

Semantic Collaborative Platform for Industrial Diagnosis in Nonwoven Spunlace Production Enterprise

Fatima Zohra BENKADDOUR¹, and Noria TAGHEZOUT¹

¹Laboratory LIO, Computer Science Department, ORAN University, Algeria
benkaddour.fatima@gmail.com, taghezout.nora@gmail.com

Abstract: *In this paper, a semantic collaborative WEB platform is proposed to implement the collaborative manufacturing environment that evaluates the costs of products, detect risk situations and provides suggestions and recommendations that can help to avoid possible undesirable situations in the spunlace nonwovens production.*

Our collaborative platform relies on WEB2.0 technologies, domain ontology and agents. These allow you to share and exchange experiences in the industrial diagnosis to have new ideas and useful information for decision-making. The global collaborative decision model is applied to the spunlace nonwovens production industry. INOTIS enterprise is a candidate for our study.

Keywords: *Collaborative Manufacturing (CM), Collaborative Platform, WEB 2.0, agents, domain ontology.*

1. Introduction

The study we describe here deals with the typical spunlace nonwovens production. «INOTIS» enterprise is a candidate for our study. Established in 2003, its major mission is to develop manufacture and sell world-class spunlace fabric for critical environments where contamination control and comfort of the use are of vital importance. This will be achieved through cost-effective production, consistency and reliability, a high level of service and quality and in partnership with customers («INOTIS» 2012).

In this study, we propose a distributed approach where the components of a Small and Medium Enterprise (SME) are modeled as intelligent agents that collaborate to create models that can evolve over the time and adapt to the changing conditions of the environment. Thus, making possible to detect risky situations for the SMEs and providing suggestions and recommendations that can help to avoid possible undesirable situations. The core of the multi-agent system are the production and coordinator agents, that incorporate new techniques to analyze the data from enterprises, extract the relevant information, and detect possible failures or inefficiencies in the operation processes. In this article, we will briefly describe the major reasons that motivate our study and focus in particular on the decisions problems in INOTIS enterprise production management [5].

The article is organized as it is explained next. In Section 2 case study. In Section 3, some related works on manufacturing SME(s) are presented. In Section 4, we present our approach: We firstly give a detailed description of the agents, then we explain some principles of WEB 2.0 technologies and we describe the most important steps in building the domain ontology for spunlace nonwoven productions are also summarized. This section is followed by a discussion of the obtained results Section 5. Finally, conclusions.

2. Case-study: the spunlace nonwovens production industry

As a brief description, we can say that the production chain in INOTIS is equipped with multiple synchronized machines with the latest technology capable of producing several product ranges with different types of fibers. The spunlace process applied to INOTIS is very complex, each machine has its own settings, changing one of the parameters automatically leads to changes in the appearance and quality of the finished product. Due to its hydraulic entanglement of cellulose fibers and polyester fibers, INOTIS created a product

category, which is defined according to the needs of the market. The fibers entanglement is made by the process of sending hydro entangling jets of water through perforated strips fed by High pressure pumps reaching a maximum pressure of 250bar.

These HP pumps showed a high failure rate compared to other resources which leads to a degradation of the finished product quality and the material itself. The process contains 06 pumps without one of these, hydro entangling cannot be done correctly.

3. Related Works

The Internet offers access to vast information resources in nearly every possible domain, but the data are published in a completely “unstructured” and “uncontrolled” way. In addition, its human-oriented representation and its size make any kind of centralized computer-based processing difficult and time-consuming [7]. The task of structuring relevant information and then extracting knowledge from that information is currently performed manually with tremendous effort. A formal representation for structuring knowledge is needed to allow for the automation of knowledge extraction from web resources.

As an example, authors in [8] developed a base ontology for rehabilitation (RO), which serves as a knowledge base to develop an ontology-based knowledge support system. This system, called OntoRis, was a comprehensive domain knowledge resource for a specific rehabilitation therapy equipped with a Web 2.0-enabled discussion forum for the exchange and sharing of experiences among patients and therapists.

OntoRis was designed to assist patients in acquiring comprehensive information about their prescribed rehabilitation, and provide advice derived from evidence-based medicine to expedite recovery [8].

