47 MANUFACTURING AUTOMATION NETWORK'S COOPERATIVE E-SPACE

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Associating people into cooperative networks can be beneficial for both the individual and the community. It can occur by sharing expertise, vision and talent of different participants. Manufacturing Automation Network - Manet - is a Brazilian academic and research network that pools together human and material resources of academic institutions and research centers active in the fields of manufacturing and automation. Currently, a logical and computing infrastructure is being developed to make the Manet operation feasible through the Internet. A distributed infrastructure, named Cooperative e-Space - CeS, is being designed offer to people that already participate in cooperative network, a new infrastructure for sharing information, taking into consideration the special characteristics of their community, in a way that can lead to knowledge sharing.

1. INTRODUCTION

In manufacturing enterprises, in an increasing way, work is being done on an interleaved and interdependent fashion. Today, the conventional paradigm of job division no longer stands as workers are requested to have multiple skills and to be able to interact with other workers that have complementary abilities. This applies especially to the intellectual processes within the enterprise, as for instance, in the product development process and this can be recognized as a general trend.

Product development process will be taken as a reference for this paper's reasoning and, the arguments and discussion can be applied to other business processes inside the manufacturing enterprise.

Product development is an area that deals with innovation and shares many aspects in common with academic research. To develop a product many different disciplines interact. Nowadays, concurrent engineering is largely diffused and requires that specialists collaborate with other specialists whose background and education areas may be different.

In the early phase of product conception, the workgroup responsible for product development is in its establishment phase In this phase some questions may arise:

Who knows about the product or about its components?

Where historical data about the product can be found?

What is the key knowledge necessary to the development?

These simple questions give a hint as to who will participate in the product development cooperation process, and what knowledge and information will be required.

The idea investigated in this paper addresses locating expertise as a key element for enabling the cooperation process. To assure better conditions for cooperation, the use of an electronic space that merges knowledge sharing and groupware techniques as a medium to facilitate it, is advocated in this work.

An environment named Cooperative e-Space – CeS – is being developed, where cooperation processes in manufacturing is enabled. People are at the center of this space that aims to support establishment of both social and knowledge networks and communities of practice.

To design and construct CeS, a cooperation with Manet (Manufacturing Automation Network) and its associates, LAAS-CNRS, USP, FEM-UNICAMP and CenPRA was started. Manet acts as both, a partner in the development of the CeS and, as a case study for exercising the concepts and tools being developed.

Results obtained in such research network can potentially be transferred to manufacturing cases since both cases share compatible investigation subjects and techniques, specially in the innovation processes.

This paper is structured as follows: section 2 presents the cooperative relationship in Manet; section 3 describes the Cooperative Electronic Space architecture, functionalities and its current status; section 4 summarizes related systems; section 5 presents final remarks.

2. COOPERATIVE RELATIOSHIP IN MANET

Manet is a non-profit multidisciplinary research effort with over 100 researchers from Brazilian universities and research centers, which are located in 10 cities of the country. It was founded in 1998 and is supported by a Brazilian Ministry of Science & Technology's program.

Manet's objective is simultaneously to strengthen cooperative liaisons and to stimulate new partnership initiatives among its members as well as other organizations.

Manet is organized as a flat structure constituted of one coordinator linked to all the researchers, individually and/or with their work groups. Open communication channels make information and view point exchange possible at any time, regardless of where they are. The coordinator enables complementary competency initiatives and also plans, consolidates and announces meetings agendas. Partnerships with public and/or private entities are always welcomed. Face-to-face meetings are programmed during the year.

Manet's participants are widely dispersed, working in a cross-institutional way both as individuals and as a workgroup. Workgroups are: self-organized – members define their proposals and make partnership agreements according to their research interests and are self-managed – they define their own priorities and can ask for funding from any federal agency.

Members' research interests are focused on the manufacturing sub-areas of: production planning and control, robotics, shop floor control, product development, and fast prototyping. They spend time creating, specifying, designing and managing their research.

Cooperation initiatives can consist in co-advising graduate students, co-authorship, cooperative development etc. involving researchers from only one group or from several groups. The intentionally loose hierarchy enables all the members to make their opinions explicit in the decision-making process. However, their numberless activities limit availability and become a critical factor to any knowledge sharing effort. Critical components of the Manet's culture include continuing efforts to enhance liaisons and contacts among its members.

