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Agent-SSSN: a strategic scanning system network based on multi-agent intelligent system and ontology

Yman CHEMLAL *, Hicham MEDROMI *
*(EAS- LISER) Systems Architecture Team, ENSEM) - Hassan II University, Casablanca, Morocco

ABSTRACT
This article reports a development of a strategic scanning system network prototype system based on multi agent system and ontology, called Agent-SSSN, for developing business intelligent strategies. This is a cooperative approach to integrate the knowledge of experts in business intelligent system. The approach presented in this chapter is targeted towards using ontologies. The use of ontologies in MAS environment enables agent to share a common set of concept about context, expert user profiles and other domain elements while interacting with each other. In this paper, we focus especially on the modeling of the system Multi-Agents using O-MaSE (Organization-based Multiagent Systems Engineering Methodology) and a conceptual diagram of the ontology database.
Keywords : business intelligent, multi-agent intelligent system, ontology, O-MaSE, strategic scanning system network.

I. INTRODUCTION

There is a growing recognition in the business community about the importance of knowledge as a critical resource for enterprises. The purpose of knowledge management is to help enterprises create, derive, share and use knowledge more effectively to achieve better decisions, increase of competitiveness and fewer errors. In order to run business effectively an enterprise needs more and more information about competitors, partners, customers, and also employees as well as information about market conditions, future trends, government policies and much more.[2]

Different applications within information systems (IS) that support wide range of functionalities need to be integrated in order to provide the appropriate level of information support [6]. One of the prominent approaches for IS integration is the use of Business Intelligence (BI) processes and Multi-Agent Systems (MAS).

Business intelligence applications are not a new trend any more, but they have become a must during the last decade as a basic tool used by the modern management. Business intelligence is the result of the natural evolution in time of decision support systems and expert systems, systems that aimed at replacing humans in the decision making process or, at least, at offering solutions to the issues they are concerned of. *Gartner's definition*

Integrating Business Intelligence (BI) processes in an information system requires a form of strategic scanning system for which the information is the main source of efficiency and decision support [1]. The strategic scanning system is based on a strong idea: any actor in the company is likely to hold information elements and it is the synergy of these given elements which rise to usable information for action [7].

"Business Intelligence as a strategic scanning system network is the collective process by which a group of individuals track down and use anticipatory information about changes likely to occur in the external environment of the company, in order to create business opportunities and reduce risk and uncertainty generally" [11].

So according to the definition a strategic scanning system network is the **network of observers** that are attached to the group of expert and provide it informal information collected for example from customers, suppliers, competitors [4].

It is believed that, for the business intelligence (BI) of an enterprise, only about 20% of information can be extracted from formatted data stored in relational database. The remaining 80% of information is hidden in unstructured or semi-structured documents [5]. But relevant information gathering in the web is a very complex task. The main problem with most information retrieval approaches is neglecting the context of the pages [14]. For that reason in Business Intelligence we introduce a specific cooperative information gathering approach based on the use of software agents and ontologies to represent the knowledge of experts, named **AGENT- SSSN**.

Multi Agent technology is often mentioned as an approach to design and develop flexible and distributed software systems [3]. The development process of a Multi System Agents consists of four stages namely the analysis, design, development and deployment [9]. Many methodologies allowing the development of SMA, have been proposed. Among which, we chose the **O-MaSe** methodology to develop our SMA. This methodology is selected for its simplicity.
The use of ontologies in MAS enables agents to share a common set of facts used in user profiles, products and other domain elements, while interacting with each other. With exploiting reasoning mechanisms new knowledge can be derived from known facts and improve the Knowledge base (KB).

Organization of this paper is as follows: Firstly, the presentation of the problem studied by giving an overview of the state of the art. Next, in section 3, the multi-agent architecture of the Agent-SSSN system is presented with the roles of agents and ontologies. Finally, the conclusions are drawn with further research work envisaged.

1. Related work:

The Business Intelligence aims at enabling decision makers and managers of a company to have strategic Information. It therefore involves learning, observing, understanding an external environment and apprehending the events to make the best decisions for more competition and innovation. This involves a several approach deal with agent and ontology to improve a process of business intelligence (BI).