Many businesses and scientific communities have adopted ontology as a way to share, reuse and process domain knowledge. Ontologies are now central to many applications such as scientific knowledge portals, information management and integration systems, electronic commerce, and semantic web services (Horridge et al., 2007)[9]. Furthermore, ontologies play a key role in information retrieval from nomadic objects, the Internet and heterogeneous data sources. Authors in [15] proposed to use a rule-based ontology reasoning method for decision support in iron and steel industry. It relies on constructing a shared and evolutionary ontology, and formalizing the condition–action decision rules. The ultimate aim is to facilitate the senior managers of the core company in one Global Supply Chain to learn the successful experiences from its competitors, and adjust its own operating strategies to improve the company performances and industrial practices as well [17].

4. Methodology

We were inspired by two main research works. Firstly, in [11] a brief overview of Web 2.0, social media, and creative consumers was provided, and the challenges and opportunities that these phenomena present to managers generally and to international marketers and their strategies in particular were explored.

In spunlace nonwovens industry, the senior managers of companies are faced with more complicated and dynamic situations to make decisions than ever before. It is very necessary to develop suitable decision support systems (DSSs) to facilitate the decision-makers to compile and utilize the multi-source knowledge to answer the questions arising from the managerial and industrial practices. In our previous work, we have engaged in developing a feasible DSS with an agent-based architecture to support decision-makings. One of the main aspects addressed in the decision-making process is the knowledge management of the most frequently failures of machines as the card, aqua jet etc. [16]. To enable interoperable decision knowledge structures for knowledge sharing and utilization, a collaborative platform is described here. Thus, we proposed an integrated approach for the development of a collaborative platform that gives the possibility to production agents to share exchange and discuss failures diagnosis and resolution of machines breakdowns with each other [12].

4.1 SNOC platform design

As shown in Figure 1, the system architecture picture design consists of 4 modules: (i) the knowledge domain (database, knowledge base and domain ontology), (ii) the collaborative WEB 2.0 environment, (iii) The collection of decision support that enables he functionalities of the system (named agents), and (iv) the WEB interfaces that enable information exchange among the enterprises recognized as participants [17].

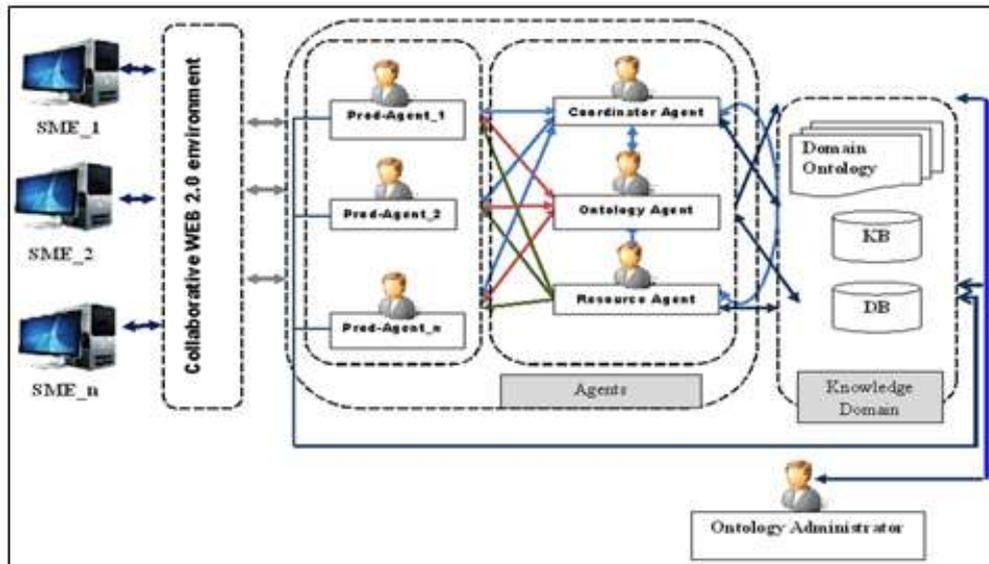


Fig. 1: Our agent-based approach [17]

4.1.1. Knowledge domain

For our study, this module focuses on the designing of a relational database, a knowledge base that is capable of storing structured decision-making data, knowledge and some agent's behaviors. One of the critical challenges in our study is to assist a CMN in the conversion of tacit knowledge to explicit knowledge so that it can be formally stored in the knowledge base. Domain ontology has been developed for this manner.

