

Towards an Intelligent Decision Support Architecture in Extended-Enterprises

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Abstract: *Decision-makers exploit several channels to acquire up-to-date and reliable information, which they combine with background knowledge to formulate their decisions. In the last years, such information is increasingly acquired from the Internet by a conceptually straightforward process that involves: the identification of relevant information sources, the specification of filters that query the sources regularly and return the relevant documents in a local repository, the extraction of the information pieces of interest and the integration of these information pieces with previously accumulated information for subsequent querying or statistical analysis. In this paper, we present a distributed, service-oriented architecture for decision making systems based on Web services, and intelligent agents.*

Keywords: *Decision making, Web Services, Semantics, Content Retrieval & Discovery, Intelligent Agents*

1. Introduction

One of the most demanding tasks an enterprise manager phases today is the daily response to changes and how these changes affect his/her decision making process. The task is simple but hard to accomplish. It requires a clear view of the market's whereabouts, a clear view of his/her organization mission, goals and structure, and the ability to define a solid and viable strategy for the enterprise. This might seem a straight-forward process, but reality has shown otherwise. Information Technology (IT) practices offer a set of tools and methods to remedy manager burdens, including data warehousing, data mining, artificial intelligence predictive analytics just to name a few. However, at the very end it is a human brain that takes the decision (that of the enterprise manager, who is liable for them).

In an effort to colorize the difficulties that a manager deals with in the every day practice let's assume the following test case: Regardless of the intensity of IT support services through Customer Relationship Management (CRM) or Enterprise Resource Planning (ERP) systems, the manager cannot solely rely on "flat" reports, charts and figures. The actual requirement is to have a daily picture of the enterprise insights. He/She needs to know what the tangibles and intangibles are, the market drives in general, which sketch a (hopefully) unique, strong, and promising business profile for the enterprise. This profile has to be justified by identifying both its competitive aspects, and its weaknesses. Then, the business profile is to be aligned with the enterprise mission and the market

outlook, by refining the enterprise goals and most importantly realizing the processes through which these goals are to be achieved.

Looking from outside, an enterprise manager needs to be aware of the *market outlook*. This means that at least he/she has to be informed about the specific market domain, the competition and the competitors, the market in general, the coming trends, the technology shifts, the customers, the suppliers and the dealers. All these impose a vast amount of information to be accessed, processed and analyzed frequently. The complexity of such an activity is high, and it may get even higher when we are consider Extended Enterprises (E-E), which are comprised of several SMEs in horizontal or vertical alignments, each one of which has its own customers, suppliers, market domains and so on. Then the amount of data increases with exponential rates, as consequently the market outlook/screening tasks and the risks that an enterprise manager is liable for.

This paper focuses in the management processes involved in Extended-Enterprises that follow the vertical scheme. In such cases, the manager of the coordinating (dominant) enterprise is required to gather data from the rest partnering companies, acquire market analysis, and ultimately proceed to the strategy formulation process. In this respect, the major requirements for the intended architecture can be summarized:

- a. To support powerful, easy-to-use and effective knowledge management in distributed environments,
- b. To operate in time-evolving and value-changing operational business environments,
- c. To exploit existing infrastructures, that include diverse legacy ERP and CRM systems of the partnering companies and internet/intranet facilities for dealing with volatility of data, intolerance towards missing information, tolerance towards superfluous data and time-dependent value of information.

In the followings, we propose an architecture for supporting the decision making in Extended Enterprises.

2. Problems and abstractions

The proposed approach has been inspired from a previous work held in the framework of the *e-Volution II* “**Roadmap for e-business implementation in Extended Enterprises**” - G1RD-CT-2002-00698 - Project funded by the European Community under the ‘Competitive and Sustainable Growth’ Programme (1998-2002), in which two of the authors actively participated.

The project highlighted various problems faced by the managers in the context of an Extended Enterprise formation of SMEs. We could highlight the most sensitive ones, in the following lines.