Research in (kishore, zhang.2006) [19] showed that MAS provides an excellent approach for modeling and integrated business IS. In (Soo, Line.2006) [20] authors propose a cooperative MAS platform allows the invention process to be carried out though the cooperation and coordination among software agents delegated by the various domain experts in the complex industrial R&D environment. In (Olivier Chator, Jean-Marc Salotti. 2012) [21], a solution focused on the implementation of a collaborative tool based on MAS where agents are skills, has been proposed. Authors in (Espinasse, Fournier, Freitas .2006) [14] conducted an interesting research about collecting and extracting relevant information gathering in the web based on software agents and ontologies. In (Amos David, Sahbi Sidhom. 2005) [15], a proposal focused on some models and tools for the implementation of the complex processes of Business Intelligent, has also been used. In (Dejan Lavbic. 2012) [5] author propose an approach in integration of unstructured information found in the web with information available in several internal data sources. In (Maizura, Rosmayati. 2010) [17] architecture for MAS based decision Support Systems has been used.

2. Proposal for solution

The review of related work presented in previous section focused on improving how multiagent systems and software agents have been applied in BI and how can their potential be used for business intelligence systems improvement or on domain of research and collect information in the web independently on the BI, However, these researches do not consider the process of strategic scanning system in the Business Intelligence to realize the routine monitoring of technological sectors and the market competition then the rational use of captured data.
This chapter presents a proactive process of observation and analysis of the environment for integration a strategic information in Enterprises, using agent oriented approach based on ontologies. Fig1
This approach focuses on a collection and extraction of information domain specific from the Web based on software agents, with a consideration of the context of the search using the ontology and the information dissemination by simply delivering the right information at the right time to the right expert in the system.

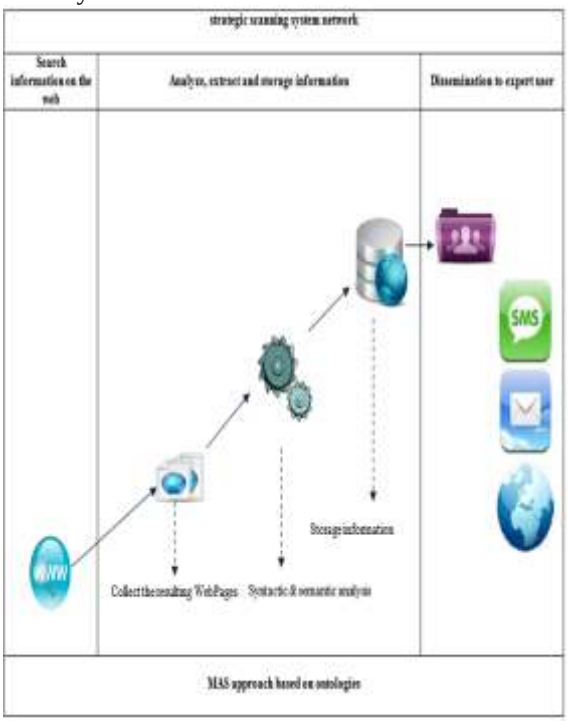

Fig.1 Global System Architecture

2.1 The role of ontology

Ontology represents the domain knowledge and can be used to support various processes within a multi-agent system. Ontology is high expressive knowledge models and as such increase the expressiveness and intelligence of a system. Ontology provides a common way of understanding between different agents.[18]

Nowadays Web-based information retrieval systems are widely distributed and deeply analyzed from different points of view. The main objective of all of such systems is to help users to retrieve information they really need (obviously as quickly as it is possible) [16], then the combination of the multi-agent approach with declarative knowledge, leading to the use of ontologies is relevant for the development of Web-based information retrieval systems.

The knowledge of the expert is crucial to the interpretation of extracted patterns, one of the challenges of **Agent-SSSN system** is to collect and extract information that is interesting and useful for **expert users**.

