Trends of Semantic Web Services and Technologies : Focusing on the Business Support

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During the decades, considerable human interventions to comprehend the web information were increased continually. The successful expansion of the web services made it more complex and required more contributions of the users.Many researchers have tried to improve the comprehension ability of computers in supporting an intelligent web service. One reasonable approach is enriching the information with machine understandable semantics. They applied ontology design, intelligent reasoning and other logical representation schemes to design an infrastructure of the semantic web. For the features, the semantic web is considered as an intelligent access to understanding, transforming, storing, retrieving, and processing the information gathered from heterogeneous, distributed web resources. The goal of this study is firstly to explore the problems that restrict the applications of web services and the basic concepts, languages, and tools of the semantic web. Then we highlight some of the researches, solutions, and projects that have attempted to combine the semantic web and business support, and find out the pros and cons of the approaches. Through the study, we were able to know that the semantic web technology is trying to offer a new and higher level of web service to the online users. The services are overcoming the limitations of traditional web technologies/services. In traditional web services, too much human interventions were needed to seek and interpret the information. The semantic web service, however, is based on machine-understandable semantics and knowledge representation. Therefore, most of information processing activities will be executed by computers. The main elements required to develop a semantic web-based business support are business logics, ontologies, ontology languages, intelligent agents, applications, and etc. In using/managing the infrastructure of the semantic web services, software developers, service consumers, and service providers are the main representatives. Some researchers integrated those technologies, languages, tools, mechanisms, and applications into a semantic web services framework. Therefore, future directions of the semantic web-based business support should be start over from the infrastructure.

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1. Introduction

Internet and Web-based digital revolution is having innovative effects on global business (Turban, et al., 2009). The core contribution of the Internet andweb could be attributed to its ability to publishing information on a global network. With the advantage, the web service providers could present an easy way to access to various components available via the Internet. It has drastically improved the availability of electronic information, as well as the way to interact with consumers and partners. Therefore, business transactions over the web are rapidly increasing, and are allowing the users to reach the information of product/service across a global market (Trastour et al., 2003).

The more information has been published on the web, however, the more human interventions we need to find, access, and understand. The most of consumers consider the interventions as a time-consuming big burden. For these reasons, as the web grows in both size and diversity, there is an increased need to automate the web services (García-Sánchez et al., 2009). This is because most of contents presented on the web are primarily shown in a natural language form and machine could not understand it. Therefore, a wide gap has emerged between the information machine executable and the information human readable (Ding et al., 2002). The gap may be considered as a tackling point to overcome for intelligent transactions in e-business.

To narrow the gap, XML-based a new gen-eration of electronic data interchange protocols (OASIS, BizTalk and RosettaNet) was proposed (Trastour et al., 2003). Then the semantic web was proposed and it enabled the users to access the web resources through semantic contents rather than the keywords (Berners-Lee et al., 2001). Before the emergence of the semantic web, users had to find the appropriate information just using some of keywords and/or terms from the data repository published on the web (García-Sánchez et al., 2009). The basic concept of the semantic web is on enriching the information (semantics) with flexible knowledge representation feature, to allow inference over the web contents. On the semantic web, therefore, we can reduce our burdens by using a set of 'machine-understandable' or 'machine-operable' semantics. To accelerate the development of the semantic web, the World Wide Web Consortium (W3C) is proposing a series of guidelines, standards, web ontology, and other resources. Its goals include the production of Internet-scale inference mechanisms, knowledge markup languages, and intelligent information intensive operations over the web (Trastour et al., 2003).

2. Semantic Web Technologies and Semantic Web Services
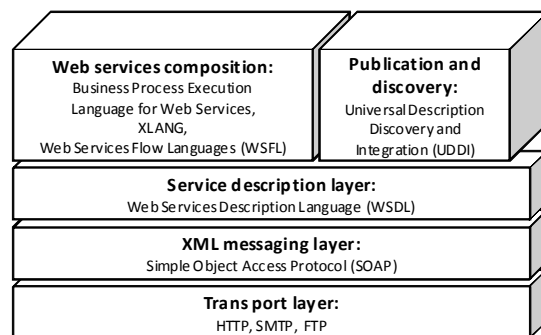
2.1 Web Services Technologies

Web serviceis a phrase used to describe the way and/or architecture in which assembled services can be presented and used on a network.