As the three fourths an organization’s in-house information is contained in unstructured (non-database) formats, including documents and reports [1], the challenge is to transform them into “usable content”, thus supporting business acceleration. The consequences to the Extended Enterprise management can be view from two perspectives: The first regards the accumulation of “internal” organizational information, whilst the second refers to the gathering of market information “external” to the E-E. With the term external we regard any information that is outside the E-E boundaries of the Extended Enterprise formation. That is information coming from the market domain, the end-customers, the competitors, and so on, through diverse channels for market screening including the legal registries, mass media and the press, market exhibitions, and human contact among others. Thus there is the need to effectively and efficiently develop a solution able to intelligently “*find*”, “*filter*”, “*format*” and “*focus*” the vast amount of information available. The task is to offer a methodology and tools to support the decision making process in an Extended Enterprise. In other words the exercise is to manage and filter the amount of data in a way that will be fairly comprehensible without compromising the essence of the information.

In the abstract scheme of Figure 1 a modular, distributed view on the EE knowledge flow is depicted. A community of peers, could be SMEs, in the case of vertically organized E-Es, are producing gradually the Extended Enterprise's knowledge. Peers' knowledge turns out in various formats, at different timescales and possibly in conflicting semantics (i.e. different currencies, or coincident naming) which is required to be whipped out for extracting the actual information required for decision support in higher E-E levels.

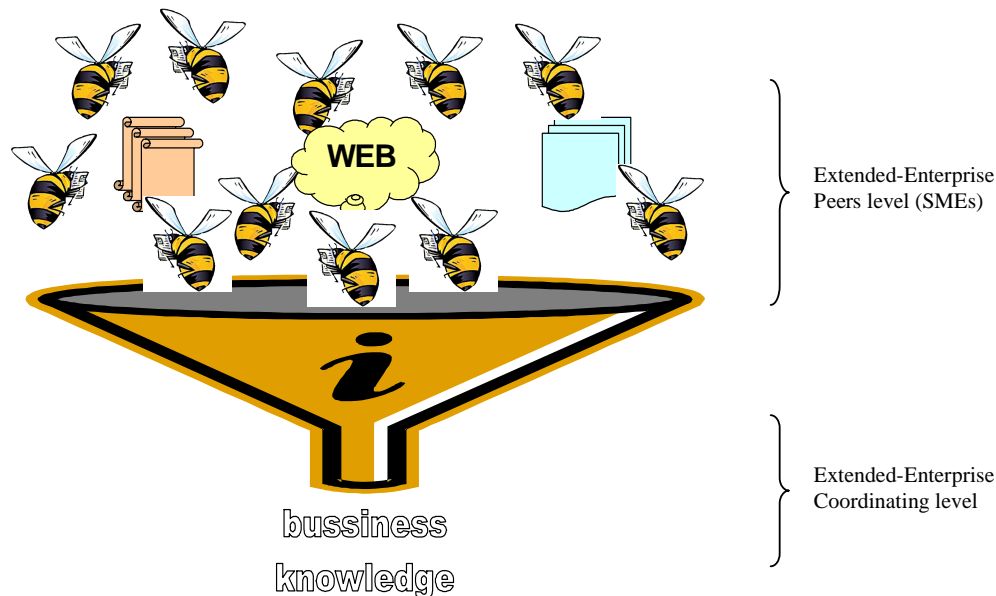


Figure 1: An abstract architecture of an Extended Enterprise and the knowledge flow

Lets first examine the various aspects of the knowledge flow required for management decision making in an Extended-Enterprise. This will eventually lead us to a proposed solution for the market information retrieval architecture.

3. A distributed architecture for knowledge sharing

Different peers (SMEs partners) usually employ different legacy systems. Thankfully, the era of business communication via e-mails and faxes, is (slowly) passing away. However, the problem of interoperability is still dominant in E-Es and is twofold. From the one side there is the actual communication and from the other the actual content of it (meaning of the communications).

Internal Knowledge and content interoperability issues

The partners involved is envisioned to order rules of data visibility. Not all essential company data should be exposed at the E-E level, as the integration (coupling) level within an E-E might vary This implies the requirement for a common and agreed set of information to be exchanged. Additionally, this information is stored and managed differently across the E-E enterprise peers.

