework that enriches functional descriptions of mobile services with semantic annotations from DBpedia knowledge (the semantically-structured version of Wikipedia) which covers multiple domains and provides lightweight ontologies. In addition, it offers open tools that can be used to simplify the provisioning and discovery of mobile services. The framework allows users to rank services using non-monotonic rules, which define their desired choices based on the context and quality of service information. Experimental results show that our framework provides efficient discovery results of efficient mobile services.

1. Introduction

The number of mobile phone subscribers is constantly increasing. According to PortioResearch [1], the trend has been transcending such that the prospect of subscribers by the end of 2016 is expected to reach 8.5 billion from the figure of 6.5 billion recorded at the beginning of the year 2013. It further indicates that the handset industry will continue to grow in the next couple of years as more users are getting broadband access to Internet services through their mobile devices. On the other hand, performance of mobile devices is constantly enhancing, with rapid growth in mobile communication networks. This rapid evolution has resulted in the wide proliferation of pervasive environments in which services are accessible, regardless of the time and geological locations. As they are improving consumers daily life, these services are massively expanding across our ecosystems; expected to provide novel experiences and personalization opportunities to the consumers. Hence, providing efficient discovery mechanisms to locate intended services in mobile and dynamically changing environments is expected to meet the challenges of these advances in mobile service provisioning.

Service discovery is the process of finding appropriate services by evaluating a service query [2]. This process usually consists of matching a user query to a set of service definitions, in order to retrieve targeted services. In mobile environ-

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. R. K. Murugesan.

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http://dx.doi.org/10.1016/j.compeleceng.2016.02.016
0045-7906/

ments, user discovery request have to take into account context information (such as location, time and preferences), as well as Quality of Service (QoS) information (such as price, rank and service availability). These criterions play a significant role in the discovery, while helping deliver the right services to the right users, at the right time, in the right place, and with the right QoS expectations.

Mobile service discovery based on semantic matching techniques has received significant attention from researchers in recent years. Considering concepts and their relationships, semantic matching could overcome the limitations of traditional matching models that are based on purely syntactic matching. Semantic matching relies on conceptual models describing specific domain knowledge, known as ontology. Ontologies are widely used to describe services as well as their context and their intrinsic QoS information. The formal language representation of these semantic attributes allows a common understanding and facilitates sharing, integration and reasoning of information [3].

Previous research works have used in either generic or domain-specific ontologies to enrich their mobile service descriptions [4]–[9]. These ontologies usually cover a restricted number of domains, are costly in terms of maintainability [10, 11] and some of them are considered to be over-expressive for semantic search and discovery processes. In addition, due to the variety of mobile services, they could not be well covered by domain-specific ontologies, and as domains evolve, old service descriptions become obsolete. On the other hand, most of domain ontologies are mono-language; as extra effort will be required to as much as consider multilingual discovery, for example by translating concepts and properties into a target language.

In this paper[1], we propose to overcome these limitations by annotating functional aspects of mobile services using DBpedia [10], a multi-domain knowledge base extracted from Wikipedia, to enable the design and development of a semantic Web services discovery framework based on structural containers (concepts, resources and categories). DBpedia covers multiple domains with a large number of concepts, instances and categories that can be used to describe a considerable range of services. It combines advantages of multi-domain and domain-specific ontologies by linking its instances to concepts from hand-crafted ontologies to enable rich semantic applications development. Besides, DBpedia evolves dynamically as Wikipedia changes. Hence, DBpedia is constantly updated with regular addition of new information. Our proposed discovery framework supports multi-languages, where users have the ability to search for mobile services across different languages, thanks to the globalized characteristics of DBpedia.

The proposed approach is user-centric, where the discovery solutions involve service providers who describe their services in terms of offered capabilities. Users issue requests using keywords, without getting involved in the semantic details that are used to annotate provisioned services for effective discovery. The framework provides a ranking mechanism of non-functional mobile services properties to sort them according to users context and the expectations of QoS information. The user defines a list of choices represented by non-monotonic rules in order to select services satisfying his/her context and QoS requirements, based on extended context ontology.

The contributions of this paper can be summarized as follows:

- A user-centric mobile services discovery framework based on the consumption of Linked-Data provided by DBpedia and non-monotonic rules. DBpedia enfolds cross-domain ontologies to describe functional properties (capabilities) of mobile services.
- To represent non-functional properties of mobile services, we propose an extended ontology to represent context and Quality of service information, to enable:
- A ranking and filter process for mobile services is based on the application of non-monotonic semantic Web rules where users represent their non-functional mobile service needs through semantic rules.

In this work, we consider mobile services as one that can be published in a mobile environment, for the purpose of being discovered by moving users from their mobile devices. Context information distinguishes these services from traditional ones. Service providers are able to announce the provision of concrete services that could be discovered from mobile devices, such as restaurant service, taxicab service, healthcare service or mechanic service; in addition to software services.

The remaining sections of this paper are organized as follows: Section 2 outlines some of the related research works. Section 3 introduces a motivational scenario illustrating the importance of mobile services discovery. Section 4 introduces MobiSO, a mobile services specification of an ontology to describe and annotate mobile services, their context and related QoS information. Section 5 discusses semantic annotations and the integration of DBpedia in mobile services specifications. Section 6 discusses semantic Web rules focusing on non-monotonic rules. Section 7 reveals the architecture of the proposed discovery framework. Section 8 provides a prototype implementation of the proposed discovery framework along with an overview of the used technologies and tools. This is followed by an evaluation of the proposed framework focusing on the discovery effectiveness and performance. Finally, Section 9 concludes the paper with a summary of our work and a proposed set of future research perspectives.

2. Related work

Traditional UDDI based discovery approaches have adhered to many limitations; for they have not been designed to support semantic search or adapt discovery processes to take into consideration mobile services context and QoS properties.

[1] This article is a revised and extended version of [12].