Enhancing Decision and Negotiation Support in Enterprise Networks Through Semantic Web Technologies

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Abstract. The SEWASIE project within the Semantic Web Action Line of the European IST Programme focuses on the question how to assist networks of small and medium enterprises (so-called Integrated Economies) in enhancing their intra-and inter-organisational information management capabilities. While the project also includes novel techniques for semantic enrichment, query management, and presentation techniques in multi-lingual information acquisition from the web, this paper addresses the question how to further exploit the acquired information; firstly, by linking it into more established decision support environments based on OLAP technologies; secondly, by using it as a basis to engage in negotiations concerning inter-organisational cooperation across European countries. Specific application domains studied within the project include financial reporting and controlling systems for the intra-organisational aspects, and fashion design applications as a typical example of inter-organisational cooperation.

1. Introduction

Large portions of Europe's industrial fabric are composed of small and medium-sized enterprises (SMEs). SMEs are often organised in industrial districts, i.e. sectorial and regional clusters, for social and historical reasons. In times of globalisation this structure causes severe vulnerability. In order to compete in a global market it is thus vital for European enterprises to form strategic alliances.

Even in a regional context, many studies show the need for cooperation competence development as a prerequisite of success, and a number of analysis and support techniques have been developed [JaKe99]. At a European level, many additional issues arise, of which we focus on the information and communication aspects. In particular, these include finding the right partner who brings in suitable products, methods, partnerships, or customer networks – or to be found by customers and potential strategic partners to prepare for business interactions leading to a deal. Cooperation also requires significant additional capabilities of financial information management, using not only internal accounting data but also external information sources to retain financial stability in a rapidly changing world. Last not least, it requires trustworthy

and cost-effective means of entering into actual business, usually via a negotiation process.

The European SEWASIE[1] project investigates the applicability of Semantic Web and Agent Systems in such Integrated Economies. Generally speaking, SEWASIE strives for methods and tools that provide sophisticated and integrated retrieval, brokering, and communication services for business-related information based on semantic web technology. These methods will be demonstrated in the context of a large network of small and medium enterprises surrounding the fashion industry in Northern Italy. Figure 1 shows the general architecture of the SEWASIE system.

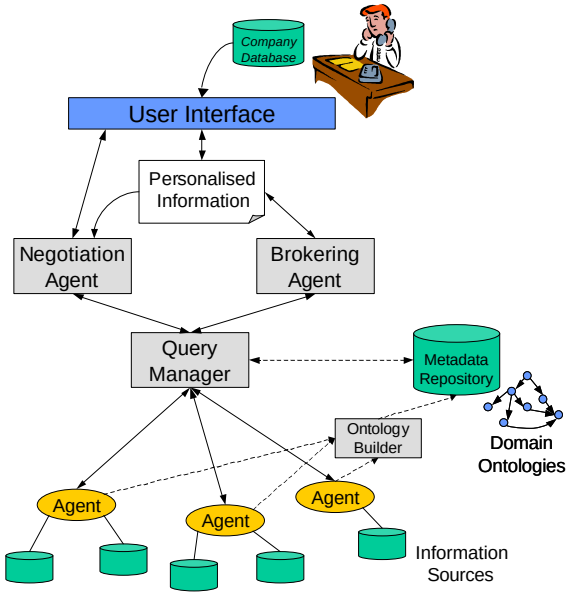

Figure 1. SEWASIE Architecture

Starting from carefully managed *domain ontologies*, the first step in constructing a distributed network of *intelligent information sources* is to semantically enrich the data sources by intelligent agents. Furthermore, the SEWASIE project will develop a *query management component* that is able to detect which data sources are able to provide answers to a query. In addition, the query manager will combine the results from different sources and present to the user an integrated and reconciled representation of the answer via a *user interface*. A specific focus will be a user-friendly and application-effective interaction environment, not only for the end users, but also for the information administrators who manage domain ontologies exploiting description logic technologies.

As in other Semantic Web approaches (e.g. [DM+01, MS+01]), XML technologies such as RDF, XML Schema, or XML Query will play a central role in the SEWASIE project. These standards will be mainly used to describe and exchange data in the

[1] Semantic Webs and AgentS in Integrated Economies

distributed network of agents and data sources. However, in the user interface, we will focus on an understandable and meaningful representation of the data that encapsulates the technical complexity of the core of the system. On the other hand, data sources that provide data in XML format are rare. Therefore, the system must be able to access heterogeneous sources that may have many different physical access methods and different logical representations of data.

However, as indicated above, acquiring and representing information in this manner is not enough to gain a business advantage from the usage of Semantic Web technologies.