Remarkable growth of the World Wide Web (WWW) led us into a common framework for the web services. In perspective of messaging andinformation distribution infrastructure, the framework includes the basic protocols (TCP and HTTP) and the markup languages (HTML, XML, VRML, DAML, OIL, OWL, etc). On the framework, the web services can communicate with other services (Muschamp, 2004, Turban et al., 2009). The major technologies supporting the current web services include eXtensible Markup Language (XML), Simple Object Access Protocol (SOAP), Universal Description, Discovery and Integration (UDDI), and Web Services Description Language (WSDL) (Turban et al., 2008).

Davies et al. (2004) classified these technologies into three principal building blocks. The first block is an XML Messaging Capability. Then the second block is a Service Description Capability, and the third one is Service Registration Capability. Where, XML was a logical starting point for platform-independent content descriptions and it was regarded as a standard for exchanging structured data on the web (Davies et al., 2004; Muschamp, 2004).

SOAP is a XML-based standardized message-passing protocol for exchanging information in a decentralized, distributed environment using typed message exchange and remote invocation. Then the WSDL is an XML format for describing network services based on a standard messaging layer such asSOAP. WSDL was also presented as a merged specification incorporate with information specification, service description,

and contract. UDDI defines a set of services supporting the description and discovery of business, organizations, and other web services providers (Aalst, 2003; Muschamp, 2004). <Figure 1> shows the relation between web services composition languages and other standards such as SOAP, WSDL, and UDDI.

<Figure 1> Overview of web services technologies (Aalst, 2003)

However, in spite of thecapabilities of the major web technologies proposed by Davies et al. (2004), there were limitations. For example, UDDI do not provide a rich enough description of a web service. Generally, after the searching of the UDDI registry, users can look around a large number of candidate services. In those cases, users may require a more detailed selection for precise information. However, it is very difficult to return the most relevant information to them with using the traditional web search engine. In addition, even though WSDL could describe the input/output format of a web service, it has not crucial effects on the web services execution and business process. We can assume

that it comes from the lack of an explicit semantics (Davies et al., 2004).

To overcome these limitations, we desired a richer description infrastructure of the web services. In response to this requirement, Tim Berners-Lee referred to the future of the web as the 'semantic web'–a second generation of the web (Berners-Lee et al., 2001). It is essential of machine-readable information and automated web services (Ding et al., 2002).

2.2 Semantic Web and Ontology Representation

The purpose of the semantic web is adding semantics to the data published on the web and it is based on XML (Berners-Lee et al., 2001; Davies et al., 2004). Therefore, it is considered as an extension of the current web. The semantic web documents are annotated with meta-information along with human-readable information, so that computers are able to cooperate with the data in a similar process humans do (Davies et al., 2004; García-Sánchez et al., 2009). Software agents supporting the web services can understand and process the information (Benjamins, 2003). To define the information, a meta- language was required which isdifferent with traditional markup languages (Davies et al., 2004). In other words, there was a need for a new description language which can express the machine-understandable semantics (Davies et al., 2004).

An important requirement for the machine readable web document is formalizing the struc-ture of data (Ding et al., 2002). For this, ontology is the backbone technology in producing semantic web information (García-Sánchez et al., 2009). They blend machine-understandable semantics with real world semantics understandable to humans (Ding et al., 2002). Knowledge representation languages, markup languages, resource description languages and other ontology design tools were used with this purpose. In this section, the languages and supporting tools are introduced.

2.2.1 Ontology

Ontology is originated from philosophy and it is regarded as the most important technology to express the semantics in a way precise enough for humans and machines to understand it (Izza et al., 2008). Since the early 1990s, in the fiel-dof artificial intelligence (AI), it has become an interesting research topic to facilitate knowledge sharing and re-use (Ding et al., 2002). Among many definitions of ontology, the widely used one clearly identifying the concept of ontology is "a formal, explicit specification of a shard conceptualization (Gruber, 1995)" (Ding et al., 2002). Where, the term Formal refers to the fact that the ontology should be understandable to computers and there are different levels of formality. Second, Explicit means that the type of concepts used in ontology and the constraints should be explicitly defined before their use. Third, the term Shared reveals an idea that the ontology generally captures common knowledge

that is no restricted to some individuals, but accepted by at least a group or a community. Fourth, the Conceptualization refers to an abstract model identifying the relevant concepts of some phenomenon occurred in the real world (Gruber, 1995; Ding et al., 2002; Izza et al., 2008).

With the concept, since 1990s, ontology became a relevant systematic approach to explain shared beings and was used in several applications such as Knowledge Engineering (KE), Natural Language Processing (NLP), AI, Intelligent Information Integration, Cooperative Information Systems, Information Retrieval, Electronic Commerce (EC), Knowledge Management (KM), and Web community (Ding et al., 2002; Izza et al., 2008).