4.1.2. Collaborative WEB 2.0 environment

This interface allows decision-makers to interact with the GMDSS with minimum requirements and highest flexibility. This WEB based environment can best support the dynamic features and maintain the correct displaying format of the user-interface. This module has an important role to guide decision-makers (participants) through a decision-making workflow.

4.1.3. Agents

Here, agents mentioned above reside at distinct physical computing servers so that each acts independently and the system workload balanced. Furthermore, every agent can communicate with other agents to smooth out the decision process. When an agent conducts a decision-support activity, it consults the knowledge base and the database located in various sectors of the information center. The proposed Web-based DSS mainly includes four components: Ontology Agent (OA), Resource agent (RA), Production Agent (Prod_A), and Coordinator Agent (CA). In particular, the agents are used to collect information and generate alternatives that would allow the user to focus on significant solutions.

The system administrator is responsible for incorporating, maintaining, and managing ontologies to provide users with a comprehensive knowledge base.

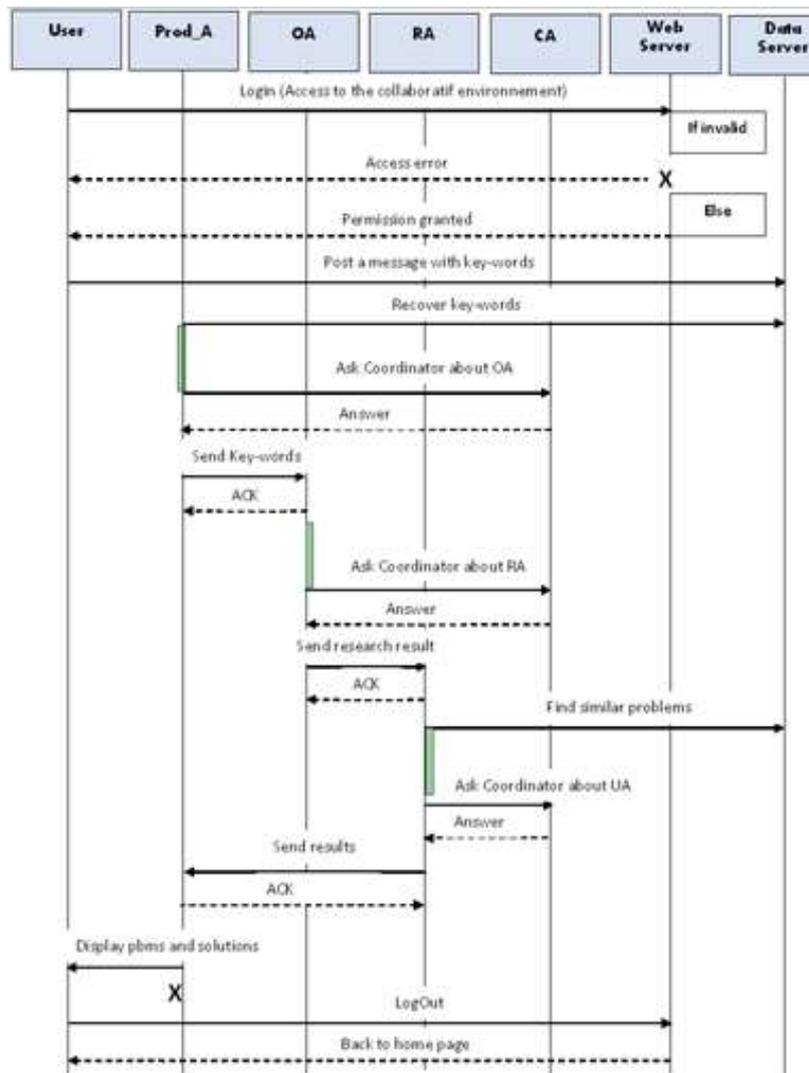


Fig. 2: Time sequence of the multi-agent process with AUML

Figure 2 shows the detailed system operation process with a time sequence diagram from which it can be seen that the system analyzes the manager's request and outputs a solution to the posted problem.

4.1.4. WEB interfaces

This module is responsible for managing all the modules and interfaces of other agents control access to the system. It also allows the introduction of agents CA, Prod_A and RA in particular, and the sniffer is an agent that allows the display of results and messages exchanged between agents.

