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Virtual Work Group Collaboration in a Manufacturing Process

Jorge Luis González-Trujillo
Departamento de Electrónica, Sistemas e Informática
Instituto Tecnológico y de Estudios Superiores de Occidente (ITESO)
México

1. Introduction

People work together, and groups make most of the complex decisions in organizations. Managers and staff continuously make decisions, design and manufacture products, develop policies and strategies, design software and so on. Even in hierarchical organizations, decision making is usually a shared process. A group may be involved in a decision or in a decision related task. However, work group may have both potential benefits (process gains) and potential drawbacks (process losses). When people work in teams, especially when members are in different locations and may be working at different times, they need to communicate and collaborate and access a diverse set of information sources in multiple formats. Thus, supporting work group emphasizes the important aspects of communications, computer technologies and work methodologies. Other reasons for support are cost savings, expedited decision speed, the need to support virtual teams, the need for external experts, and improving the decision making process. Almost all organizations, small and large, are using some computer-based communication and collaboration methods and tools to support people working in teams or groups (Turban et al., 2007). Moreover, the importance for businesses have been increased in such level, that collaboration technology (CT) has been hailed as the hallmark of an empowering organization, as it goes beyond the scope of traditional e-mail systems to allow people to collaborate electronically, fostering creativity, and teamwork in the process (Regan & O'Connor, 2002).
Working with teams and groups it is a complicated process, even for the clear advantages that can be obtained, there is a great chance for process losses. Therefore, a multidisciplinary approach is usually required for the multiple and diverse aspects that have to be considered for a successful implantation of the appropriate technologies, where some of these aspects are related to personal behaviour and work styles, group's functionality and dynamics, organizational culture and learning, knowledge sharing and conversion, technical skills and expertise (Wallace, 1997; Nakayama & D´ávila, 2003; Samarah et al., 2007). Since CT belongs and represents a paradigm shift for computer science, one in which human-human rather than human-machine communication, coordination, and problem solving are emphasized (Baecker, 1993). Then, it is important to realize how this technology can enable and improve the group work performance through a successful selection and implementation of the right

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infrastructure, allowing an effective technology appropriation and user acceptance (Youngjin, 2003). In this context, virtual teams require the use of information technology (IT) to exist, little is known about how the technology can be configured to optimize work group performance (Hacker & Kleiner, 1996).
Although some of these aspects and concerns have been discussed before, in previous research works, more and diverse cases are need to support, design and establish a framework for best practices and lessons learned, that if the case, serve as a baseline to look for models, explore and develop standards based in a common standard-based foundation (Tomek, 2003), that in consequence will address common efforts of researches, developers, and practitioners dedicated to all different and diverse aspects of collaboration.
In this chapter, discussion and topics of virtual work group collaboration are explored within a real and practical case of a selection and implementation of an integrated web-based IT infrastructure for a manufacturing process.

2. Virtual work group collaboration

2.1 Work group collaboration

Just as societies are collections of individuals, collaborative computing is the collection of existing and new hardware and software that enables people to communicate, share information, and work together. Collaboration can happen no matter where people are physically located and no matter whether they interact in real time or asynchronously (Woodcock, 1997).
The web supports intra- and inter-organizational collaborative decision making through collaboration tools and access to data, information, and knowledge from inside and outside the organization. Groupware tools can support decision making directly or indirectly, and they provides a mechanism for team members to share opinions, data, information, knowledge, and other resources. Different computing technologies support groupwork in different ways, depending on the purpose of the group, the task, and the time/place category in which the work occurs (Turban et al., 2007).
Groupware tools go by a variety of names, including group support systems (GSSs), group decision support systems (GDSSs), computer support for collaborative work (CSCW), electronic meeting systems (EMSs), collaborative systems, or simply teamware. Groupware products can be organized by their complexity and the length of the time they have been in the market. Level 1, groupware products support communications. Level 2, systems include software tools with statistical features designed to help groups solve complex, unstructured, problems. Level 3, systems in various stages of development, are behind the scenes software agents that can operate to keep projects on track as a virtual team member or serve to facilitate information gathering needs of group members (Regan & O'Connor, 2002).
The effectiveness of a collaborative technology depends on the location of the group members and on the time that shared information is sent and received. DeSantics and Gallupe (1987) proposed a framework for classifying IT communication support technologies. In this framework, communication is divided into four cells that are organized along the two dimensions time and place. Groups, groupwork and teamwork in organizations are proliferating. Consequently, groupware continues to evolve to support effective groupwork, mostly for communication and collaboration. Modern web-based ITs provide an inexpensive, fast, capable, and reliable means for supporting communications. But computers cannot support all communication areas. Networked computer systems, such

as the Internet, intranets, extranets, and proprietary private networks, are the enabling platforms that support communication (Turban et al., 2007).

2.2 Virtual collaboration

The leadership traits and skills needed with virtual teams are not different from those used with collocated teams (Siakas et al., 2005). The difference is in the way they are exerted to create the desired results. Collaboration has three facets (Balstrup, 2004), namely:

- Collaboration within each collocated group
- Collaboration between dispersed group of the virtual team
- Collaboration between the groups and the leader

A potential conflict arises when the team consists of members from different organizational units, because the team does not know where to place its loyalty. In virtual environment this is amplified, because informal communication is reduced (members seldom meet face-to-face). Lewis (2006) stated that Language is a poor communication tool unless each word or phrase is seen in its original cultural context. Therefore, a successful leader of a virtual team must excel in applying the right choice of communication means along with a profound knowledge of the effect of applying it (Siakas et al., 2005).

