

©2008 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.

Developing a Conceptual Framework of Semantic Search Engine to Promote the Collaborations between SMEs in the Digital Ecosystems Environment

Hai Dong¹, Farookh Khadeer Hussain², Elizabeth Chang³

¹Hai Dong, DEBII, Curtin University of Technology, Perth, Australia, e-mail: hai.dong@cbs.curtin.edu.au

^{2,3}Farookh Khadeer Hussain and Elizabeth Chang, DEBII, Curtin University of Technology, Perth, Australia
e-mail: (farookh.hussain, elizabeth.chang)@cbs.curtin.edu.au

Abstract—The research with regards to digital ecosystems emerged in the end of last century, and has developed in this century. Due to its immaturity, some fields within it are deemed to be blank. This research proposes to fill one of the blanks in the digital ecosystems research. By analyzing the issues in the current research, we propose to develop a semantic search engine, with the purpose of querying services provided by SMEs. The objective of this research is to build a reliable and trustworthy link between SMEs in the digital ecosystems environment. Relevant research methods and steps are discussed in this paper.

Index Terms—digital ecosystems, semantic search engine, SMEs.

I. INTRODUCTION

Within the digital ecosystems (DE), species can play dual roles – service providers (servers) who provide services, and service requesters (clients) who need services. However, current literature does not indicate that there is technical support to assist and to guide service providers and service requesters to form a reliable and trustworthy link with each other. In addition, existing semantic search engines appear to be problematic in many aspects. Based on these issues, an innovative semantic search engine with the purpose of querying services in the digital ecosystems environment is proposed.

In order to realize this objective, literature with regards to services in digital ecosystems and semantic web technologies will be reviewed. A proper research approach will be selected among existing paradigms. Based on the theory of the chosen research approach, a four-stage research process is designed. Meanwhile, a draft of the conceptual model design workflow is presented, which contains six basic phases including distinctive design objectives in each phase.

II. LITERATURE REVIEW

Digital ecosystem (DE) is defined as “an open, loosely coupled, domain clustered, demand-driven, self-organizing and agent-based environment, which each species is proactive and responsive for its own benefit and profit” [2] [3], which is a neoteric terminology and its appearance is as a result of the natural existence of business ecosystem, along with the evolution of business network and information technology. The goal of DE is to improve the efficiency of the communication between internal agents and to structuralize the existing business ecosystem [7]. The contemporary DE researches focus on theoretical study and application

development [4].

DE is composed of two basic elements: species and environments [3]. Species are mainly categorized into three types: biological species, economic species and digital species. Species play two different roles in digital ecosystems, which are service requester (client) that needs services and service provider (server) that provides services.

Small and medium enterprises (SMEs) are the major targets which DE serves [3]. SMEs are regarded as the major power promoting the economic growth of the world [1]. SMEs urgently need collaboration other than competition with the assistance of ICT. This owes to their features of fragility, small size and the lack of capability, power and speed [2]. However, the cost of current ICT support is beyond the affordability of SMEs, which is one of the reasons why DE has emerged.

DE comprises heterogeneous and distributed species [3]. These species are distributed over the existing network infrastructures. Currently available services are less semantic in the network. There is no quality-of-service information available in the network. Thus, it is not possible for a given service requester to know all the other service providers based on a service request. That is the reason why we plan to design to semantic search engine to build a reliable and trustworthy link between service providers and service requesters in the DE environment.

III. EXISTING ISSUES

The issues/problems in the current DE research are:

There is no literature to provide technological support for building reliable and trustworthy links between service providers and service requesters in the context of DE environment, while there is a strong need that a platform is requested for querying desired services in order to be able to form a link between them.

There is no specific platform available for SMEs to publish their services.

There is no specific search engine available for querying services provided by service providers (SMEs).

The service information in the current DE network is less semantic, limited, unreliable and untrustworthy [3].

IV. RESEARCH OBJECTIVES

The following primary and secondary research objectives will be addressed in the study.