Ontology is composed of five main components Concepts, Relations, Functions, Axioms and Instances (Gruber, 1995). AConcept means a set of entities within a specific domain. Then the Relations represent the interaction between concepts of the domain. Functions mean and/or formalize specific relations in which the nth element of the relationship is unique for the n-1 preceding elements. Axioms are declarations that allow defining constraints among concepts and relations. Instances represent specific elements of concepts (Gruber, 1995; Izza et al., 2008). <Figure 2> shows the relationships among ontology, applications, context, devices and services in ubiquitous computing environment.

From the left, an Application states its requirements in terms of Concepts and the Ontology is organized by those concepts. Then the

Classifiers analyze the context (services and devices) and store the result of classification in a Catalogue. The Catalogue is used to associate concepts with services during concept instantiation.
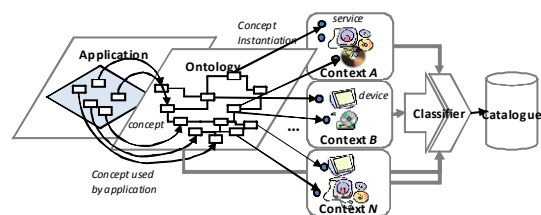
<Figure 2> The relationships among ontology, devices, and services(Schubiger-Banz et al., 2002)

2.2.2 KIF

Knowledge Interchange Format (KIF) is one of knowledge representation approaches designed with the goal of graphically and/or textually representing knowledge. These approaches include Concept Map (CM), Semantic Networks, Conceptual Graphs (CGs), KIF, the Common Logic (CL) Standard Initiative, Unified Modeling Language (UML), and Object-Process Methodology (OPM) (Dori, 2004). KIF is a computer-oriented language designed for the interchange of knowledge among disparate computer application/ systems. Therefore, it was known as one of the first knowledge representation languages (Stanford Logic Group, 1998; Ribiere and Charlton, 2002). Even though KIF could be also used for the interaction with human users, it was not concentrated on it. It attempted to interact with other computer systems and applications. Therefore,

distributed computer applications could interact with their users without concerns for the forms of knowledge used in their applications such as Prolog, Conceptual Graph (CG), Natural Language (NL), and etc (Ribiere and Charlton, 2002). KIF has four essential features as follows.

First, KIF has declarative semantics. With the semantics, it can understand the meaning of expressions in the language without interpreters such as Prolog and Emycin. Second, KIF is logically comprehensive. Therefore, it is feasible in expression of arbitrary logical sentences. However, it differs from relation database languages and logic programming languages such as Structure Query Language (SQL) and Prolog. Third, KIF provides a formatfor the representation of knowledge about knowledge. With the format, KIF allows the users to make knowledge representation decisions clear and allows the users to establish new knowledge representation without changing the language (Stanford Logic Group, 1998).

2.2.3 XML

The extensible markup language (XML) is a meta-language developed by the XML working group of the W3C and it was derived from Standard General Markup Language (SGML). Therefore, XML is regarded as a mechanism for standardized representation of other languages. It allows the users to define their own (application-specific) markup tags, attributes, data structure, and extract data from documents (Ribiere and Charlton, 2002). A document type definition (DTD) or an XML Schema might be used to specify the vocabulary and to define the combinations of tags (Ding et al., 2002). The advantages of XML are as follows (Ribiere and Charlton, 2002) :

Extensible: Users can define any languages by just defining a distinguishing DTD.

Simple : Users can understand the meaning of XML documents and create it without a specific difficulty.

Separation of syntax and semantics: XML allows the users to define the rules for well-structured documents and the semantics depend on the application that processes the document.

Separation of content and presentation: XML gives users a way to define application-specific markup tags. However, it does not imply the way of visualizing the information. It means the possibility of applying different visual presentations to the same XML document.

Distribute knowledge over WWW: Fundamentally, the information represented by XML can be embedded in web documents. Therefore, it can be used to represent distributed knowledge across the web.

While XML is feasible to define all kinds of data structures in an unambiguous syntax, it does not state the use of data and their semantics. On an XML document, the meaning of a piece of it may seem clear to humans. For example, the user-defined tag <author>Jin </author> shows an obvious meaning that 'The author is Jin'. However, it does not mean the use of data or formal interpretation. The XML document just forms a labeled, ordered tree with named entities,

sub-entities and its values. It is both XML's strength and its weakness (Ding et al., 2002). Even though XML is useful for data exchanging and formalizing the structure of web documents, it states nothing about semantics and its use (Davies et al., 2004).