Teamwork is in essence a result of human interaction, but, in an environment where organizations formulate strategies for becoming global, working in a common place becomes less common. Two important factors for supporting collaboration are loyalty and commitment. The individuals of the virtual team and the leader must build a cohesive team committed to the common goal and through interdependent interaction generate group identity and create the feeling of belonging to the "we" group (Balstrup, 2004). Creation of cohesion is fragile and requires effective interpersonal leadership. The cultural dimension divides the teams into culturally homogeneous and heterogeneous teams. Culture is the most difficult to assess as it embraces facets like language, tradition, values, core beliefs, humor and many more. The virtual leader must posses a profound understanding of the cultural differences within the team (Siakas et al., 2005).

2.3 Virtual teams

Today, technology, speed, globalization, and complexity are rearranging the root premise of work design. Two things happen: Distance and time become problems to solve, and organizational issues develop within rigid hierarchy-bureaucracies. To deal with the demands of competition that force cross-boundary work, organizations create virtual teams. A virtual team is a group of people who work interdependently with a shared purpose across space, time, and organization boundaries using technology. Electronic media together with computers enable the creation of new kinds of spaces. They are real to the groups that inhabit them, yet are not the same as physical locations. However, successful collaborative work requires 90 percent people and 10 percent technology. What works can be boiled down to one word: trust. Technology and resources alone do not enable success; people do. Relationships—technological and human—drive the reorganization of work. Four words capture the essence of virtual teams: people, purpose, links, and time. We are learning new, more horizontally connected, participatory ways of achieving higher levels of small-group performance. We are rediscovering ancient small-group, face-to-face knowledge. At the same time, we're inventing some brand-new skills for the geographically diffuse groups of the future. Teams with trust converge more easily, organize their work more quickly, and manage themselves better. Trust builds with the recognition of the contribution that everyone makes. This "matter of faith" comes from past experience, however brief or extensive. The importance of trust cuts across a team's life cycle (Lipnack & Stamps, 2000).

A virtual team is first at all a team, they see each other like a team more than anything else, and it is characterized by interdependence, shared values, and common goals. Additionally, it is characterized by members who are geographically separated from one another, who communicate mostly through electronic means, and whose boundaries maybe stretched by the inclusion of core and peripheral members, members from multiple departments, and smaller teams subsumed by larger teams (Nemiro, 2004).

Duarte and Snyder (2006) refer about the factors for virtual teams that affect the probability of their success:

- Human resource policies
- Training and on-the-job education and development
- Standard organizational and team processes
- Use of electronic collaboration and communication technology
- Organizational culture
- Leadership support of virtual teams
- Team leader and team member competencies

In addition, they mention that there are different kinds of virtual teams as described:

- Networked teams
- Parallel teams
- Project or product development teams
- Work, functional, or production teams
- Service teams
- Management teams
- Action teams

Nakayama and D´ávila (2003) explain the advantages, benefits, and needs of virtual teams: As for the advantages of virtual teams, we verified that they comprehend both employees and employers. Employees are benefited because they save time that was once spent going to other company units to take part of meetings, and thus they have more time to dedicate to work. Projects can be developed using communication technologies extremely agile and fast, such as e-mail and videoconference. Participants of virtual teams may have in a videoconference the same level of understanding they have in a traditional meeting, besides receiving the information at the same moment. Besides, there is the possibility that members of these teams count on the participation of people from anywhere in the world, or from the company. The organization may also benefit from this practice reducing costs on physical spaces, travel expenditures and other operational expenses. However, the organization must be prepared to implement and maintain the technology necessary for the teams work. It is also necessary that the company provides training and all the support in what concerns communication and collaborative technologies. Employees need to have discipline and work in differentiated times, they need to know available tools and must be aware of the difficulties the lack of physical contact may bring: possible communication noises, lack of motivation or even of confidence (Nakayama & D´ávila, 2003).

2.4 Collaborative work systems

Collaborative work systems (CWSs) are those in which conscious efforts have been made to create strategies, policies, and structures as well as to institutionalize values, behaviors, and practices that promote cooperation among different parties in the organization in order to achieve desired business outcomes. While many organizations vocalize support for teamwork and collaboration, CWSs are distinguished by intentional efforts to embed the organization with work processes and cultural mechanisms that enable and reinforce collaboration. New forms of organization continue to emerge with CWSs as an essential facet. Team-based organizations and self-managing organizations represent types of collaborative systems. The computer revolution has made possible network, cellular and spherical forms of organizing, which represent more trans-organizational forms of collaboration. CWSs provide one of the key competency areas that organizations can focus on for building vitality and excellence, including competitive and collaborative advantage (Beyerlein et al., 2004).

Some forms of CWSs are listed below (Beyerlein & Harris, 2004):

Group Level

- Team. A group of people who have interdependent tasks and shared purpose and who are held mutually accountable for shared goals.
- Community of practice. An informal group or network of people who have shared interests, stories, and common language, but are not necessarily held mutually accountable.

Organizational Level

- Team-based organization. Teams are the unit of work, managers are in teams, and the organization is designed to support teams.
- Collaborative organization. Both formal and informal collaboration is supported, teams are used where need, and the organization is designed to support collaboration.