A. Primary research objective

The primary research objective in this study is:

“This research proposes to design a semantic service search engine for the DE environment, with the purpose of facilitating a reliable and trustworthy association or relationship between service providers and service requesters.”

B. Secondary research objectives

The following secondary objectives will be included in the study:

This research aims to design a semantic search engine to retrieve the services requested by a given service requester with high precision and proper recall, to promote the collaboration within DE.

This research aims to design a platform to allow small and medium enterprises (SMEs) to publish services in a specific DE domain.

This research aims to design a mechanism to allow users to momentarily customize the knowledge structure in the proposed search engine, in order to adapt to the change of users and domain experts' requirements and environment.

This research aims to facilitate the process of forming associations and relationships between service providers and service requesters in the DE-based environment on the concept of trust and reputation.

V. RESEARCH SIGNIFICANCE

This study will focus on the theory of semantic web technologies and DE as well as the development of the semantic search engine. The contributions of this research will be categorized to theoretical aspect and potential commercial aspect.

A. Theoretical research significance

The contributions of this study in theoretical perspective are discussed as below.

The service knowledge in a specific DE domain will be conceptualized, structuralized and systemized.

This research will provide an interactive platform allowing users to customize the service knowledge structure on their demand.

A policy is designed to keep the impartiality and uniformity of the domain-specific service knowledge structure based on the voting result of all participants (domain experts and users).

This research will create a unique semantic search engine to query services in a specific DE domain.

The semantic search schema involves innovative interactive search processes and search interfaces to guide service requesters forward to their query objectives.

An original mechanism is involved in this research, which allows users to evaluate the reputation of service providers according to the domain-specific criteria.

One of the semantic search engine's functions is allowing users to rank service providers in a service category, according to the evaluation values towards the provided service in different criteria or the service providers' reputation.

This research will design a platform allowing users to

customize the criteria of evaluation.

B. Potentially commercial significance

The potential contributions of the study in commercial field are concluded as below.

The outcome of this research will provide SMEs with great convenience to publish their services.

By means of utilizing the semantic search engine as a marketing tool, SMEs could gain direct and obvious benefit from the publication of their services.

By evaluating and ranking the reputation values of service providers, the outcome of this research will inspire SMEs to improve their competitive abilities.

By building the trustworthiness and reputation evaluation system for service providers, service requesters can gain confidence and make trust-based decisions regarding interactions.

The outcome of this research will bring forward significant advantages of the DE, which could inspire more SMEs to join and thus benefit the spread of DE technologies.

This research will provide a platform to promote the collaborations between SMEs. All species or organisms in the DE environment can obtain mutual benefits by means of the platform proposed in this study.

VI. RESEARCH METHOD

The research will employ a non-empirical research method – design research, which aims to create innovations to solve issues/problems [8]. The innovations base on the application, extension, modification or test of existing kernel theories [6].

Design research contains three levels: in the first level namely conceptual level, the new ideas and concepts are generated by means of analysis; in the second level namely perceptual level, the new ideas are implemented by means of specific tools, environment or systems, which generates a new method or approach; in the final level namely practical level, the new method or approach is tested and validated by the experimentation with real world examples, using laboratory or field testing [5]

Based on the three research levels, we design a 4-stage research process. The four research phases are discussed in detail as below.

A. Preliminary literature review (conceptual level)

The aim of this stage is to analyse existing semantic web technologies towards the proposed customized semantic service search engine in the environment of DE, by means of literal research. This stage paves the way for the next stage and the perceptual level research, which comprises three steps as follows.

Step 1 – Researching services in DE environment

This part of literature review focuses on the current state of relationship between service providers (SMEs) and service requesters in the Australian business environment to gain an understanding of main activities or issues in the service transactions. However, since this research mostly concentrates on technical perspective, this step will not be a

main task.

Step 2 – Researching semantic web technologies

This part of literature review focuses on the existing semantic web technologies used in semantic search engines, semantic crawlers, ontology-based knowledgebases, meta-data design, customized ontology structure, reputation evaluation systems and voting systems.

