Semantic Service Search, Service Evaluation and Ranking in Service Oriented Environment

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Abstract. The theory of Service Oriented Environment (SOE) emerges with advanced connectivity of the Internet technologies, openness of business environment and prosperousness of business activities. Service, as a critical object impenetrating every corner of SOE, is a hot research topic in many research domains. Software Engineering (SE), as a subject in engineering field, its researchers pay more attention to supporting advanced technologies for promoting service activities in SOE. In this paper, we draw the position in the research field of semantic service search, service evaluation and ranking in SOE. By means of the case study and literature review research approach, we discover the research motivations and research issues in this field.

Keywords: quality of services (QoS), research issues, semantic web technologies, service evaluation, service search, service oriented environment (SOE), service ranking.

1 Introduction

Service Oriented Environment (SOE) as defined by Chang et al. [1] is a collaborative, shared and open environment which provides agents with infrastructures and technologies to carry out business services. It consists of four basic components, which are agents (service providers and users, buyer and sellers, websites or servers), business activities (product sales, service deliveries, marketing or information sharing), infrastructures (networks communications), and technologies (service publishing, discovery, binding and composition) [1]. Service, as a critical object impenetrating every corner of SOE, is a hot research topic in many research domains. Software Engineering (SE), as a subject in engineering field, its researchers pay more attention to supporting advanced technologies for promoting service activities in SOE. In this paper, we draw the position in the research field of semantic service search, service evaluation and ranking in SOE.

The rest of this paper is organized as follows: first of all we attempt to explore the research motivations in this field by a case study, then by literature review, we will discover the issues in the field of semantic service search, service evaluation and ranking in SOE; next we will formally define the research issues in this field; and finally the conclusions are drawn in the end.

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2 Case Study for Studying the Motivations of Semantic Service Search and Service Evaluation, Ranking Research

In this section, by means of a case study, we will analyse the research motivations in the fields of semantic service search and service ranking.

As an example, let us assume that John lives in Perth (capital city of Western Australia) and desires a horse moving service provided by a local competitive company, in order to help him to move horses from Perth to City B. From the perspective of the internet services, there are two primary categories of service search engines that can be found by John.

The first category is generic search engines, such as Yahoo and Google. For example, John can enter "*horse moving companies in Perth*" into a generic search engine (here the example is Yahoo). From the retrieved results from the search engine (Fig. 1), it is observed that most of the retrieved results do not match John's search intention – horse moving companies in Perth, and the service information is difficult to be distinguished and identified from the results. Thus, it is asserted that the performance of the generic search engine is poor in this service search case study.

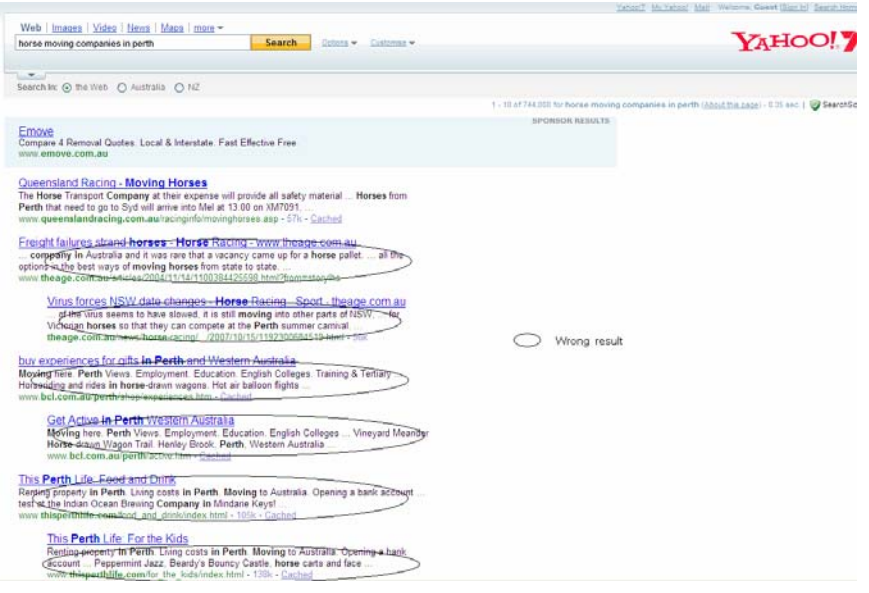

Fig. 1. Retrieved results of horse moving companies in Perth from Yahoo search engine

The reasons behind the poor performance of the search engine can be concluded as follows:

- The search engine uses traditional keywords-based search strategy without incorporating or taking into account semantic web technologies to assist the search engine to fully understand the sense of the user's query words. This causes the poor performance of the search engine in precision.

- The generic search engine is not specially designed for the purpose of service searching. As a result of this, the search process has to be carried out against a much larger information source. Due to this reason and due to the fact the search process is keyword-based the retrieved search results are not accurate and do not consider the context of the search query.
- The format of the retrieved service information is not standardized, which makes users difficult to read and comprehend the retrieved service information.