We used in our research the knowledge management approach where every agent has knowledge about its own research context, our system is based on the semantic representation of the knowledge used by agents:

According to [6] ontology can be structured into different sub-ontologies –upper ontology, domain ontology, task ontology and the application ontology. Following similar guidelines we have defined upper ontology named **organization domain** and combined domain and task ontologies in **monitoring ontology, notify ontology and specific ontology**, Organization ontology is limited to abstract concepts and it covers reusable dimensions. Task ontologies specify concepts of **monitoring ontology, notify ontology** and application ontology specify a **specific ontology. (see Fig. 2).**

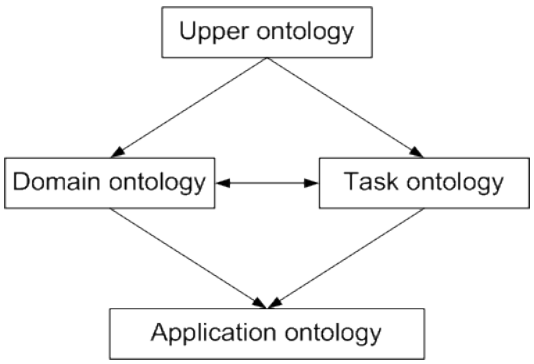

Fig 2. Modularization of Ontologies depending on the scope and partial ordering defined by inheritance

Agent-SSSN integrates expert knowledge throughout the process of information retrieval on the web; knowledge is structured and organized in the Knowledge Base (KB). Our system is based on the semantic representation of expert knowledge, For this we use the proposed clustering of ontologies is based on the common understanding of the business activity domain being defined in organization ontology. Every agent has its own interpretation of a Knowledge Base (KB), which is a specialization of Organization ontology with detail definition of knowledge required by individual agent.

2.2 Knowledge modeling

Ontologies are not available; they must be constructed specifically by asking experts. Their role is to provide a common vocabulary to several agents and to facilitate a particular context, in this case the search and retrieval of information on the Web based on the expert knowledge.

The construction of ontology goes through the following phases:

- Delimit the domain of interest and the level of abstraction to describe it,
- Define specific vocabulary knowledge of the domain, that is to say a set of terms of assertions and semantic constraints on the domain,
- Model the knowledge in terms of concepts and taxonomy of individuals, relationships between them, constraints and inference rules.

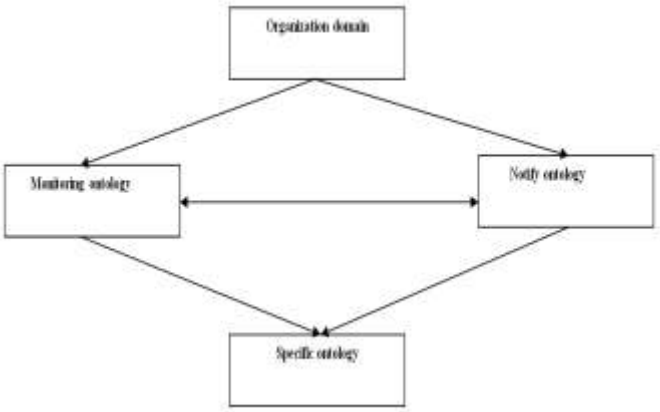

Fig 3 Modularization of Ontologies

2.3 Construction of the knowledge base

In the present version of our prototype, all ontologies are combined in a single knowledge base .This part of the system include the information shared between agents and interpreted by the group of experts.

It is composed of three main families information:
organization domain : subsumes all concepts of global ontology concepts for the activity domain of the organization
monitoring ontology: groups all the expert knowledge about monitoring activities (sales, marketing, competitive…)
notify ontology: All knowledge about notification is defined in notifying ontology, where every expert user has his own context defined and the position within organisation across two dimensions – organisational unit (e.g. Marketing, Sales, Human resources etc.) and decision making level.
specific ontology: includes all concepts is the domain of the organization's activity and linked to a specific monitoring domain.
Web ontology: define web concepts.