2.2.4 RDF and RDF Schema

XML was designed to structure data, but the resource description framework (RDF) was designed to tell something about the data. The RDF data model is simple and encoded as Object-Attribute (Property)-Value (OAV) triple, written as A(O, V) or P(O, V) (Broekstra and Kampman, 2001; Davies et al., 2004; Ding et al., 2002). It means that an object O has an attribute A with value V. Another way to describe the relationship is as follow : [O]‒A -> [V] (Broekstra and Kampman, 2001). For example, the object Vehicle1 could have property Color with value Green just as follows.

Color (Vehicle1, Green)

The data represented by RDF is called 'meta data'. With Statement, Resources, and Properties, RDF gives a specific meaning to something on the web. The Statement in RDF describes Resources such as web pages and object. Resources and Properties are described with RDF Schema (RDFS) (Ribiere and Charlton, 2002).

RDFS extended RDF by adding modeling primitives such as Classes, Class inheritance, Property inheritance, Domain, and Range restrictions (Ribiere and Charlton, 2002). The RDFS describes how to use RDF to build RDF voca-

bularies. Therefore, RDFS is regarded as a mechanism that helps the web service developers to define a particular vocabulary for RDF data and specify the kinds of objects to which there attributes can be applied (Broekstra and Kampman, 2001). However, RDF is not a language but a model for representing data (Alesso and Smith, 2005; Ding et al., 2002). The specification of RDF syntax and the RDFS build upon existing web standard XML and XML Schema (Alesso and Smith, 2005).

The advantage of RDF is the use of XML Namespace and Uniform Resource Identifier (URI) to identify entities. It helps in sharing knowledge (ontology) through the web and reuse knowledge to define other knowledge (Ribiere and Charlton, 2002). The following example shows the header of RDF file describing the RDF and RDFS namespaces.

```
<?xml version="1.0" encoding="utf-8"?>
<rdf:RDF xml:lang="en"
xmlns:rdf                            =
"http://www.w3.org/1999/02/22-rdf.syntax-ns#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-sche
ma#"

...
</rdf : RDF>
```

2.2.5 Web Ontology Language(OWL)

If web users want to compare/match conceptual information across the distributed knowledge bases on the web, ontology should support the process. To compare the information on the web, ontology has a general mechanism to dis-

cover common meaning (Alesso and Smith, 2005). Originally, OWL is based on description logics, which is a subset of First-Order Logic (FOL) that provides sound and decidable reasoning support. FOL is used in mathematics, philosophy, linguistics, robotics, and computer sciences. OWL allows specifying a terminological hierarchy using restricted set of first-order formulas (Hsu, 2009). Therefore, OWL facilitates greater machine readability of web content than that supported by XML, RDF, and RDFS (Alesso and Smith, 2005). The W3C OWL recommendation consists of three languages : OWL Lite, OWL Description Logic (DL), and OWL Full. Where, OWL Lite is a subset of OWL DL, which is a subset of OWL Full. OWL Full extended RDF and RDFS to a full ontology language (Hsu, 2009).

Basically, ontology includes four concepts: Classes, Relationships (between classes), Properties (of classes), and Constraints (on relationships). With the concept, OWL document identifies the following information: Class definition, Class hierarchy, Synonym, Class association, and Property metadata (Alesso and Smith, 2005). In addition, OWL supports the development of multiple-layered ontology (Hsu, 2009).

2.3 Semantic Web Services(SWS)

During decades, the Internet and web has been conceived as distribution channels of information. Then the web service can be defined as a service located at some point on the Internet that can be accessed through standard Internet communication protocols (Booth et al., 2004). Where,

the web services connect computers (users) and the other devices using the Internet for exchanging and integrating data (García-Sánchez et al., 2009).

Semantic web service is regarded as a combination of two other technologies semantic web and web services. Therefore, it takes advantages of these two technologies and can also improve them in order to develop absorbing new applications (García-Sánchez et al., 2009). SWS consist in describing web services with semantic content so that automated service discovery, composition, invocation, and monitoring can be done automatically by computers/intelligent agents (Davies et al., 2004; García-Sánchez et al., 2009). With regard to web services interoperation and composition, the use of semantic web technology in expressing web services provide the possibility of an automated way to achieve a specific user requirement (Davies et al., 2004). <Figure 3> shows the evolution of the web from the primary web to semantic web service (Davies et al., 2004; García-Sánchez et al., 2009).
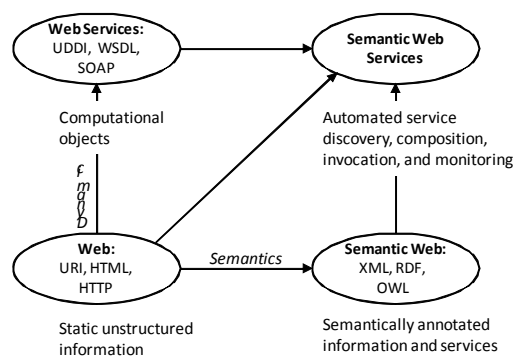
<Figure 3> The Evolution of the web
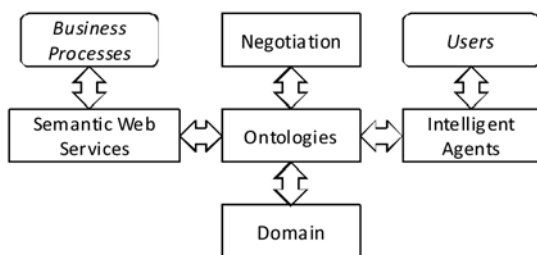(García-Sánchez et al., 2009)