On the one hand, the external information collected via the web must be integrated with company-internal information, re-targeted and personalised to the right people within a participating organisation. On the other hand, these people might not only need this information for company-internal analysis and decision-making but often wish to use it in a seamless manner to engage in communication and negotiation with other companies. This value-adding process of (internal) decision support (via a *brokering agent*) and (external) negotiation support (via a *negotiation agent*) beyond the information search task is the focus of the present paper. Altogether, the resulting system aims at helping European SMEs to find the right strategic information at the right time in a multinational environment; provide advanced and novel services for monitoring and linking information in the context of risk management and competitor analysis; and provide ontology-based communication mechanisms for negotiation in multi-language environments.

The paper is structured as follows. Section 2 presents an information brokering component for collecting, contextualising, and visualising semantically enriched information. Such contextualised information can be used in business communication. Section 3 presents a communication component for ontology-based electronic negotiations. The paper concludes with a brief summary and an outlook to future work.

2. Monitoring and Brokering Semantically Rich Controlling Information

Analysing business-relevant multidimensional data is one of the key activities in risk management and competitor analysis. Flexible reporting tools are useful in looking for causal relationships between key figures. Recent studies, such as the ones reported in [Uhr99], provide ample evidence that additional assistance from automated analysis, information filtering, modelling, and retrieval tools for numerical as well as textual data is extremely important.

Consider the following scenario in the areas of collaborative fine planning and analysis of supply chain measures: An analyst uses ontology-based information brokering services and a semantic search engine in order to look for potential products and suppliers. A collaborative fine planning task then adjusts the quantities for products and product groups for each period at specific prices between supplier and customer. The analysis of a supply chain process is implemented by appropriate and standardized measure trees (like the SCOR level 1 metrics) and quantifies the quality of the supplier or customer relationship, respectively. These multidimensional and hierarchical structures require support given by an OLAP planning systems. Thus, a seamless

integration of information monitoring and searching tools as well as numeric analysis systems would offer significant benefits for the analyst.

We focus mainly on the following requirements for an effective tool-support. First, high quality and reliability of the additional data sources is essential. Thus, an appropriate information filtering mechanism needs to monitor semantically rich and trustworthy data sources. Second, for the analyst it is sometimes hard to formulate an appropriate query for getting the required information. Consequently, (s)he needs tools that cope with vague queries and present monitored or retrieved information in an intuitive way so that the user can explore potentially relevant information. Finally, of course, filtering, analysis, and retrieval tools must not be stand-alone but need to interoperate seamlessly.

To achieve this, we will develop a brokering agent for financial controlling and management that acts as a broker between the users and the system by monitoring relevant data sources, contextualising the information according to the user profile, and visualising it in an easy-to-use and understandable representation. The basis for the development will be the following technology portfolio:

- the b2brain® multidimensional business information suite, developed by Thinking Networks AG [TN02]: This product supports strategic and operational corporate planning, controlling, optimisation and decision support by its data collection, reporting, analysis and information filtering components. Basis for integrating b2brain® with the other tools via Semantic Web technology is its powerful interface for meta-data support.
- the Broker's Lounge environment for the creation of context-specific brokering systems, developed at Fraunhofer-FIT [JKN01]: Broker's Lounge supports domain experts to set up domain specific information brokering and filtering applications. Core of the technology is an ontology-based domain model which serves as the basis for information filtering. Furthermore, the domain model provides the user with context information regarding the filtered items.
- the interactive, visual corpus analysis and text-mining tool DocMINER, developed at RWTH Aachen and Fraunhofer-FIT [BeJa01, Be01]: DocMINER automatically generates an intuitive graphical overview of text corpora, using a modular combination of algorithms from classical information retrieval, spatial scaling, and self-organising neural networks. The document analysis component – which calculates the similarity of the input documents – can be adapted to domain-specific needs. The system's interface tightly integrates the graphical display with explorative and goal-directed interaction methods.

The interoperability of these tools will be achieved by flexible meta-data exchange. More precisely, the information brokering agent collects information from heterogeneous information sources, using search robots with knowledge provided by the ontology metadata (in RDF or XML Schema) and domain/interest models stored in the user profile.

The broker provides a user-oriented contextualisation of collected information along given ontologies. Furthermore, multi-dimensional OLAP data will be linked to observed information sources (mainly in XML) using ontology-based relevance measures.

The text-mining tool will display the semantic structure of collected information based on a combination of metadata and textual content. This will allow detailed

analyses of delivered information and the material's semantic context. Furthermore, it will allow to view filtered information (due to a personal profile) in relation to the material available from the brokering service, thus offering a means for an adaptive profile and query refinement.