The main concepts of the knowledge base, shown in Fig 4, using the UML formalism are: Concept-OD, Concept- MO, Concept-NO, Concept- SO.
Each cluster is attached to a single domain defined by a specific ontology.

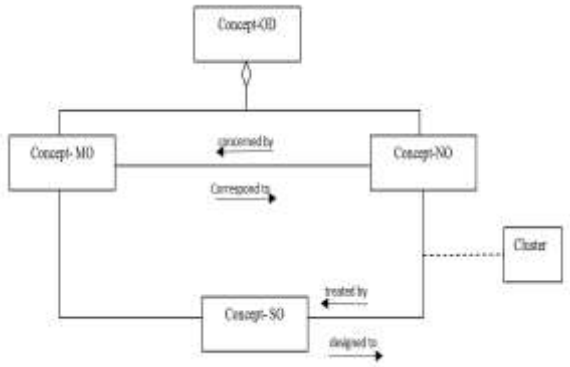

Fig 4. Main classes and relations of the ontology

2.4 The role of agent

Strategic scanning system network or **Network knowledge production** is a complex system. This complexity is particularly due to the collect public data that are freely available on Web in order to support the decision-making process. Information agent is capable of collecting information and organizes it as a local database.
The multiagent approach offer modular, flexible, scalable and generalisable algorithms and systems solutions for information retrieval, extraction, fusion, and data-driven knowledge discovery using heterogeneous, distributed data and knowledge sources in information rich, open environments [17] .Indeed, this approach relies on the assumption that a system is composed of autonomous entities, called agents, that interact in order to deal with a global goal or some local tasks. Intelligent software agents, as a new artificial intelligence technology, may bring benefits to the strategic scanning system network [13]. In this study, the Agent-SSSN system is based upon the task-sharing framework and the task-sharing are assigned to relevant strategy agents and using ontologies for several tasks, that ontology is used by every agent to represent the interpretation of a domain observer or relevant information for network observers but also for communication between agents and the network of experts.

To model our **system Multi-Agents**, we used the methodology O-MaSE [Deloach, 2005]. O-MaSE (Organization based Multi-Agent System Engineering) is a extension methodology MASE [Deloach 1999] which completes the organizational dimension. O-MaSE considers a multi-agent system as an organization social. Each agent is a member of this organization and plays a specific role according to its capacity. It is composed mainly models (goal, Organization, Roles, Ontology, Agent, Agent Protocol and State). [9]

2.4.1 Goals Diagram

In our problem, the main goal is to integrate an observing network for collecting information on restricted domain of the web. This objective is the global goal "**goal 0"**. The **"goal 0"** dependent on the completion of another two sub-goals which are: cooperative information gathering "**goal 1"**, Broadcast information **"goal 2". "goal 1"** depends in his turn on the implementation of many authors goals. Indeed, to collect information, we must start by search information **"goal 1.1"**, analyze information **"goal 1.2",** extract information **"goal 1.3" and** storage information **"goal 1.4".**

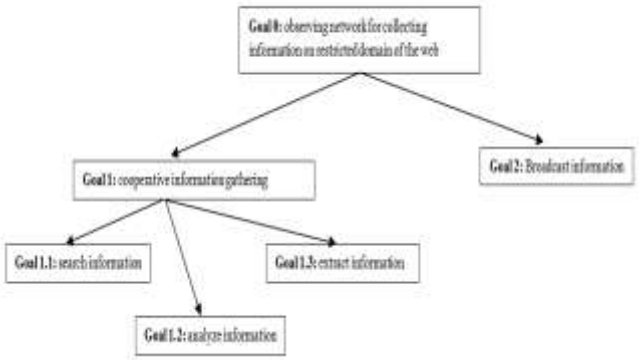

Fig 5. Goals Diagram

2.4.2 The multi-agent architecture of the Agent-SSSN

The starting point of this architecture is a prototype already achieved the system AGATHE. This system already adopted the agent and also uses ontologies

approach to realize classification and information extraction tasks on the Web using a specific ontology, but as previously mentioned our approach develop a conceptual ontology stored in knowledge base (KB) and instanced by a specific agent described in agent platform table. See table 1

2.4.3 Agent's platform

Our objective is to describe the different roles that can be exercised by the agents of the system. For each goal /sub goal previously identified, we must create a role for achieving this.
In order to achieve a goal, a role must have at his disposal one (or more) ' capabilities' which translate, usually by execution plans (Diagram states / transitions describing the manner in which an agent should behave).
As described previously, five goals consist our goals diagram. To realize them we identified five roles.
Each class represents a model for a type of agent that can be instantiated many times according to the system requirements.