W3C is currently examining various approaches with the purpose of reaching a standard for the SWS technology : Web Ontology language for Services (OWL-S), Web Service Modeling Ontology (WSMO), Semantic Web Service Framework (SWSF), WSDL-S, and Semantic Annotation for WSDL (SAWSDL) (García-Sánchez et al., 2009).

3. Semantic Web-Based Business Support

3.1 Business Support Framework

3.1.1 Ontology-Based Semantic Web Services

García-Sánchez et al.(2009) supposed the foundation of ontology-centered semantic web services (SWS). <Figure 4> shows the ontology-centered approach in SWS.

<Figure 4> Ontology-centered approach (García-Sánchez et al., 2009)

In the above approach, the SWS include the Business Processes and interaction between Human Users and Intelligent Agents (IA) (García-Sánchez et al., 2009).

First, in <Figure 4>, the ontology operates as the 'glue' that binds together the other components.

Second, the ontology acts as universal vocabularies so that web services and intelligent agents can share the knowledge.

Third, therefore, the ontology is useful to semantically describe web service capabilities and processes. The semantic descriptions can then be automatically processed by software entities, so that web service Discovery, Composition, Selection, Execution and Monitoring can be done without user's participation.

Fourth, in the above approach, the negotiation processes between agents may take place in accordance with protocols represented in the ontology.

García-Sánchez et al.(2009), also proposed a multi-tier framework for SWS. The framework is composed of four layers such as Business Logic Layer, Semantic Web Service Layer, Intelligent Agents layer, and Application Layer. <Figure 5> shows the framework.
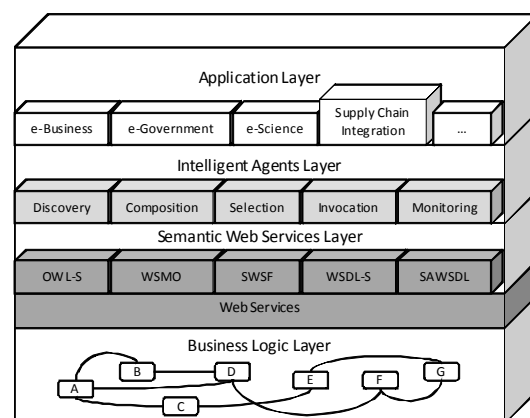
<Figure 5> Multi-layered infrastructure (García-Sánchez et al., 2009)

The Business Logic Layer provides the specific operations. It includes the internal and private business processes. Therefore, a set of web services can be implemented on the business processes.

The public services with the semantic descriptionlay on the Semantic Web Services Layer. The intelligent agents (IAs) are located in the Intelligent Agents Layer and interact with each other. Finally, the Application Layer is responsible for organizing agents to actually perform useful activities for the users (García-Sánchez et al., 2009).

3.1.2 DAML-S

DAML-S is an RDF-based language which defines ontology through a set of basic classes and properties. Especially, DAML-S provides the required semantics to enable Semantic Web Services (SWS). For this reason, it provides an upper ontology for SWS. Where, an upper ontology is limited to concepts that are generic or abstract, and are general to address a broad domain. More specific concepts are not included in upper ontology. The DAML-S ontology for web services has a resource and three key classes as follows (Davies et al., 2004).

ServiceProfile: Advertising and discovering services by describing the functionalities.

ServiceModel : Gives a detailed description of a service operation

ServiceGrounding : Provides details on how to send and receive messages from each service.