Some reasons for focusing in CWSs are listed below (Beyerlein & Harris, 2004):

- To increase a competitive advantage
- To create a context for team success
- To promote lateral integration and alignment
- To better connect to your environment
- To increase flexibility

The optimal CWS occurs when group members are provided access to information, knowledge and resources that allow them to participate to the design of unit-level methods for accomplishing the work and the construction of environmental support systems and enabling arrangements. The quality of the participation depends on the ability of group members to establish relationships with other individuals and groups so that decision making (formal authorization, empowerment) and accountability (structure) are clearly communicated and mutually understood within the context of support systems and enabling structures (Beyerlein & Harris, 2004).

3. Practical selection and implementation

3.1 Work process

In the manufacturing process of the company where the study was conducted, when a product requires a replacement part, a swapping sub-process is then followed, where

different teams or groups of different areas conform a virtual work group (for this particular sub-process), they participate actively in order to obtain the required part in time, following the required processes, fulfilling and even over-passing the objectives established. This is a key and sensitive sub-process, due the product will be on hold until a good part is obtained, replaced, tested and only then, it can returned to the manufacturing process again. The cost for having a product in this condition is high in several and different manners, like storing, waiting, transportation, moving/storing materials/paper-work, that according to the Lean 6-Sigma initiative (George et al., 2005), those are waste in the process and have non-value add (NVA) to customers. In addition, the materials' handling increases the possibility of damage in the product, and also impacts the cost. Thus, the different teams that participate require to be focused and have an effective communication and collaboration mechanism.
This is the main reason why we decided to built a system that supports this virtual work group and established the following research question: How an integrated and web-based IT infrastructure conformed by dashboards, workflow and a part's tracking system, can provide of a mechanism for an effective communication and collaboration for a virtual work group in a manufacturing process?. Other objectives for this initiative and project are: improve the compromise and responsibility between participants, and collect historic information to perform further analysis.

3.2 Issue description

Before the prototype was used, the sub-process followed, mainly used the e-mail as a groupware tool, where in every shift (almost at the end), it was prepared a report with the summary of parts pending for replacement, and then it was sent to all teams involved. At the beginning of the following shift, a revision was conducted in order to know which parts will be available during the shift or still will be waiting for a further period of time. However, if a product (that it was waiting for parts), is considered critical or in a high priority, then the communication by e-mail was increased and this also increased the possibility of errors and mistakes, miscommunication, and then process losses. In fact, when there was a high demand of parts, it could happen that the participants look for other communication channels like phone calls, instant messaging (IM), and others, in order to fulfill quickly their needs, where sometimes not all participants and teams were informed or included in the agreements. In addition, this process has implicit many considerations like cycle-time consumption, performance losses, lack of real-time information, workload, lacks of level of detail, less reliable information, deficient historic data for quality analysis as others. All aspects mentioned before, for this particular sub-process.

3.3 Selection of the integrated IT infrastructure

We collected information from all participants of the four different teams, in order to have the best approach of their needs, followed the selection process described below, and built a minimal system in order to put as soon as possible a prototype in production to see if the benefits of the technology after six months of being used, could fulfill the work group needs, the objectives of the process, and the interest of the company. Therefore, the intention of this study is to describe in detail how those objectives could be met successfully.
The mission statement and concept generation, user needs and requirements were followed according to the models and suggested practices presented in the work, Product Design and Development (Ulrich & Eppinger, 2004), and additional references like: IEEE Recommended Practice for Software Requirements and Specifications (IEEE Std. 830-1998), IEEE Guide for

Developing System Requirements Specifications (IEEE Std. 1233-1998), and IEEE Recommended Practice for Software Design Descriptions (IEEE Std. 1016- 1998).
The customization of the selection process includes the following steps: mission statement, gathering information from users, interpret information in terms of user needs, concept generation, establishing requirements, evaluation and selection of the collaborative tools. We adapted and followed up this six step process where allowed us to be focused and keep consistency, where we could have the requirements as objectives for this project that finally, give us the direction for the evaluation and selection of the integrated IT infrastructure.

3.3.1 Mission statement

The mission statement presented below (Table 1), summarizes the direction followed by the project team, and includes some of all of the following information: the product vision or brief description of the product, key business goals, target market for the product, assumptions and constrains, that guides the development effort from the stakeholders. The mission statement belongs more to the product planning phases, but is presented here as a base and initial phase for the selection process.

Mission Statement: Selection and Implementation of an Integrated Web-based IT Infrastructure for a virtual work group collaboration in a manufacturing process.	
Product Description	Integrated and web-based collaborative IT infrastructure using dashboard's functionality (cycle time, aging, and product inventory's levels on hold), with workflow management, and parts' tracking operations.
Key Business Goals	Provide an effective communication and collaboration. Improve the compromise and responsibility between participants. Collect historic information to perform further analysis.
Primary Market	Current manufacturing process for the company of this study.
Secondary Markets	Free open source worldwide community.
Assumptions and Constraints	The system will be accessed by a web browser where in same window the user will interact with all different functionalities required to follow up tasks and parts during the process. Have coordination between participants of the different groups. Execute all steps of the replacement process. And monitor the levels of the Key Process Indicators (KPIs).
Stakeholders/Teams	Warehouse. Test. Quality. Material's planning.

Table 1. Mission statement

3.3.2 Gathering information from users

The gathering information was performed having contact with users and participants through interviews, brainstorming sessions, and observing the areas where the system will be used. Also, the project team belongs to those areas, and this help to understand and identify better the different teams' needs.