Goals	Roles	Capabilities	Agent	Ontology
Goal 0: observing network for collecting information on restricted domain of the web	management of dynamic interactions between network actors	Activate the search process by creating a Information Retrieval Agent, supervise the flow of information, efficient running of the negotiations to synthesize and analyze information, it is capable according to the needs of creating agents or delete,	**Mediator agent**	**Organization ontology**
Goal 1.1 search information	Play information retrieval role for the purpose of decision making.	querying external search engines on the Web (like Google) to obtain web pages	**Information Retrieval Agent**	**Specific ontology**
Goal 1.2: analyze information	Syntactic analysis	analyze and classify the web pages according to a specific ontology	**Analyst agent**	**Web ontology**
Goal 1.3: extract information	Classify and extract information	A semantic classification of pages received, as well as information extraction. Each extractors agents is associated with a particular concept in the specific ontology	**extractor agent**	**Specific ontology**
Goal 1.4: Storage information	Storage information	processes the information received in order to comply with the	**Database agent**	**Specific ontology**

		format suitable storage device according to the database structure		
Goal 2: Broadcast information	delivering of the right information at the right time and the right expert user	Information is proactively delivered by agents to the expert without a specific request. All knowledge about notification is defined in Notifying ontology, where every expert user has his own context defined and the position within organization across two dimensions. *in our approach we implemented the "push model"*	**Notification Agent/ Push agent**	**Notify ontology**

Table 1. Agent platform table

The whole architecture is depicted in Figure 6.

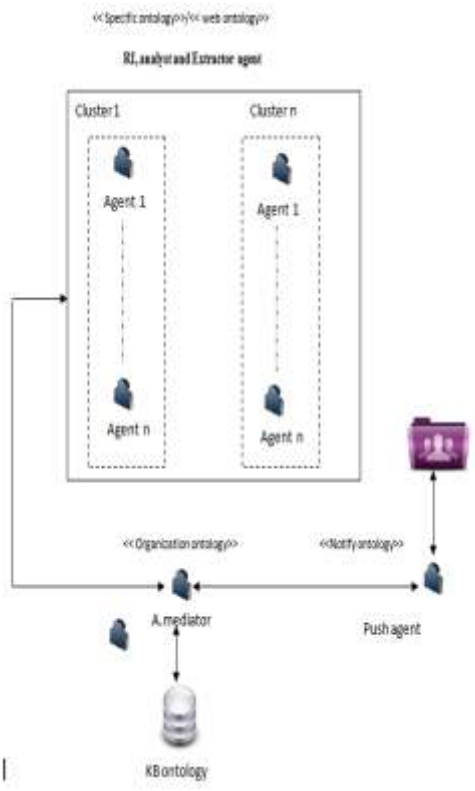

Fig 6. The global architecture

2.5 The logical flow of the Agent-SSSN system execution

The logical flow of the Agent-SSSN system execution is shown in Fig. 7 which is briefly described below:

Step1: a **Mediator agent** activates cluster of Information Retrieval Agent, Analyst agent, extractor agent and assigns to him a concept of a specific ontology for a specific cluster.

Step 2: a group of **Information Retrieval Agent (IR)** transfer the request to the various search engines and collects the resulting WebPages

Step 3: These WebPages are transmitted to the **Analyst agent** for treatment.

Step4: Analyst agent makes a syntactic analysis the web pages according to web ontology.