<Figure 6> shows the DAML-S upper ontology.
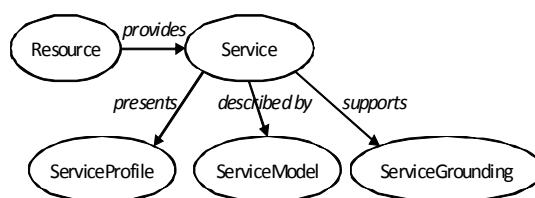
<Figure 6> DAML-S upper ontology(Davies et al., 2004)

In <Figure 6>, ServiceProfile informs us "what the service does." That is, it contains information that an agent would require in order to determine whether the service meets its needs. Table shows the properties of the three sections of the ServiceProfile in upper ontology (Davies et al., 2004).

3.1.3 Web Services Modeling Framework (WSMF)

The recently proposed Web Services Modeling Framework (WSMF) defines a fully developed conceptual model for SWS. WSMF has two main goals as follows. First, it defines description elements for adding semantics to web services. Second, it also defines description elements for providing web services as a scalable
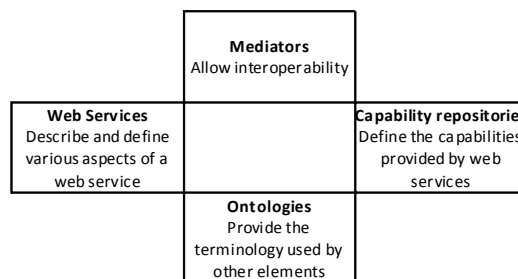
<Figure 7> WSMF elements(Davies et al., 2004)

infrastructure for e-Commerce (Davies et al., 2004). <Figure 7> shows the four main elements of WSMF Ontologies, Capability repositories, Web services, and Mediators.

3.1.4 Semantic Web Services and Multi-Agent System

García-Sánchez et al.(2009) proposed a framework for the semantic web services and multi-agent system (SEMMAS). <Figure 8> shows the framework. The framework is consists of 7 agents and they are grouped in three main categories.

First, Service owners/providers agents (Provider Agent and Service Agent)

In the first group, Provider Agent and Service Agent act on behalf of Service Owners/ Providers. Therefore, Provider agent and Service agent act as a representative of service providers and services respectively. After the entities and service providers set their preference concerning about service, it is taken into account during the negotiation with the service consumers.

Second, Service consumers agents (Customer Agent, Discovery Agent and Selection Agent)

Customer Agent, Discovery Agent and Selection Agent act on behalf of Service Consumers. Customer agent acts as a representative of individual consumers. First, the consumers suggest their preferences and state the goal. Discovery agent is in charge of searching in the semantic web services repository. Selection agent is in charge of selecting the most relevant service from the set of services recommended by the dis-

covery agent.

Third, Framework management agents (Framework Agent and Broker Agent)

Framework Agent and Broker Agent perform management tasks just like Managers. Framework agent is responsible for checking and ensuring a correct role of the platform. Broker agent has to resolve the interoperability issues. Data mediation, process mediation and functional interoperability are considered.
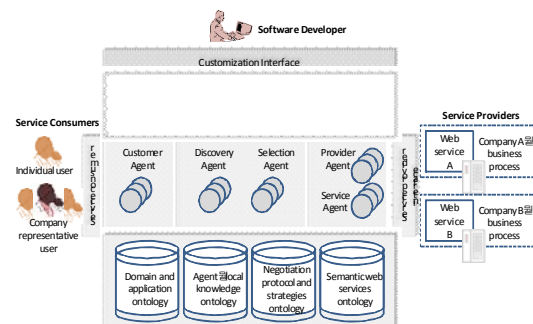

<Figure 8> The SEMMAS framework
(García-Sánchez et al., 2009)

3.2 Ontology Editors and SWS Browser

Ontology editor helps web service developers to build ontology. Especially, it supports the developers to define the Concept Hierarchies, Attributes for the concepts, Axioms, and their Constraints. For these, it is required to have a graphical interface and has to follow the existing standards for the web services. In details, it allows Inspecting, Browsing, Codifying and Modifying of ontologies and thus supports development and maintenance of the ontologies (Grosso et al., 1999). In addition, aside from offering ed-

iting support, semi-automated tools in ontology development help SWS developers to improve the overall productivity. By using the tools, developer can discover new concepts and stipulate relationships among concepts. <Figure 9> shows an example system Protégé.