4.2 Building Domain Ontology for Production Management in spunlace nonwovens industry

According to the most popular definition, ontology is an explicit specification of a conceptualization [13] in which 'conceptualization' is an abstracted view of domain world that we wish to represent. Therefore, ontology has become popular as a paradigm for knowledge representation and engineering by domain experts [14] by providing a methodology for the shared understanding of a domain of interest. Related research on using ontology has attracted a great deal of interest and is extensive. The sharing and understanding of the knowledge in a given domain is a central role of the ontology.

Here, the Domain Ontology is developed by acquiring knowledge from documents, domain experts and the collaboration of INOTIS managers. Applying such domain ontology to decision support improves effectiveness of decision-making process. Currently, we have implemented the spunlace nonwovens concepts for production management in Protégé 4.2. Figure 3 depicts an overview of the main concepts and classes of the domain ontology.

Coordinator Agent has been designed to provide a more active intelligent management of the model using a knowledge base and domain ontology. From our point of view, ontology will provide significant

benefits for the interoperability and reusability of the multi-agent system, as well as support for system analysis and agent knowledge modelling [17].

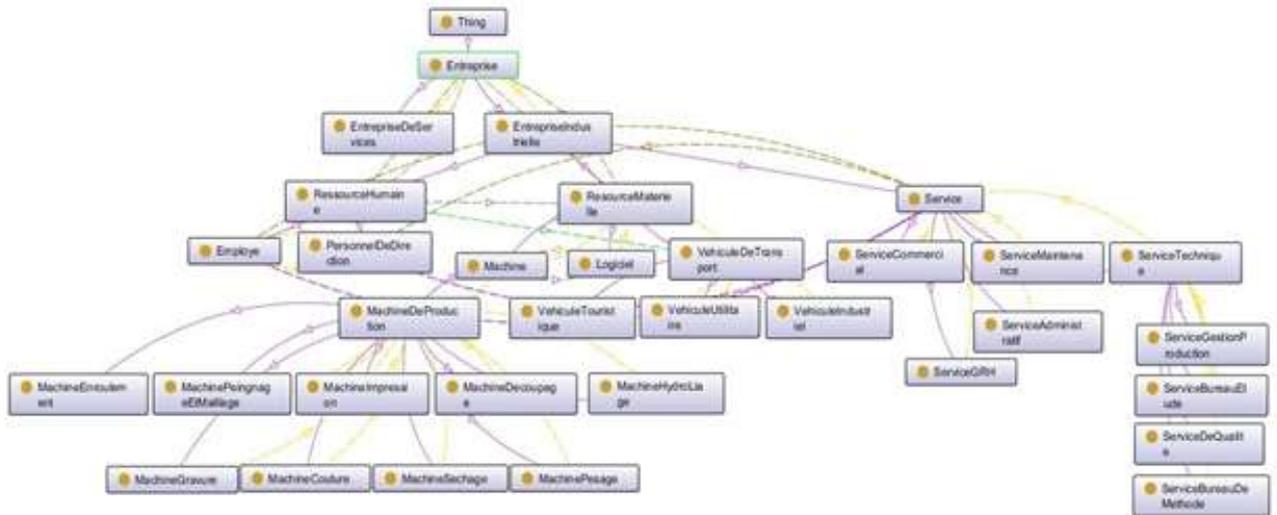


Fig. 3: A snapshot of the spunlace nonwovens production management created in Protégé 4.2

5. Issues of implementation

Currently, the industrial diagnostics costs can be expensive for SME(s). It's why we developed SNOC (Social Network Ontology Collaborative) platform with some tools as follows: JADE platform for multi-agent systems, PHP my admin for databases and PROTEGE 4.2 for ontologies and AJAX. To illustrate the general functioning of our system [17], we consider the following scenario:

Fatima is an employee in a spunlace nonwovens production company X. She is facing with a typical problem of diagnosis. For this purpose, she accesses the collaborative work space by using the WBE 2.0 interface. She decides to post the encountered problem via the interface given in Figure 4.



Fig. 4: Production Operator connected to the collaborative platform SNOC

Through the Knowledge domain, the most important similar cases are shown in the list. The solutions and the ratings for solutions and other services are also, offered by the collaborative work platform. To each identified and posted problem in the platform, are associated some keywords. To be more precise, a problem description will contain the most relevant and significant keywords. These later will be used as input data for the domain ontology. Furthermore, the collaborative space work takes into account all additional new keywords as entered by the user. This is possible thanks to the learning abilities of our developed system. By offering her (Fatima) a conversation history, this can lead to check at any moment the exchanged messages among other participants (operators and experts (see for example Figure 5)).