3.3.3 Interpret information in terms of user needs

The information is organized regarding to the participant's comments and user's feedbacks, then the information is interpreted in terms of user needs. In this sense, user needs are expressed as written statements and are the result of interpreting the need underlying the raw data gathered from the users.

3.3.4 Concept generation

A product concept is an approximate description of the technology, working principles, and form of the product. It is a concise description of how the product will satisfy the customer needs. The degree, to which a product satisfies customers and can be successfully commercialized, depends to a large measure on the quality of the underlying concept. Good concept generation leaves the team with confidence that the full space of alternatives has been explored (Ulrich & Eppinger, 2004). For the concept generation of this project, it was developed four steps fully explored, that are described as follows: mission statement (as input), technological review, market (business unit) analysis, and generating the concept (in an iterative and spiral approach).

3.3.5 Establishing requirements

Establishing requirements takes an additional importance and is substantially more challenging when developing a high complex product, consisting of multiple subsystems designed by multiple development teams. In such context, specifications are used to define the development objectives of each of the subsystems, as well as the product as a whole (Ulrich & Eppinger, 2004). This step allowed us reflecting user needs and concept generation in terms of product requirements.

3.3.6 Evaluation and selection of the collaborative tools

Evaluating the collaborative tools depends on many factors (Brown et al., 2007), where previous research works have been discussed the need to consider all different aspects that impacts the virtual teams performance (Hacker & Kleiner 1996; Wallace 1997; Nakayama & D´ávila, 2003). For our case and due the nature characteristics and needs of the virtual teams, the manufacturing process itself, the project's objectives, the current capabilities, and the intention to measure all steps in the process in order to look for the continuous process improvement. The workflow, dashboards, and parts' tracking system, were the most appropriate tools to use and integrated in the infrastructure.

3.4 Virtual work group characteristics

The virtual work group of this study is conformed by four different teams or areas as: test, warehouse, quality, material's planning. All teams work for same company but are located at different places and all of them never get together through the process at once. In this sense, some of these different and diverse participants integrated in those different teams;

work at different locations into the company. In addition, there are three different production shifts and one administrative shift, where the process flows and participants communicate and collaborate together as a virtual work group. Therefore and according to the time/place communication framework (Turban et al., 2007), the technology proposed is featured as different time/place. Another classification for this virtual team is for its kind, where and according to Duarte and Snyder (2006), this virtual work team can be considered as for work, functional, or production team.

3.5 Methodology

For the software development process, we decided to follow a composite model from two different approaches. The iterative life cycle model that has become a standard in the software industry lead by Rational Unified Process (RUP), where on behalf the waterfall process, the iterative approach is superior providing a mature, rigorous, and flexible software engineering process (Kruchten, 2000). On the other hand, the requirements prototyping model aims to build a partial implementation of a the system, where the main focus is to express purpose of learning about the system's requirements and capture what was learned when working with the prototype and then use it in documenting the actual requirements' specifications for the real system development (Thayer, 2000). Both models allowed us to construct a prototype in few weeks (four weeks in total).

3.6 Architecture

The diagram presented in the fig. 1, describes the system's architecture with all of its subsystems included. The Web Access to Views/Tabs of System represents the main access' channel; this access can be performed using any Internet browser. In addition, with the back-end application that runs the system. Users and groups' participants defined by category and profile are the users that are only able to access. The Web Services' module makes available the system through the web. The Coordinator Module is the system's core where organizes all in-out operations in an overall perspective. The Management and Security module controls every operation within a security scope, and also manages and coordinates the different collaborative modules/subsystems of the infrastructure. The

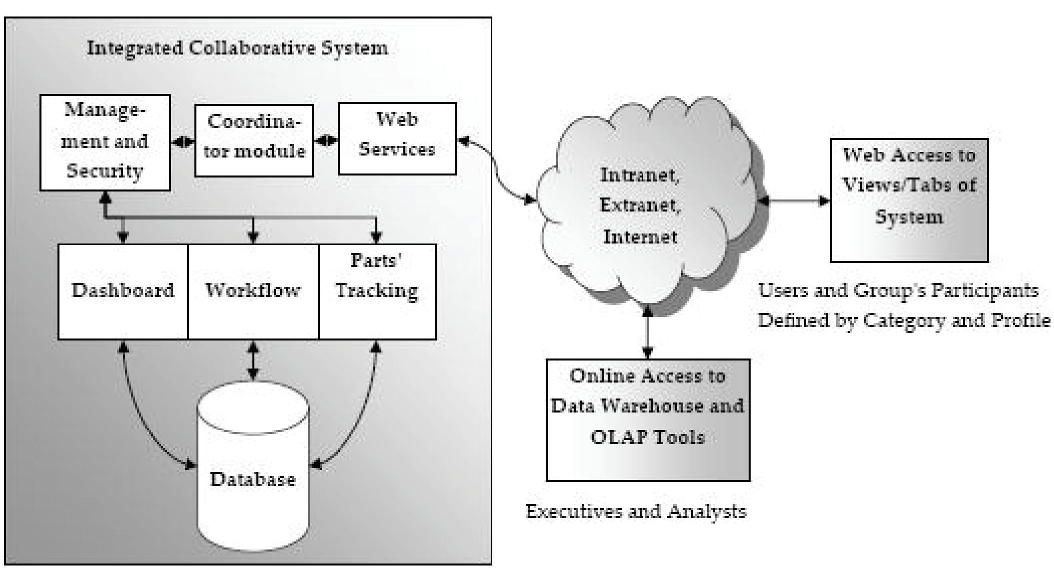

Fig. 1. Architecture. Adapted from González-Trujillo, 2009

Dashboard, Workflow, and Part's Tracking are the integrated collaborative subsystems. The Database is a common repository of all records that are being uploaded to the system. The Online Access to Data Warehouse (DWH) and OLAP Tools module is a complementary subsystem that performs information retrieval (IR), historic analysis, and knowledge discovery for Executives and Analysis usually, but not restrictively.