Step 3 – Proposing research methodologies in detail

In this step, by means of literature review, a detailed research methodology will be drawn based on the design research method.

B. Conceptual model design (conceptual level)

The aim of this stage is to design the conceptual model of the proposed semantic service search engine, by means of referring to the knowledge accumulated in the first stage. In this stage, the roles of species, formal definition of DE and the service domain will be clarified. It comprises two steps as follows.

Step 1 – Proposing conceptual model design workflow

Based on the understanding of services in DE environment and semantic web technologies through the literature review, this research begins with an analysis of which functionalities or components of a semantic service search engine in DE environment will have. In this step, the process of the semantic search engine's conceptual framework design will be drawn. Fig.1 is the draft of the design process, which involves six primary phases as below:

Service concept hierarchy design phase – the concept of service in DE environment and the hierarchy of service concepts in a specific domain will be defined by ontology.

Service metadata crawling design phase – the conceptual model of a crawler will be designed to extract and to convert the service information on webpages to metadata.

Service metadata and service concepts association design phase – a semi-automatic association mechanism that links the service metadata in Phase 2 with the service concepts in Phase 1 will be designed by combining a semantic matching algorithm and a customized association process.

Service concept hierarchy customization design phase – a voting policy for service concept hierarchy change will be projected in this phase.

Semantic service search engine design phase – the conceptual framework of the search engine will be defined, including a semantic search algorithm and a semantic ranking algorithm.

Service providers' reputation evaluation design phase – a mechanism that allows service requesters to evaluate service providers' reputation values will be proposed in this phase.

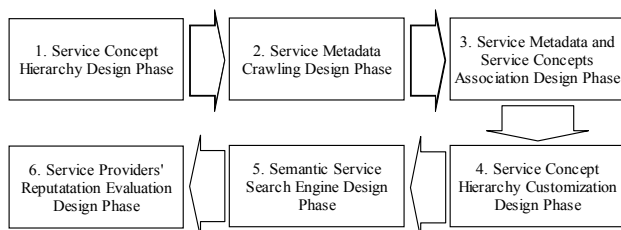


Fig.1 Draft of the conceptual model design workflow

Step 2 – Conceptual model design

This section is to select both existing and additional architectural patterns and styles that induce identified properties, and combine them to form a new semantic service search engine architecture pattern/style based on the proposed design process in the last step.

C. Prototype implementation (perceptual level)

The aim of this stage is to design and build the semantic service search engine system through implementation in order to formulate the newly proposed architecture.

In correspondence with the conceptual model, the six components involved will be implemented one by one. First of all, the service ontology and service concept hierarchy ontology will be constructed by Protégé-owl. Then, semantic crawler program will be coded in Java. The semantic crawler will extract the service information of SMEs from Yellow Pages® website, and then add owl tags to create service metadata. A semantic matching model will be designed to match the service metadata with the most appropriate service concepts in the service concept hierarchy ontology. In addition, an online interface will be designed by web page design software to assist users to customize the links. Fourth, a voting policy and corresponding online interface will be developed in order to assist users to customize the service concept hierarchy ontology. Fifth, an online semantic search engine interface will be designed by the combination of use of Java, web languages and online thesaurus. Finally, an online platform is designed by the use of web languages and database technologies, with the purpose of allowing users to evaluate the reputation values of the retrieved service providers, and to rank them according to the criteria of reputation. A corresponding online interface is designed to help users to change the criteria.

The functions of the proposed prototype are:

The proposed semantic search engine will include a service concept hierarchy in the specific DE domain.

A semantic crawler program is designed, which can extract SMEs' service information from web pages (e.g. Yellow Pages®) and semanticize them into metadata. In addition, the crawler can automatically match the metadata with the service concepts in the hierarchy.

A user interface is proposed to allow service providers to manually edit their service metadata and link the metadata to the relevant concepts.

A voting interface is designed in order to allow users to vote for the change of the service concept hierarchy and the criteria for service providers' reputation evaluation.