These two needs order the employment of semantic-aware approaches. Semantics offer the conceptual bridge for the sharing of information and knowledge between different applications. This semantic bridge can be accomplished by a shared set of terms describing the application domain with a common

understanding. Such a set of terms is called Ontology [3]. Ontology is an explicit specification of a conceptualization [2]. When the knowledge of a domain is represented in a declarative formalism, a set of objects and their relationships are reflected in the representational set of terms with which a system represents knowledge.

The approach proposes the development of ontologies that will map the information held in the knowledge management systems. These will be published in registry like UDDI to be available across the E-E. There are major benefits following this approach. There is cost saving of developing new applications to ensure interoperability between the legacy applications. Secondly, there is an increase to flexibility and maintainability, as semantics can easily and cost effectively host alterations to the information stored in DBMS. Standardization of business models, processes, and business knowledge architecture will be achieved through coherence formulation and mapping of the respective knowledge, increasing the inside knowledge and minimizing information acquiring.

Service oriented application – web services

Having developed the ontologies, which will capture and represent the information needed, the next step is to develop web-services that will take advantage of the semantics and communicate the knowledge management information across the E-E. These will be published into the enterprise registry to be accessible by partners. Well known standards like WSDL, SOAP, HTTP can be employed seemingly to assist the development.

Taking External Knowledge under account

To address the market analysis information acquiring, is not a simple task. There are numerous ways of market content retrieval. The real requirement the manager is seeking is the up-to-date information arrival. He needs to be aware of the immediate changes minimizing the search and filtering time. Ideally he would like to present his preferences and the filtering rules ordering his to a magic box, and then this magic box present him with the filtered acquired information from the outside (i.e. internet) world.

The aim of these rules and preferences is to order the development of the information clusters (ICs) which will represent groups of different kinds of useful information, like units of figures, stocks data, or market raw information, etc. and can be retrieved through requests. The proposed approach addresses the issue of content retrieval in E-E distributed environment by using intelligent agents, which are able to obtain both preferences of the managers, as well as data into consideration, stored inside services.

Intelligent Agent functionalities

The intelligent agents function in a particular environment (i.e., an agent platform) which is often populated by other agents and processes. They have the ability to learn from their experiments, communicate and cooperate with other agents. In addition, they exhibit mobility, interactivity (exhibiting social and adaptive behavior), and ability to cooperate, learn and even reason, based on certain knowledge representations. These characteristics (personalization and information filtering), boost the usage of intelligent software agents in the context of market analysis. A possible enhancement could be that of a user-friendly interface, used to acquire the manager's specifications of market content. The agent can then be used to search for matching ICs on behalf of the manager. Figure 2 presents an abstract architecture of the proposed solution.

The concept is to define the agent platform environment, so that the agents can be executed to retrieve the ICs, wrapped through web services. The search parameters of an agent, the start of a search, or the access to the list of retrieved ICs, for example, can be controlled by calling appropriate Web service operations which will extract metadata from ICs.

The platform will comprise a community of Intelligent Agents (IA) that retrieve information from content pools and a Querying Module for accessing information in a competitive way. The Intelligent Agents will access diverse document pools and the internet, extract content, and tag documents. Then the Querying module will be responsible for transforming IA's findings into business knowledge through a competitive querying-voting system implemented as IA's synergies.

The proposed platform operates on several "document pools". A community of IAs "dives" (autonomously) into this pool, i.e. scan documents and tag them, according to their beliefs. Using agents for this task, semantic relations between words in a document and the topics that the agent is aware of can be efficiently captured. Agents that "tag" the documents formulate a loose "semantic network" of the concepts managed. In this way, a document pool operates as a live environment where autonomous agents are responsible for tagging documents "at will". Acting like insects, agents harvest content of the documents in the pool. In this way, as bees fly from flower to flower, agents move from document to document and tag them according to their values/concepts/topics. Consequently, from time to time agents come back to documents already visited in the past and "update their tag" on the document (dealing with time-dependency of information value). Beyond this abstract functionality, agents will be empowered with state-of-the-art algorithms for topic spotting, text mining and seasonal concept identification for tagging documents.