3.7 Data acquisition and data analysis

In order to retrieve, collect and manage with a proper mechanism the system's data recorded and historic information (around 2,946 records in the table of parts, and 11,474 records in the table of changes), during the period where the prototype was used (six months from March to August of 2008), we built a data-mart (fig. 2), following a multidimensional database model and star-like schema design, where using a DWH and OLAP technology allowed us to acquire all information using pivot tables as visual tool for the Knowledge Discovery Process (fig. 3). This subsystem is considered a complement of the system's proposed.

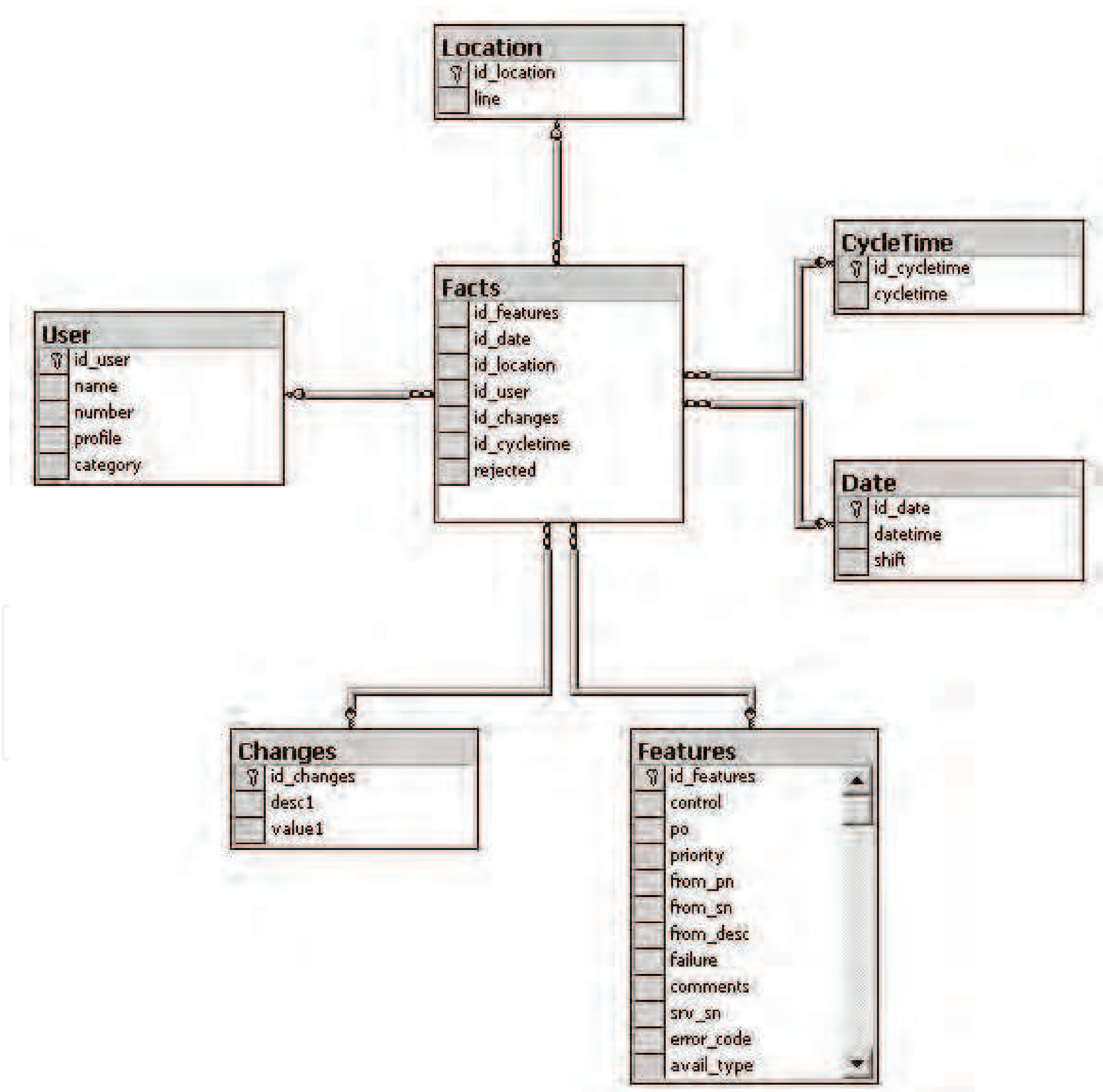

Fig. 2. Data-mart, multidimensional database model, star-like schema design

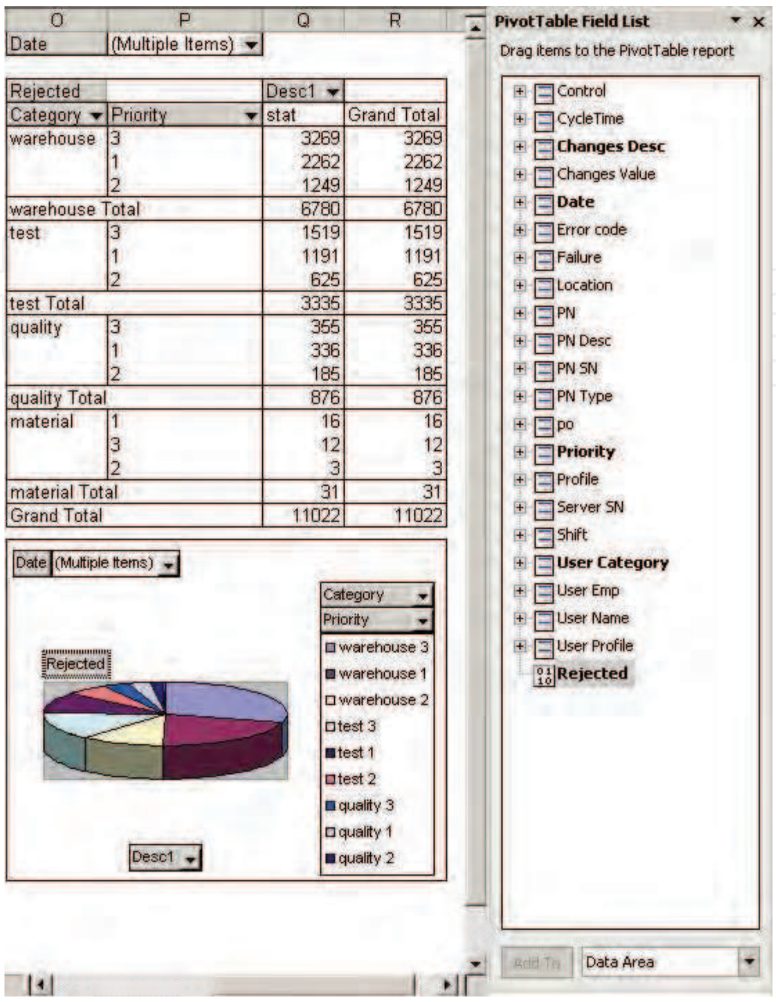

Fig. 3. Pivot table for the Knowledge Discovery Process

Additional comments and suggestions from participant's experience were collected conducting a survey by a questionnaire with open-ended questions, where 22 virtual team members participated from 27 users that worked with the prototype during the six moths of period for this study, representing 81.5 % of total.

3.8 Functionality and operation

The system has different tabs for the same window in the Web browser that constituted all the dashboards required. The first of them is the control panel, followed by the priority, after the detailed tasks' list, and the tasks' capture. Every user in the system is being configured and must be part of a category and profile. Each user's category can participate and work with one or more state changes in the workflow process and which is showed in control panel. Each user's profile represents an administration level in the system, where users of read-only level, can login but not change the process' states, the users of basic level, can change the state and the tasks' features, meanwhile users with admin level, can do all before but add new users. Finally, the user of higher level (root user) also can do all before but add new admin users.

Each task has a state and a group of features (fig. 4). The state' indicators can be configured with different colors or can use a neutral color, and also can select a particular figure for a better identification. When a state is changed by user, the system requests an acknowledgement for security and process' control purposes, and only is accepted if the user belongs to the category and profile required by this particular state that was previously configured. In a sense that users for a category and profile specified are able to change only this state and others with the same characteristics per configuration at the workflow. The same behavior occurs for every feature of each specific task.