3. Structured Web-Based Negotiation

A business interaction in a B2B network of SMEs usually follows a three-phase pattern [SK+01]. Starting with a search for business partners, contract conditions are negotiated before the contracted task is executed and monitored for contract fulfilment. A semantic search engine using business ontologies enables efficient search using the ontological structures. Most approaches are not concerned with the communication about these structures with the aim of knowledge sharing and knowledge transfer.

Our approach will be concerned with structured web-based communication exemplified for electronic negotiations in e-commerce. The search and negotiation phase of a business transaction will be combined through the continued usage of search results and ontologies in the communication/ negotiation phase. A typical scenario would be a fashion designer configuring a vision of fabrics, colouring, and production technologies from a multitude of highly specialised potential and actual suppliers, each with their specific capabilities, reputations, idiosyncrasies, interests and business conditions.

A negotiation support tool will be developed using speech act elements [Se69, Ha81] and deontic logics [Ki98] in addition to ontologies for structured messages exchange (in XML) between human agents. Communication agents are also integrated for use in the early phases of electronic commerce. The negotiation process will be structured as follows. The early phases of a negotiation will be conducted by intelligent software agents. Based on the search results that will provide information about the desired services or products and the related provider or information about possible customers, these agents will find out details about potential partners, ask for references, ask for preliminary quotations, contact the companies etc. Thus, the informal part of any negotiation can be conducted by such agents after which a human negotiator then takes over and is efficiently supported by the communication tool.

The next step is that of serious negotiations performed by human agents. Based on the reaction of the business partners, complex negotiations will be conducted directly between representatives of the related companies, supported by an integrated system of structured message exchange and efficient document management [SQ01, SQ00]. Each interaction is performed via a structured message that then leads to a document representing a contract version. The structure is based on speech act terms and deontic logic to ensure unambiguous interactions. For example, each message has a message type that specifies the illocution of the exchange to make it clear to all partners involved how a particular utterance is meant, e.g. as a mere request or as a formal offer.

Communication problems are also due to problematic message contents. In order to avoid such problems, the novelty of ontology-based negotiations will be developed. The propositional content of each message is linked to the business ontology, i.e. the user can use the ontological terms and relations for the message content. On the other hand, the message exchange enables an extension of already defined ontological elements to account for the fact that each negotiation is different and that there are

many contexts that require specific contractual terms. Therefore, the message exchange is semi-structured by providing a message structure (e.g. illocution, negotiation protocol, the related obligations) and a propositional content that can use the business ontologies for communicating while enabling user-driven extensions to the propositional structures. By aiming for semi-structured message content, the communication partners are, on the one hand, able to refer to shared ontologies and thus to be able to express themselves in an unambiguous way and to avoid many terminological problems while, on the other hand, the problems associated with rigorous forms and templates in human interaction are avoided. Reasoning mechanisms will be developed that are able to reason about the structure (e.g. a directive commits the recipient to the action specified), content (e.g. this offer is unsatisfactory in the current context due to a lack of resources), and interrelations of negotiations (e.g. there is a cycle in the negotiation, the current state has occurred before).

4. Conclusion

In this paper, we discussed the potential of semantic web technologies in the context of electronic commerce for SMEs. For such companies, to find potential partners offering the required services or products and to be found efficiently by potential customers is essential. In a European context, SMEs form strategic alliances to be able to compete against large companies.

Once the business partners are found, contact is being made and contract conditions are negotiated. The communication should be based on the ontology used in the search phase while enabling user-driven extensions to the message content. This provides the basis for efficient communication exchanges. Standards in the area of B2B communication such as ebXML [www.ebxml.org] or RosettaNet [www.rosettanet.org] might be used as the basic protocol in which the messages between business partners (or their software agents) are exchanged. However, our approach goes beyond the usual standards as our aim is to provide support to understand the *contents* of a message. The contents of the messages will be linked to ontology elements, thereby providing a clear understanding of the message.

Since SMEs are characterised by a high level of flexibility and individuality [QS00], they require tools that enable a personalisation and contextualisation of information. Furthermore, information such as financial facts can be taken into account when searching for or looking at other information sources.

We introduced ontology-based negotiation and knowledge-based retrieval for SMEs and discussed their application in the context of the European SEWASIE project. By combining the two applications presented in this paper with semantic search engines, two of the three phases of a business transaction for SMEs will be covered, namely search and negotiation.

Our next steps include the detailed design and implementation of the described approaches. Furthermore, we will analyse the potential of semantic web technologies for the final phase of a business transaction, i.e. the fulfilment phase. Applications could include monitoring exchanges and re-negotiations in case of conflicts.

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