Partnerships among researchers and solid relationships with other cooperative networks are also of utmost importance to Manet.

As a matter of fact, Manet can be thought of as a distributed manufacturing Research and Development chain and becomes similar to a virtual enterprise, where companies compete for the same market niche.

3. COOPERATIVE ELECTRONIC SPACE

Cooperative Electronic Space (CeS) is a web-based environment primarily conceived to support teams to work together, providing services that help them to organize and coordinate activities, exchange ideas and facilitate their knowledge sharing. CeS must merge both characteristics of collaborative systems and knowledge management systems. The approach is centered on identifying communities in domains of interest and supporting them by providing already existing functionalities of collaborative systems. To work together teams must develop a common "world view" and vocabulary; such development can be associated to ontologies in their particular knowledge domains.

In the research phase of a product development, technical cooperation is carried out by enterprises combined with research centers and universities even when there is no equity involvement. The interest is conducted in terms of what knowledge can be exchanged and trust in the knowledge's sources. Searching for excellence or economic convenience are the two main objectives of technical collaboration (Cagliano and Chiesa, 2000).

Computer-based collaborative systems promise to highly increase information sharing within and across organizations. Such systems encourage sharing of ideas in a free-flowing manner as well as in a form of structured repositories (Jarvenpaa and Staples, 2000).

Bafoutsou and Mentzas (2002) in their collaboration system's review said: "...collaborative systems bring geographically dispersed teams together, supporting communication, coordination and cooperation". They point out, in their conclusions, that existing systems could be ameliorated by providing integrated workflow services containing features such as notifications to users, activity context visualization and monitoring of processes. Additionally to their suggestion, this work considers the necessity of a knowledge view in collaborative systems.

Figure 1 depicts CeS' architecture. To indicate the cooperation as a main characteristic of the system, it is shown ahead of other functionalities. The system's

core is based on ontologies. The ontologies provide a meta-model in which both already existent and future functionalities rely on. They have two main purposes that are: to make knowledge acquisition and support knowledge sharing. The ontologies are developed for each specific knowledge domain, merging and/or reusing already developed models that represent the user's profile, knowledge domains, meeting environments, documents and their privileges and other characteristics. Each of those characteristics are mapped as classes and subclasses, and the description of the relationships and restrictions among them.

The approach is toward open system construction where the use of standards is enforced and automatic information retrieving is considered. CeS' functionalities will be deployed in the form of tools. The aim is to develop an ontological view of CeS that enables interoperation of tools by means of a control system using events and rules. The system has its development based on the Java language and uses existing applications in Java.

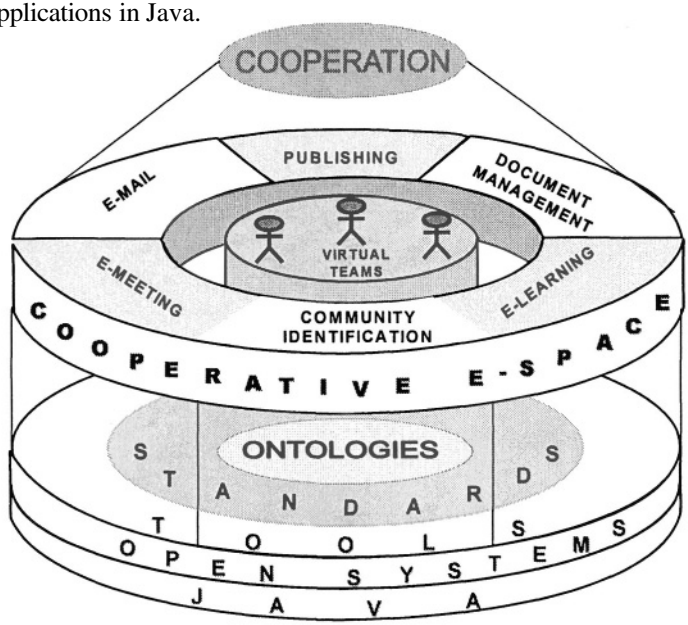

Figure 1: Cooperative electronic Space architecture

3.1 CeS Functionalities

CeS main functionalities involve community identification and recommendation, electronic meeting support, e-mail services, electronic publishing facilities, document management and e-leaming tools. As previously mentioned they are located on the top of the CeS' architecture (see Figure 1), and described as follows.