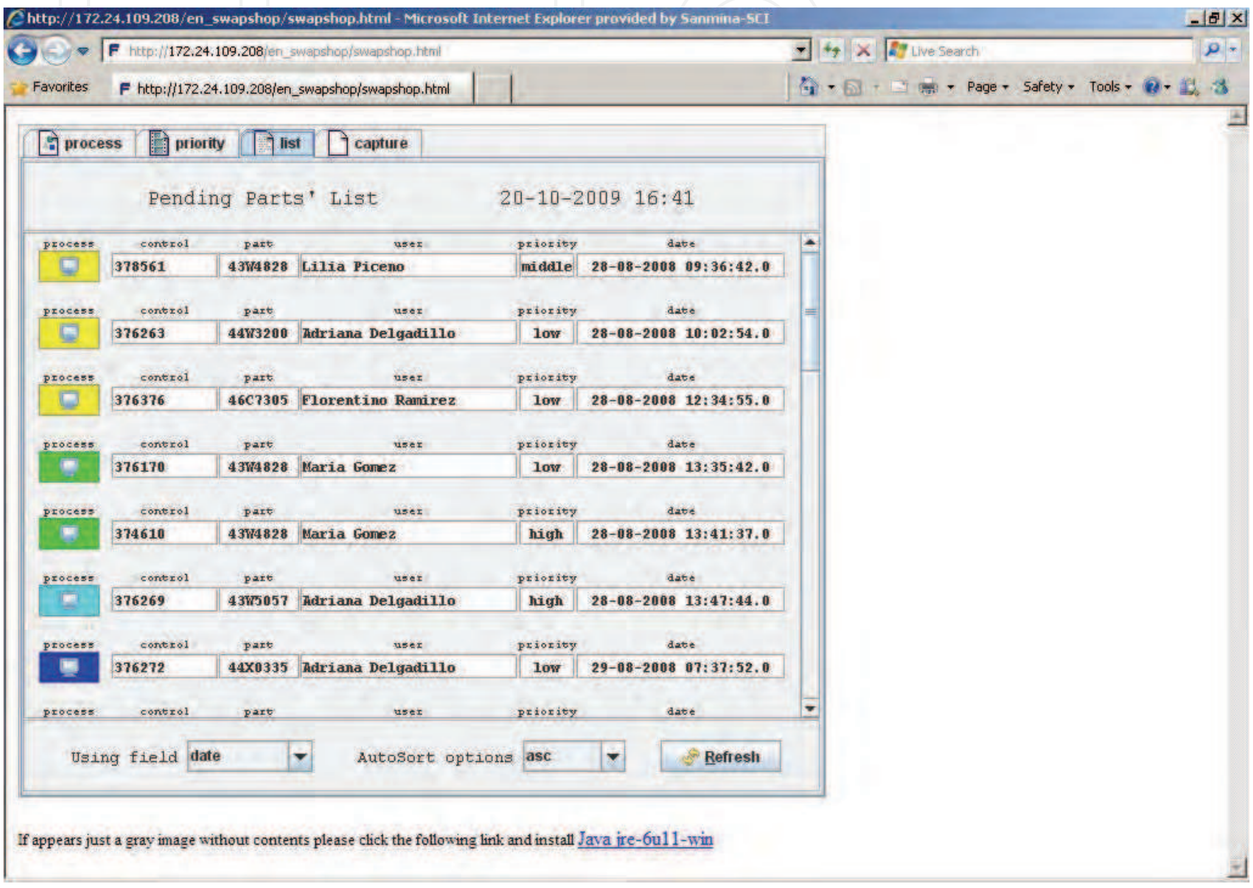

Fig. 4. States of tasks with key features

When a task has concluded the overall process at the workflow, the last operation that is being executed changes the state to historic mode, then the task disappears immediately from all views in the system, giving the impression of not longer exist, but still being available to be acquired through an IR process, with the intention to perform further analysis.

In order to capture the hidden needs and specific knowledge about tasks and parts, we included a box for comments as an additional feature for every task, where users (if they require), can add any comment or extra information required to follow up a particular task through the workflow process. With this, we expect to acquire some knowledge about additional features required for tasks and parts that need to be included but are not in the prototype or in the current production version of the system, even some specific knowledge like detractors, errors and issues found during the process, and being identified by users. After, these comments can be retrieved by other system's mechanisms like IR, for a further support and exchange between participants as knowledge sharing.

4. Findings

4.1 Collaboration results

For this exploratory study, the test team has the most quantity of participants with 74.07%, quality with 14.81%, warehouse 7.40%, and materials' planning with 3.70%. However, the most active collaboration is for the warehouse team with 61.83 %, test with 30.54 %, quality with 7.35 % and material's planning with 0.26 %. This access and collaboration's level is expected due the process' workflow. In this sense, while most changes are performed by warehouse with 50 %, test 25 %, while quality has lesser participation with 12.5 %, and. materials' planning has a maximum of 12.5%, because its collaboration is required just in some cases, therefore is not mandatory (Table 2).

Virtual Work Groups	Collaboration Required	Collaboration Registered	Collaboration Percentage	Partici -pants	Participants Percentage
Warehouse	50 %	6,780	61.51 %	2	7.40 %
Test	25 %	3,335	30.26 %	20	74.07 %
Quality	12.5 %	876	7.95 %	4	14.81 %
Material's Planning	0-12.5 %	31	0.28 %	1	3.70 %

Table 2. Analysis about collaboration

4.2 Communication results

We collected hidden needs and specific knowledge about tasks and parts from the box of comments located in each task, where users could add comments and extra information as knowledge required to follow up the tasks and parts through the process. During the six months of period where the prototype was used, the system registered 440 comments from the different tasks and found that those comments are related with: substitute parts, parts' inventory, part's availability, information sharing, messaging, process related, and blank (Table 3).

Additional comments and suggestions about other benefits from participant's experience were collected conducting a survey by a questionnaire with open-ended questions, where diverse users perceived a cycle time's optimization, system's use simplicity, process' optimization, operation's improvement, better control of tasks and parts, workload's reduction, and acquiring information about operator's performance. We could also have other measurements like cycle time and product inventory's levels on hold, which never before could be collected and analyzed with these levels of detail.

Category	Quantity	Percentage
Substitutes	184	41.82 %
Blank	120	27.27 %
Availability	54	12.27 %
Information	40	9.09 %
Messaging	29	6.59 %
Process	8	1.82 %
Inventory	5	1.14 %

Table 3. Analysis about communication

5. Discussion

Previous research works refer to provide flexible integration of tools for the purpose of business process and workflow process definition (Nagypal et al., 2001). In addition, with integrating individual synchronous tools such as multi-user editors and virtual whiteboards, into a process executed in a workflow management system (Ben-Shaul & Kaiser, 1996). Other works also referred the integration of same technologies like the scalable middleware framework, which can support high-degree decoupling between workflow and groupware (Shaokun, et al., 2008). Our main interest and proposal is focused and dedicated more in the integration of Business Intelligence (BI) using dashboard's functionality (cycle time, aging, and product inventory's levels on hold), with workflow management, and parts' tracking system's operations in a web-based IT infrastructure, to provide of a mechanism for an effective communication and collaboration for a virtual work group in a manufacturing process. The inclusion of dashboard functionality not just allows monitoring the levels of the KPIs in order to keep process' control but for contain in a faster manner issues and within using historical information, optimize the process through analyzing and detecting bottlenecks and repeated patterns of problems that may arise. In addition, it can move forward to keep updating the system with hidden user needs obtained also from the system, and issues found within the information collected, that allows improving the overall system and process together in a continuous process improvement cycle.