An online semantic search engine is designed by providing a keyword-based search interface and multiple choices-like search processes. Moreover, query results can be ranked according to their reputation values and single criterion values.

An evaluation interfaces is provided to allow service requesters to evaluate service providers' reputation after transactions, according to the domain-specific criteria.

The implementation stage comprises two steps as follows.

Step 1 – Initializing programming environment

Before starting the systems design and coding, in this

research, it will need to initialize the programming environment including install: (1) Windows XP Professional; (2) Protégé-owl; (3) Adobe Dreamweaver CS3; (4) MS Visual Studio 2008; (5) MS SQL Server 2005.

Step 2 – Coding

Coding is the expression of algorithm design. In this research, it will use programming language Java and OWL as the development environment.

D. Test and validation (practical level)

The aim of this stage is to carry out testing and validation through using field-testing. The test and validating stage comprises three steps as follows.

Step 1 – Test and debugging

Testing and debugging should be regarded as one of most important steps in this research. Testing mainly focuses on whether or not the program works properly. Due to the time limitation of this research, testing could not be a main task, but it does process steps like review of users' requirements, error checking and program maintenance.

Step 2 – Validation

The application of semantic service search engine with DE environment might be a rather longer process than just validation. Considering the time limitation of the research, validation could not be a main task. However, the semantic service search engine will be deployed and the results will be captured to validate the effectiveness and the efficiency of the prototype.

Five sub-steps are involved in this level. First of all, the crawler program will be run in the online Yellow Pages® website to extract service information, and then the extracted data will be converted into metadata which will be stored into a database. Moreover, the crawler will automatically match the metadata with the concepts built in Protégé-OWL. Secondly, towards each concept and its associated metadata, an instantiated query will be executed. Thirdly, each query result will be analyzed with the supposed result by means of comparison, in order to measure each query's precision and recall. Fourthly, all the recall and precision values are averaged to count the overall performance of the semantic search engine. By comparing with the two parameters in

other semantic search engines, the prototype is tested and validated.

Step 3 – Analysis and documentation writing

In this step, the research will focus on analysing findings, issues, lessons and possible further research topic and writing final documentation. Modelling specification, assumption, design process, source code and other relevant information will be involved in the research document.

VII. CONCLUSION

This study is to design a semantic search engine for service requesters to query services offered by service providers in the DE environment. By analyzing the issues in the current DE research, we decide the objective of this research, which is to build a reliable and trustworthy link between service providers and service requesters. This study will bring theoretical efforts to the research field and potential business values to the commercial field. In correspondence with the objective, we propose a research method and corresponding research steps.

VIII. REFERENCES

- [1] "The Digital Ecosystems Research Vision: 2010 and Beyond," Creative Commons, Stanford 2005.
- [2] E. Chang, M. Quaddus, and R. Ramaseshan, "The vision of DEBI Institute: digital ecosystems and business intelligence: Digital Ecosystem and Business Intelligence Institute," DEBI, Perth 2006.
- [3] E. Chang and M. West, "Digital Ecosystem - A next generation of the collaborative environment," in *iiWAS2006*, Yogyakarta, 2006.
- [4] P. Dini, "Structure and outlook of digital ecosystem research," in *IEEE DEST 2007*, Cairns, 2007.
- [5] R. Galliers, "Choosing appropriate information systems research approaches: a revised taxonomy," in *Information Systems Research: Contemporary Approaches and Emergent Traditions*, H.-E. Nissen, H. K. Klein, and R. Hirschheim, Eds. North-Holland: Elsevier Science Publishers B.V., 1991.
- [6] A. R. Hevner, S. T. March, J. Park, and S. Ram, "Design science in information systems research," *MIS Quarterly*, vol. 28, pp. 75-105, 2004.
- [7] F. Nachira, "Innovation Ecosystem: una strategia europea l'innovazione e lo sviluppo economico per," Creative Commons 2006.
- [8] J. Venable, "Research methods overview," in *Research Methods for Information Systems Professional 655 Lecture Notes*, Perth: Curtin University of Technology, 2005, pp. 17-17.