Community identification

This identifies both participants' interests and those people who are related to them, providing dynamic information about a possible related network that can be formed under a specific theme (Nabuco et. al., 2003). It operates on an unobtrusive mode based on a subscription which frees users of the need to make repeated queries and updates during their participation. It automatically examines terms present in

users' documents, identifying keywords or key-phrases which are related to people's profile. A software agent captures these user's interests and transmits them to other agent that searches for the same or related interests. The knowledge base in which the search is executed contains instances of people's profiles, a manufacturing taxonomy and keywords related to them. To keep it functional the database is updated every time users acquire new documents or change already existent ones. Multi Agent System (Koyama, 2001) runs over a Protégé (protege.stanford.edu) application and KEA, a naive Bayes machine learning algorithm (Jones and Paynter, 2003) that captures keywords and key-phrases. The agents are configured according to a client-server model. The client part captures user's information, formulates queries and sends them to a server. The server part populates a knowledge base, searches for similarity and sends back this information as an ordinary e-mail to the user.

Electronic meetings

This provides services that empower users to schedule meetings, invite people to participate to the meetings, set-up environment with meetings' required tools, manage, conduct and close sessions (Molina-Espinosa, 2003). The services enable real-time discussions, provide audio and video facilities, support write and draw in real-time, and chat with previously scheduled participants. They also support document and file sharing, and work with them. An awareness service (Rodriguez, 2003) facilitates session management, graphically informing the chairman or system administrator, who is using what tool. It is a client-server application where servers are running over Java Shared Data Toolkit (http://www.sun.com/ software/jsdt), Java Web Start, and other Java applications that are public available. Microsoft Windows applications as NetMeeting server, Access Data Base, Word and Power Point can also be part of the system as tools used during the sessions. Specific tools can also be added and used.

Document management

This classifies, stores and maintains version control of documents used by session participants. It allows participants to share and collectively produce documents. Document classification and relationship descriptions will be described according to ontologies. Documents are classified according to knowledge domains and relation with people interested in and/or having authored them. Several useful links can be represented showing the documents used and/or generated during a session, authors' names, place(s) in which they are stored, versioning capability, etc.

E-mails services

This provides e-mail services enhanced by a classification system supported by the ontology. The relationship can be made by already existent keywords in the knowledge base and the keyword discovered in the e-mail related to it.

Publishing

This deals with the views that can be provided to the users. The use of ontologies organizes the contents, the authors, and the relationships with the other functionalities. The publishing activity makes documents (articles, reports, etc) authored by people inside it visible to the community. Published documents can be stored or linked to a server that advises people possibly related to them.

E-Learning
Ontologies classify videos to be used in virtual classes, documents used and recommended by mentors. It is possible to include real-time lectures with chat, video, and documents sharing, extending the electronic meeting environment.

3.2 Current Status

CeS logical structure relies on ontologies in such a way that its functionalities and inter-relations are described regarding formal representation of the knowledge domains in which they operate on. It uses tools developed by LAAS-CNRS, the electronic meeting tool, and developed by CenPRA, the community identification system. Those functionalities operate closer to a client-server model. Figure 2 shows the server side of the already existent components.

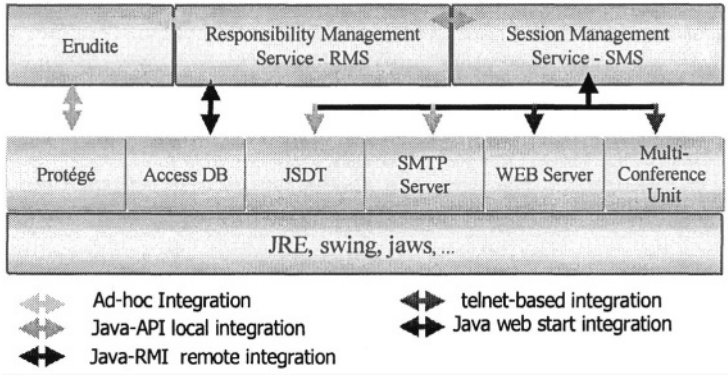

Figure 2: Server integration

Erudite constitutes the server side of the multi-agent system that performs community identification functionality. Erudite interfaces the ontology and the knowledge base system constructed over Protégé, with the rest of the system.