Through the EU 5th Framework Project entitled Semantic Web-enabled Web Services (SWWS), an SWS browser was introduced (European IST Research Programme, 2004). The purpose of the project is to demonstrate the possibilities of using semantics in Defining, Searching, Combining and Invoking web services. The SWS browser is based on DAML-S and helps the users to automate the processes (Davies et al., 2004).
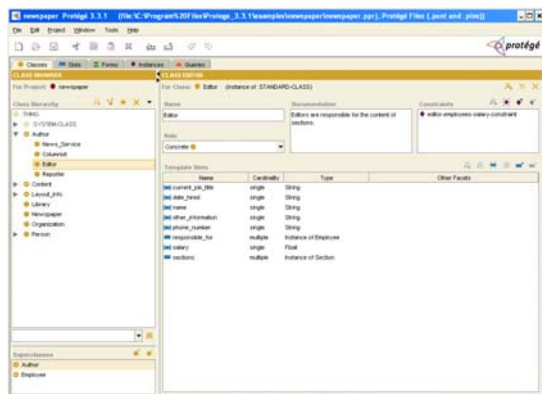
<Figure 9> The Protégé editor

3.3 Semantics in Business

#### 3.3.1 Knowledge-Based Systems(KBS)

During the past decades, due to the use of various information systems in business, a huge amount of information is accumulated in data warehouse. Usually, the information has different formats of electronic documents, databases, hardcopy documents, and etc. The main problems in managing the information can be summarized as Maintenanceof knowledge, Moving of knowledge workers, Reuse of knowledge, Dynamic modification of knowledge, and Sharing of knowledge (Huang and Diao, 2008). There were so many approaches to solve the problems. Especially, Biletskiy and Ranganathan (2008) proposed an Invertable Semantic/Software Application Development Framework (ISADF) for the KBS. In their study, they used a University- Course-Credit-Grade (UCCG) sample and a credit evaluation case to validate the usefulness of the ISADF.

The ISADF framework has multiple functions such as parsing the source document(s), creation of the domain ontology, population and maintenance of the ontology using information from the source documents, creation and maintenance of relevant conversion rules in a user-friendly format, transformation of these rules into a machine process able format while keeping the ontology in the background, querying the knowledge base along with the ontology in order to convert or deliver the information from a producer to a consumer, and the application logic (Biletskiy and Ranganathan, 2008). <Figure 10> shows the whole process of ISADF.

In ISADF, the Protégé-2000 manages the background domain ontology (RDFS). The ISADF can accept the input source documents in forms of Excel tables, Word tables, formatted text, and XML document. OO jDREW (an Object Oriented extension to a deductive reasoning engine for the

Rule ML web rule language written in the Java programming language) (Ball et al., 2005) uses the domain ontology, facts extracted and converted from source documents, and the business rules saved in Excel files to give answers for input queries.
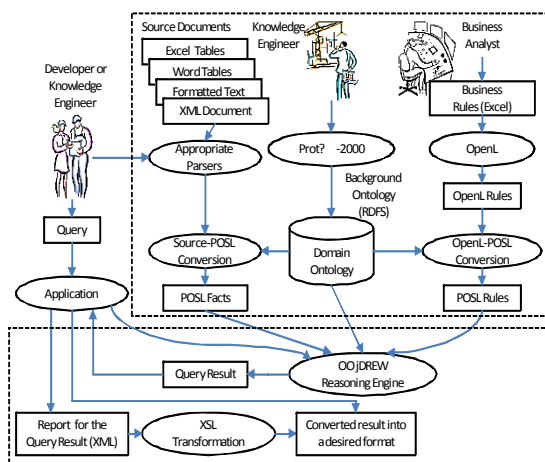
<Figure 10> ISADF for automatic delivery of information between domains
(Biletskiy and Ranganathan, 2008)
(∗ POSL : Positional Slotted Language(Boley, 2004))

3.3.2 Query on the semantic web

Fikes et al.(2004) presented the OWL query language (OWL-QL) as a standard protocol for query-answering in semantic web services. It specifies the Semantic Relationships among Query, Query answer, and the Knowledge Base. Through the query-answering dialogues, it supports the answering agent to execute the automated reasoning facility to give answers for queries. OWL-QL (http://ksl.stanford.edu/projects/owl-ql) of Stanford Knowledge Systems Laboratory is an updated

version of the DAML Query Language(DQL) developed by the Joint United State/European Union ad hoc Agent Markup Language Committee(Fikes et al., 2004).

For example, a web service consumer might ask "Who got the green jacket?" with a query having the query pattern as follows.

Query : ("Who got the green jacket?")

Query Pattern : {(got ?p ?c) (type ?c ?Jacket) (has-color ?c Green)}

Must-Bind Variables List : (?p)

May-Bind Variables List : ()

Don't-Bind Variables List : ()

Answer Pattern : {(got ?p "the green jacket")

Answer KB Pattern : ⋯

Answer" ("Dave got the green jacket")

Answer Pattern Instance : {(got Dave "the green jacket")}

Query : ⋯

Server : ⋯

Above sentence is matched with the following first-order logic using KIF syntax.