Step 5: Extractor agent receives pages from Analyst agent, makes a semantic classification according to a specific ontology. Each **Extractor agent** is associated with a particular concept in the specific ontology associated with specific cluster.

Step 6: the **database agent** processes the information received from Extractor agent in order to comply with the appropriate format storage the database structure.

Step 7: According to the expert user profile (using **notify ontology)**, push agent sent a notification by using several technologies from Windows Alert, e-mail, Really Simple Syndication (RSS), Short Message Service (SMS) etc. These notification

types are also ordered by priority for each expert user and according to this type the content is also adapted.

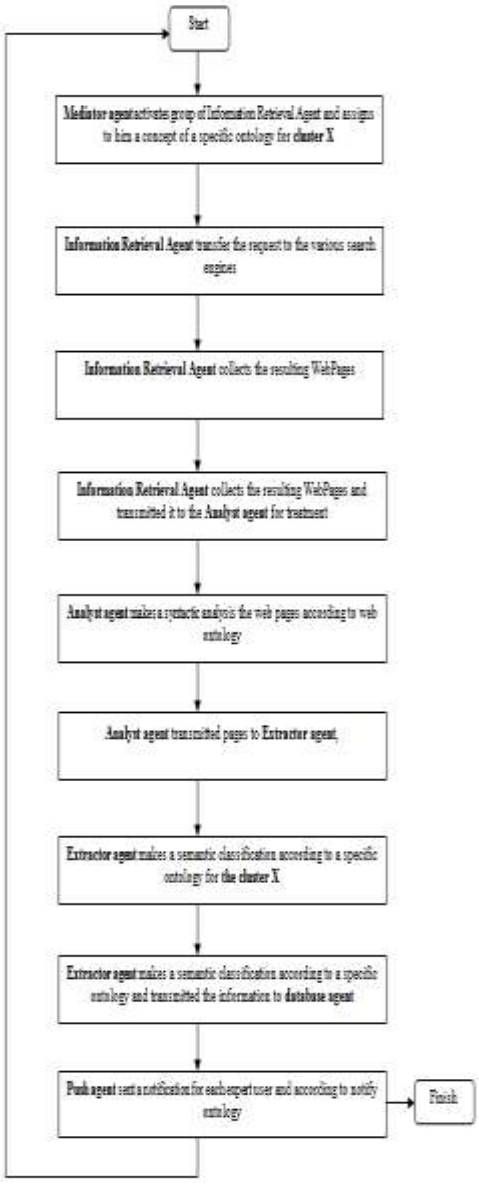

Fig 7. logical flow of the Agent-SSSN system

Conclusion & future work

This study has been sought to explore how the process of strategic scanning system network development
can be improved by multi-agent intelligent system based on ontology. To achieve this aim a platform able to integrate a process of strategic scanning system network in the business intelligence (BI) called Agent-SSSN prototype system has been created and described. This approach focuses on a collection and extraction of information that is interesting and useful for **expert users**. Sources of information discussed in this approach are the information gathering in the web.

As future enhancements we would like to:

- extend our model by defining a detailed architecture of each agent, specifying communication between these agents using ACL (Agent Communication Language) and implementing the architecture proposed in the SMA development platform Jade (Java Agent Development Framework), selecting OWL (Web Ontology Language) as a language for ontology presentation.
- Evaluate the efficiency and effectiveness of this proposal by implementation of our approach as architecture from a real case study.

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Authors

Yman CHEMLAL is an engineer in computer science from the INPT, in July 2005, Rabat, Morocco. She prepares her thesis at ENSEM, Hassan II University, Casablanca, Morocco.

Hicham Medromi received the PhD in engineering science from the Sophia Antipolis University in 1996, Nice, France. He is responsible of the system architecture team of the ENSEM Hassan II University, Casablanca, Morocco. His actual main research interest concern Control Architecture, Architecture of
System and Software Architecture Based on Multi Agents Systems and Distributed Systems. Since 2003 he is a full professor for Control systems and computer sciences at the ENSEM, Hassan II University,
Casablanca. He managed eight Research projects and he has published several Patents and publications in international journals and conferences.