A study that has been performed to analyze the current status of cooperative applications in Latin American corporations (where the company of this study is geographically located) referred that e-mail and shared data access are ranked 1/16 and 2/16 respectively, and use both by 96% of the organizations that possess some groupware tool. Meanwhile, collaborative tools are being ranked 9/16 and being use by less than 30 % of the organizations surveyed (Alanis & Diaz-Padilla, 2002). In this same study, the average operative time has been 5 years in tools like electronic mail and information exchange utilities, while the average for collaborative tools have been 3 years. The training time of electronic mail is little more than 1.6 weeks and collaborative tools are little more than 1.2 weeks of training (Alanis & Diaz-Padilla, 2002). Since the gap in both results (especially in popularity and years of use) are for consideration, it gives an idea of what it represents in regarding to the learning curve, knowledge and, experience for this initiative to shift from electronic mail to collaborative tools as proposed, and the insights obtained from this study.

By another hand, there has been reported that collaboration in the manufacturing sector is difficult to implement (Barrat, 2004). It requires the parties involved to make adequate preparation including analysis on various aspects to ensure its readiness to be engaged in such demanding relationship (Ismail & Alina, 2008). In this context, this project exposes a practical case that could help (within other related works), to understand better collaboration in the business segment (EMS: electronic manufacturing services) in order to support and establish a common framework for virtual work group and web-based collaboration.

However, this study don't propose a different approach, or a new foundation for virtual team collaboration, but also it contributes performing a quantitative analysis based in historical information collected during the period of use of the prototype implemented, that it was made possible applying DWH and OLAP technologies, that acquired, integrated and transformed the data stored when using the collaboration system in multidimensional data, that allowed to obtain an overall perspective, valuable information and knowledge, described in the results section. Therefore, it provided of a method to analyze information in a deeper and faster manner from collaboration systems that could serve to obtain further insights for this and other research studies.

6. Limitations and conclusions

This is an exploratory study, therefore the conclusions drawn for this study must be considered in this sense. The study explores the selection and implementation of an integrated and web-based IT infrastructure (dashboard, workflow and parts tracking system) that can provide of a mechanism for an effective communication and collaboration for a virtual work group in a manufacturing process.

Principal benefits describe an active collaboration between groups and participants, where groups like warehouse (61.51% registered from 50% required) and test (30.26% registered from 25% required) overpass their collaboration, quality did in a lower level (7.95%) that corresponds to a 63.60% from the expected level (12.5%), and materials' planning was between the range (0.28% registered from 0-12.5% required) due its collaboration is required just in specific cases and is not mandatory for every task. It's important to mention that the most active collaboration corresponds to groups that their participation are required at most in order to fulfill the needs for this process, due the principal objective is to obtain the replacement parts in the right time and place, and these parts are requested by the test's group and acquired and provided by the warehouse's group.

In addition, the system collected hidden needs and specific knowledge about tasks and parts from the box of comments, where we obtained 440 comments, that 120 comments are blank. Then we have 320 effective comments from 934 parts replaced, that it represents 34.26%, in a sense of having one comment per three parts followed and replaced in the workflow process. Also, it's important to establish that these comments are not mandatory for workflow process; the users place them as their response and contribution. However, we analyzed and categorized those comments into seven groups and found 120 records as blank that it represents 27.27%, but most comments are for substitute parts with 41.82%. Therefore, the participant uses the system also as a communication channel to fulfill the needs of process and teams. With this, we expect to update the system with new features and options to allow managing better this information and collect and share the knowledge during the process that could feedback other users and participants for the improvement and optimization of process and operation. Thus, we can establish a continuous improvement and updating cycle for the process and system altogether.

The use of the system allowed following up the tasks since the beginning to the end of the process with full detail for each record, keeping historic data that could be used for further analysis. Additional benefits were also obtained from the use of dashboards, workflow and parts' tracking while using the different modules visually managed by tabs through the integration of the collaborative tools. Some of these benefits are: cycle time's optimization, system's use simplicity, process' optimization, operation's improvement, better control of tasks and parts, workload's reduction, and acquiring information about operator's performance.

A major compromise and responsibility between participants were also noticed from the impressions of participants. Finally, we could capture, see and understand that the system successfully enhanced the group presence while promoting an effective communication and collaboration. Therefore, the benefits from the selection and implementation of the system answer the research question established.

7. Future research and project

Future research works can be addressed for this project and other replicas used for other business units and processes that can provide further insights for groupware evaluations (Pinelle & Gutwin, 2000), and to support, design and establish a framework for best practices and lessons learned, that if the case, serve as a baseline to look for models, explore and develop standards based in a common standard-based foundation (Tomek, 2003), that in consequence will address common efforts of researches developers and practitioners dedicated to all different and diverse aspects of collaboration.

We expect to complete the implementation of the final release of the system where we can include as new requirements, all the feedback and hidden needs coming from participants as part of the analysis, results and conclusions drawn from this study.

On the other hand, the project was already accepted as a free open source project (Gonzalez, 2009) where we are looking to include additional modules with features that allow reconfiguration and customization, and then have a system available for the free open source worldwide community.

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