An enhanced approach is that John can access into a repository of local business directory, such as Yahoo or Google local search, online Yellowpages. These local search engines (here the example is Australian online Yellowpages) normally can provide John with two options of service search as follows:

- One option is that John can browse businesses under the "*horse transport*" category in the location "*Perth WA*", by following the "*browse by category*" (Fig. 2). This style can provide John with more precise search results and structured service information. The defect is that John needs to follow the whole category of the website step by step, which is expensive in terms of time and effort.

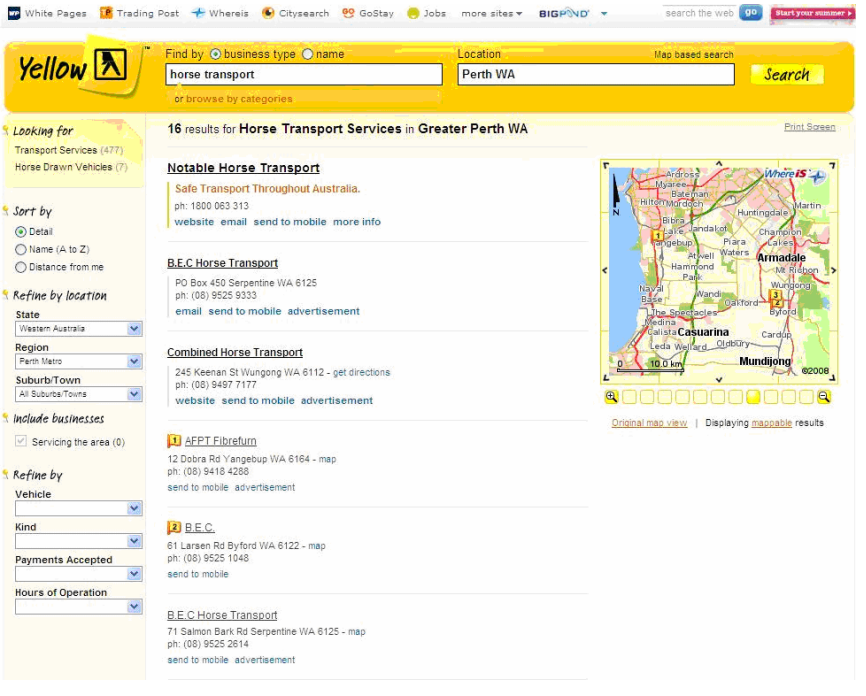

Fig. 2. Businesses under the category of "*horse transport*" in Australian Yellowpages website

- Another option is that John can directly enter "*horse moving*" into the business type box and "*Perth*" into the location box of the search engine provided by the website (Fig. 3). This can save its searching time, but this approach has its own disadvantages as well – the search engine cannot understand the user's query intention and thus returns non-relevant results. Similar to the generic search engines, the reason behind this is that the local search engine does not use semantic web technologies to help users to denote their searching concepts.

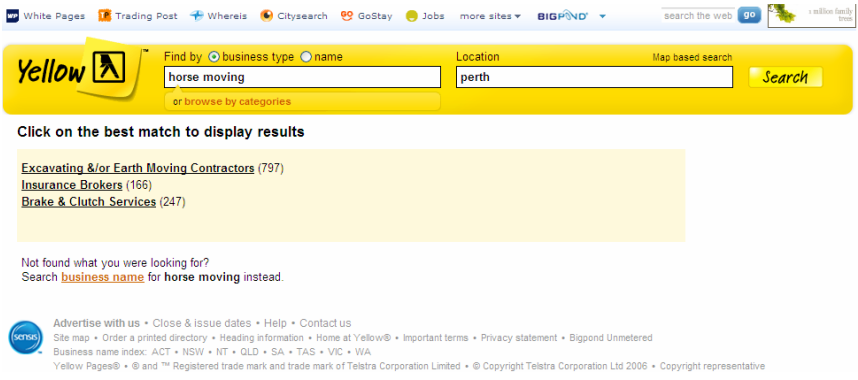

Fig. 3. Retrieved results from online Australian Yellowpages search engine based on query words "*horse moving*"

Apart from the lack of semantic web technologies' support, another limitation of the local service search engines is that John cannot find out which company has better performance from the perspective of horse moving service. The reason behind that is that these search engines do not provide user-oriented evaluation and ranking mechanisms based on the quality of services (QoS) provided by these services.

Based on the above case study, it is observed that both of the generic and local search engines are far from perfect, when searching for a given service. The research motivations in the field of semantic service search, service evaluation and ranking in the SOE environment can be concluded as follows:

- Designing multi-domains or domain-specific service search engines with semantic web technologies enhancing the search precision (and);
- Designing user-oriented evaluation and ranking methodologies for retrieved service information by means of the QoS measures.

In the next section, following the two research motivations, we will make a brief survey about the status of current research in this field.

3 Related Works

In the section, we briefly review the current literature with respect to semantic service search and service ranking and analyze their limitations.

3.1 Semantic Service Search

While there are a great number of semantic search engines being developed (e.g., SWoogle, TAP), few of them attempt to provide optimized solutions for the service search field.