Responsibility Management System, RMS, is a client-server document review meeting tool. Its server side interfaces with Microsoft Access Data Base (Acess DB) using Remote Method Invocation, RMI, allowing the use of the data base in the web. The client side provides an human interface to configure meeting's parameters and participants information such as: role, skills, formation, organizations, sessions, dates and scheduling. It provides a pre-meeting information set.

Session Management System, SMS, is a client-server tool that controls the events exchanged during a session including the floor control by the person who has the chairman role, and verifies open and close events generated during a session. Its client side has an human interface that allows participating and management of a session. It provides a control meeting environment.

The components are being integrated to form one environment to be tested and extended. At this point Protégé profiles can be populated using the information contained in the RMS data base through the use of RMS' API. Meeting information can be logged; profiles of meeting's participants are stored in the knowledge base. The names of the applications used, meeting duration and other information can be stored and kept on a history file. Manet due to its characteristics of having people

socially connected, with common interests under the manufacturing domain, will serve as a testbed, participating initially with some selected sites.

4. RELATED SYSTEMS

The CeS system has similarities with existing systems in its main objective, i. e., support distributed cooperative work through the use of platforms based on ontologies and agents. They are:

Palo Alto Collaborative Testbed (PACT) is a concurrent engineering infrastructure, based on interacting agents (programs that encapsulate engineering tools) and shared design-domain ontologies (sets of agreed-upon terms and formally described meanings), developed by several research groups (Cutkosky et. al., 1993).

Madefast is a grassroots effort involving industrial and academic participants from around US Collaborative Engineering over the Internet incorporating technology based on agents and distributed intelligence that allow contractors to compose teams of specialists from different locations and organizations as project needs arise. It provides engineering analysis and design tools, multimedia authoring environment, collaboration tools that enable to share documents and ideas both asynchronously via e-mail, and synchronously in real time (Cutkosky et. al.,, 1996).

CAIRO (Collaborative Agent Interaction and synchROnization) system (Peña-Mora et. al., 2000) is a distributed concurrent engineering environment that allows its users to work together in virtual teams by supporting multi-media interactions over the Internet and makes meetings as effective as possible through distributed artificial intelligence based on software agents. The agents advise about possible procedures during conferencing sessions. They are trained to recognize when participants use specific words during the sessions. Each time the agent discover it an action is performed linked to the word. The objective is to improve the interaction among people during the meetings.

Process-Link (Petrie, 1999) uses agents to coordinate simultaneous engineering projects in a way that agents are combined with workflow process and prevent people from making changes without the agreement of the ones implicated in the task under change.

Acacia (Dieng, 2003) Project-team is an umbrella where methodologies and tools are developed to assist people that belong to an organization (in a broad sense) to work together and profit from their know-how. They use ontologies, machine learning and multi-agents systems to achieve knowledge acquisition, storage, retrieving, and maintenance. Their ongoing project deals with corporate memory and the semantic web.

The CeS system brings functionalities usually spread over several systems and its approach privileges the product design phase in a manufacturing project. The systems cited do not merge CSCW (Computer Supported Cooperative Work) functionalities with knowledge engineering tools. They have either knowledge or a CSCW focus and they usually privilege design phase.

5. FINAL REMARKS

This paper presented the main concepts and architecture of a Cooperative Electronic

Space – CeS: a research prototype designed around the concept of cooperation and the merging of collaborative and knowledge systems. It aims to identify distributed expertise and support cooperation providing groupware tools, being an open, scalable, reproducible and extensible system.

CeS is structured to support concurrent virtual teams, each of them characterized by a specific knowledge domain, expressed by ontologies that permit to deal with dynamic aspects of the knowledge lifecycle.

In order to exercise these concepts, a concerted effort with Manet has been started under the name of a project titled Virtual Manet. This project will embody CeS' concepts applied to the Manet's requirements.

Currently, existing tools are being integrated, according to the proposed architecture and a scalable experiment is being planned. At first, the prototype will connect CenPRA, Unicamp and USP, three Manet's members. They are physically distributed and located in São Paulo State. Strategies for scaling CeS will regard the results from such a experiment. Step by step, all Manet sites will be part of the CeS, and will form Virtual Manet.

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