(exists (?c) (and (got Dave ?c)(type ?c Jacket) (has-color ?c Green)))

An OWL-QL query-answering dialogue is initiated by a client sending a query to an OWL-QL server. An OWL-QL query is an object necessarily containing a query pattern consisting of a collection of OWL sentences in which some URI refers are considered to be variables. The overall structure of the dialogue is illustrated in <Figure 11>. The detailed query-answer processes of the QWL-QL are presented in the Fikes et al.'s (2004) study.
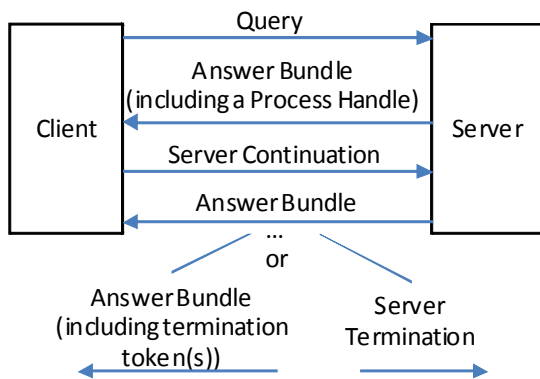
<Figure 11> OWL-QL query-answering(Fikes et al., 2004).

4. Conclusion and future work

This study is a discussion about the research trends on the semantic web and its applications in business. The study is focused on the characteristics of the web services, web services technologies, semantic web technologies, and semantic web services.

Through the study, we were able to know that the semantic web technology is trying to offer a new and higher level of web service to the online users. The services are overcoming the limitations of traditional web technologies/services. In traditional web services, too much human interventions were needed to seek and interpret the information. The semantic web service, however, is based on machine-understandable semantics and knowledge representation. Therefore, most of information processing activities will be executed by computers.

The main elements required to develop a semantic web-based business support are business logics, ontologies, ontology languages, intelligent agents, applications, and etc. In using/managing the infrastructure of the semantic web services, software developers, service consumers, and service providers are the main representatives. Some researchers integrated those technologies, languages, tools, mechanisms, and applications into a semantic web services framework. Therefore, future directions of the semantic web-based business support should be start over from the infrastructure.

Finally, to expand the semantic web-based business support semantic web services developers have to accomplish three main tasks before the execution of the services.

First, an organization which wants to carry out the semantic web services has to clarify their business processes logics. The clearer business logics will lead the developers/users to the more meaningful ontology repositories.

Second, to develop ontologies with the business processes logics, the developers have to select an appropriate ontology representation/manipulation language.

Third, for the effective semantic web services and business support, the developers need helps from the framework management agents, service consumer agents, and service owner agents. Before the activating the service, therefore, cooperation mechanism/module for the agents will be needed for the developers/users.

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Abstract

비즈니스를 지원하는 시멘틱 웹서비스와 기술의 동향

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　　지난 수십 년 동안 많은 연구자들은 "어떻게 하면 사용자들이 웹서비스의 개발 및 제공 부분에 관여할 수 있을까" 하는 의문 속에서 이러한 방법에 대한 연구를 많이 진행해왔다. 이러한 관점에서 이전 연구를 고찰하면, 웹 서비스에서 다양한 성공적인 서비스가 나타나면서 더욱더 복잡한 방법으로 사용자의 참여를 도출하고 있다는 점에서는 많은 공헌을 하였다.

　　특히, 많은 연구자들은 시멘틱 웹 서비스를 지원하는 컴퓨터의 기능을 연구하고 이해하려는 능력을 향상시키기 위해 노력했다. 이러한 연구들-합리적인 접근방식은 기계가 이해할 수 있는 의미 있는 정보를 다양하게 제공함으로써 일반적인 사용자가 이를 사용할 수 있게 하는 것-중에서 대표적인 것으로 웹 인프라를 설계하는 온톨로지 설계, 지능형 추론 등 논리적인 표현방식의 적용 등이 있다. 이는 정보에 대한 의미론적 기능의 표현, 시멘틱 웹에서의 보관 및 검색기능, 이기종 및 분산 웹 리소스에서 수집한 정보를 처리하고 변환하는 기능 등에서 보다 나은 지적 접근방법으로 판단된다. 이에 본 연구의 목적은 시멘틱 웹 응용프로그램 및 기술에 대한 연구 동향 및 비즈니스에서 활용방안에 대한 가이드를 제시하였다.

Keywords : 시멘틱 웹, 비즈니스 어플리케이션, 의사결정지원, 지식관리

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