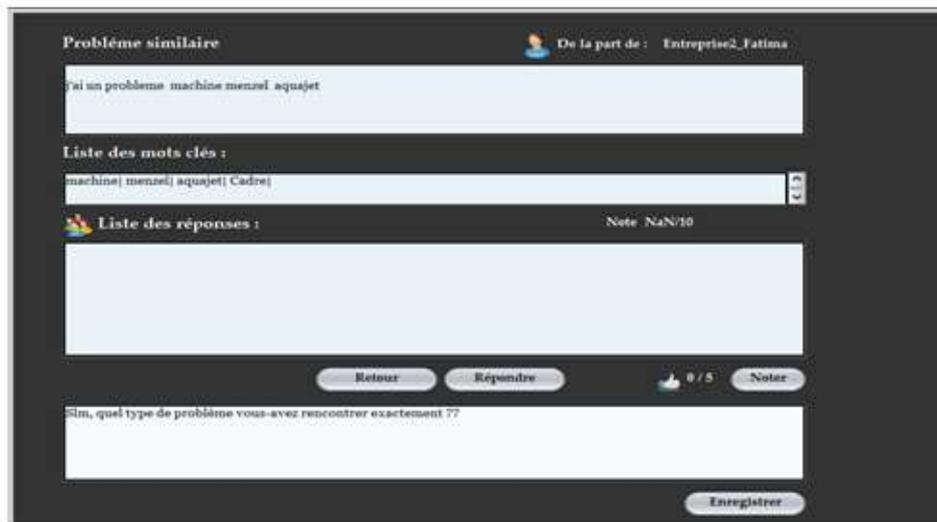


Fig. 5: Production operators consulting the similar solutions posted by other participants through SNOC

Fatima can visit the Web 2.0 collaborative space to exchange, share and discuss her experiences with other participants. This sharing of experience can inspire and encourage new ideas or useful advices for the repairing process of resources failures for example.

Some agent's performance measures are evaluated to improve collaboration and coordination during work sessions. Figure 6 illustrates the statistics calculated by the coordinator agent.

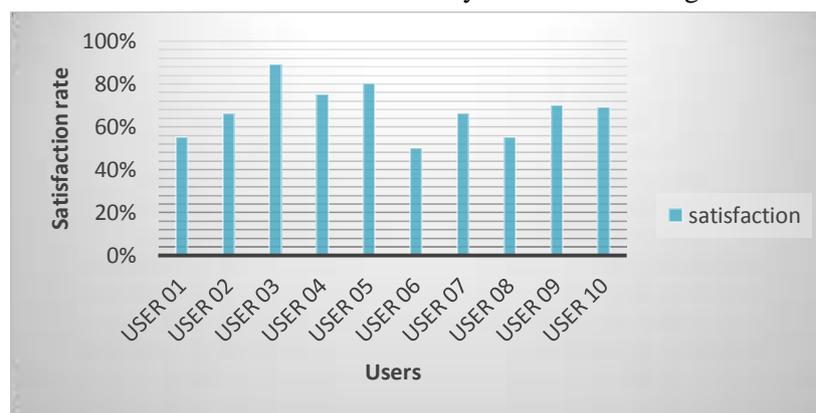


Fig. 6: Satisfaction of SNOC's users

The previous Figure 6 shows the level of satisfaction of users including experts from the Web 2.0 platform. These rates have been calculated from user responses to a series of questions that can be summarized in the following:

- I found SNOC platform unnecessarily complex,
- The SONC platform was easy to use,
- I would need a technical person to assist me.
- The interaction components (buttons, menus, textfields, drop-down lists etc) can be easily understood,
- I need to learn many things before using SONC platform.

6. Conclusion

In this paper, we describe the development of a semantic collaborative platform for industrial diagnosis in nonwoven spunlace production enterprise; the developed collaborative work space is justified by a simulated case-study on Algerian manufacturer (the most important enterprise in North Africa).

Our study presents a comprehensive framework for selecting a suitable solution based on decision analysis process. The proposed procedure allows production agents to share and exchange points of view or diagnosis built upon their experiences and knowledge. Our platform SNOC is based on web technologies capable of integrating the existing distributed information systems and its CMN and domain ontology to solve the problem of data heterogeneity.

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