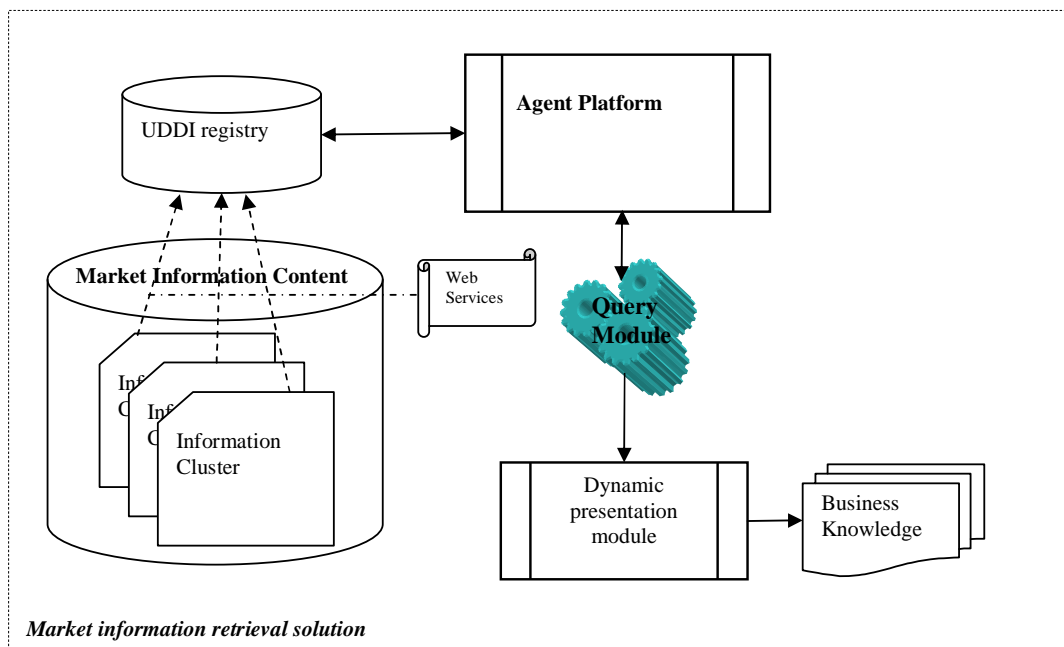


Figure 2: A market information retrieval architecture

The efficient querying module of the system operates in a competitive way: On user demand, the query is posted to the agents, who form synergies in order to reply with the related document references. The dynamic presentation module of the proposed platform integrates all agent replies and presents the results (on the fly) to the user in the pre-specified order of appearance. The order of appearance may be one of the following: "voted by agents' majority", "voted by trusted agents", "more recent first", etc. User satisfaction and interest on agent replies is passed to the agents in order to enhance their individual values/concepts/topics, and thus create the customized "trusted agents". In such way, the efficiency of the system is gradually augmented and adopted to custom user needs. Note that in this proposed approach, business intelligent and the company's intellectual capital is encoded in a multi-agent environment. Also, alien document pools can be migrated easily by the agents, already trained by a company, which enables the user company to query external sources, using the in-house expertise.

4. Conclusions

In this paper, we have focused on the information needs of an ordinary manager in an Extended Enterprise scheme, and presented an abstract architecture for facilitating knowledge sharing in E-Es. The approach takes into consideration the distributed nature of the working environment relying on a service - oriented approach architecture, for gathering and filtering viable content management information. Actually, a synergy of three fashionable technologies was employed: Semantics (ontologies), for the seamless representation of knowledge, existing in different legacy systems. Web services which have twofold implementation (the traditional one in the content of internal – organization analysis, and the one used as wrappers around clusters of market content. Intelligent agents able to query metadata, through searches of personalized specifications. The system designed here is capable for providing ultimately knowledge management in distributed, time-evolving and value-changing operational business environments, by building upon the existing infrastructures the partner companies in an Extended Enterprise.

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