Liu et al. [3] developed an e-service platform integrated with semantic search for e-service metadata. E-service metadata refers to the descriptions of e-services and providers, which is adopted to publish and to discover e-services. There are two types of metadata in the system: business level metadata – the description of e-service providers, and service level metadata – the description of basic information about e-service. The authors adopt Universal Description, Discovery and Integration (UDDI) which is a web service standard to register and search e-services. Three means for searching service and business are provided, which are find_business, find_service and XQuery. Find_business is to return a list of service providers for specific conditions; find_service is to return the information for a list of services who match customized conditions; XQuery is to query extended metadata added in a businessService list.

The limitations of the e-service search engine can be concluded as follows:

- Only one-tier (service categories-services) concept hierarchy cannot reflect the complex relationships between services in the SOE environment (and);
- There is no methodology provided for the concept hierarchy update in order to adapt for the change in service environment (and);
- The volume of its knowledge-base seems so limited that it only can be applied in limited fields (and);
- There is no ranking methodology provided for the querying results, which could lead to unorganized data structure and presentation to the user.

3.2 Service Evaluation and Ranking

While a large amount of literature focuses on evaluating quality of services (QoS), few of them study on the integration of service evaluation and service ranking system for service retrieval in the SOE.

Toma et al. [4] propose a web service ranking system based on two different ranking strategies. One strategy is to use the Web Service Modeling Ontology (WSMO) to describe the values of Non-Functional Properties (NFPs) of web services, such as QoS, Service Level Agreement (SLA). Hence web services can be ranked according to the values of user-preferred NFP. Another strategy is a multi-criteria ranking, which considers ranking multiple NFPs from three main perspectives – the user-preferred NFPs, the level of importance of the NFPs, and the ascending or descending order of services.

Gekas [2] propose a set of metrics for web service ranking. Four main categories of ranking strategies are provided by these metrics, which are degree-based rankings that calculate the percentage of fed services in each web service, hubs-authorities-based rankings that calculate the ratio between the number of incoming services and the number of outgoing services, non-functional rankings that focus on the NFPs of web service, and non-connectivity rankings that focus on the connectivity of web service networks.

The limitations of these service ranking systems can be concluded as follows:

- They are all designed for the web service environment, which cannot adapt to the broader and more complicated SOE (and);
- Despite they are all equipped with the QoS ranking methodology; none of them integrates their ranking systems with the corresponding QoS evaluation systems, which cannot ensure the correctness of the QoS data (and);
- None of them consider the factor of trustworthiness and reputation in the service ranking (and);
- None of them attempt to implement their service ranking methodologies into service search engines.

As can be clearly seen from the discussion above, research is being carried out independently in the fields of both of the semantic service search and ranking, without any attempt to integrate them together. In the next section, we define this issue formally.

4 Research Issues in Semantic Service Search, Service Evaluation and Ranking Field

In this paper, we combine our findings from the previous case study (Section 2) and our review of the existing literature (Section 3) and define the research issues in the semantic service search and service ranking field. The core research question is:

How to design a multi-domain or specific domain service search engines in SOE enhanced by semantic web technologies and QoS evaluation and ranking methodologies?

The potential research issues under this core research question are:

- For multi-domain or specific domain service search, multi-domain or specific domain service ontologies need to be designed according to the particular service domain knowledge in SOE.
- Multi-domain or specific domain service metadata format needs to be designed according to the service domain knowledge in SOE, in order to standardize service metadata.
- Conceptual frameworks of multi-agents needs to be designed to harvest service metadata from SOE according to the multi-domain or specific domain service ontologies and metadata formats.
- Multi-agent communication mechanisms need to be designed to improve harvest efficiency.
- Mechanisms needs to be designed for updating the knowledge-bases that store the multi-domain or specific domain service ontologies, in order to allow the ontologies to adapt to the dynamic change of knowledge in all service domains of SOE.
- Search algorithms need to be designed based on the multi-domain and specific domain service ontologies, in order to realize the enhancement from multiple perspectives of search engine performance.

- The conceptual framework of QoS evaluation and ranking methodologies needs to be redesigned or selected from the existing methodologies.
- Domain-specific service quality evaluation standards need to be designed according to the specific service domain knowledge in SOE.
- Mechanisms need to be designed for updating the domain-specific service quality evaluation standards, in order to allow the standards to adapt to the dynamic change of knowledge in the service domains of SOE.
- A conceptual framework for integrating the ontology-based search engines and QoS evaluation and ranking methodologies needs to be designed.

5 Conclusions

In this paper, we propose that further research needs to be carried out in the field of semantic service search and ranking in SOE. First of all, by a case study, we discuss the problems of the current generic and local search engines in the process of fulfilling users' requirements with respect to precise service search, service information standardization, service evaluation and ranking based on QoS, and so on. Based on the problems, we find the research motivations in this field. Next, by exploring the relevant literature in this field, we found that currently there is no literature on integrating the fields of semantic service search, service evaluation and service ranking based on QoS measures. Thus, we define the core research question in this field – "*how to design a multi-domain or specific domain service search engines in SOE enhanced by semantic web technologies and QoS evaluation and ranking methodologies?*". In addition, the core research question underpins ten research issues, which we have explained in Section 4.

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