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Collaborative Engineering Communities - Architecture and Integration Approaches

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ABSTRACT

Regarding the growing task distribution in the area of design and product development (engineering) the idea of communities gets more importance next to the creation of classical development partnerships in engineering. Communities are known as a new organizational kind for users of electronic communication media. The main aim of this paper is to transfer the idea of communities to engineering networks. Therefore an overview on creation, requirements and profit of collaborative engineering communities is provided. Also a possible integration is shown between collaborative engineering environments and enterprise resource planning systems.

Keywords: engineering, community, portal, collaboration, life cycle management, virtualization, ERP system, integration

1.THE CONCEPT OF A COLLABORATIVE ENGINEERING COMMUNITY

A collaborative engineering community will be understood as an organizational kind of collaboration between firms in the area of product development, which integrates all users and organizational units joining in the product life cycle and which provides all data, information and knowledge elements necessary for telecooperation.

Specially because participants of the late phases in the product life cycle like customers and consumers should be integrated (Richter and Krause 2001) common approaches for engineering networks (Puffaldt 2001) have to be widened.

The community approach presented here is different from commercial off-the-shelf product life cycle management (PLM) solutions, because these do not integrate consumers and vendor independent distributors. Available PLM systems like SAP R/3 or PTC's Windchill allow an access to data and functionality only for users directly participating on design, engineering, development, prototyping, manufacturing, assembly and quality assurance. Although it is possible to grant access to other participants in the process of product development, this is limited to users with the same role properties. Such role properties can be for instance abilities to work with engineering applications or a common understanding for the structure of the product. This is one reason that in the vendor independent truck market there is no direct access to engineering information although trucks are long living investment goods.

Also with the available PLM solutions it is not possible that consumers directly or through their distributors judge quality, lifetime and ergonomic properties of products or parts. This information has a strong influence on decisions concerning the further development of the product, but is actually only available in a derived matter (e.g. through spare part orders) or many times filtered and converted (e.g. through statistic census).

Main aim of the development of collaborative engineering communities is to integrate the groups of consumers and independent distributors in the design phase of product life cycle. The available PLM solutions are only partially appropriate to reach this goal.

Additionally representatives of the consumers are integrated in the process of engineering. The integration can be done using communities described in the following section.

2. COMMUNITIES AS A NEW FORM OF GROUP ORGANIZATION

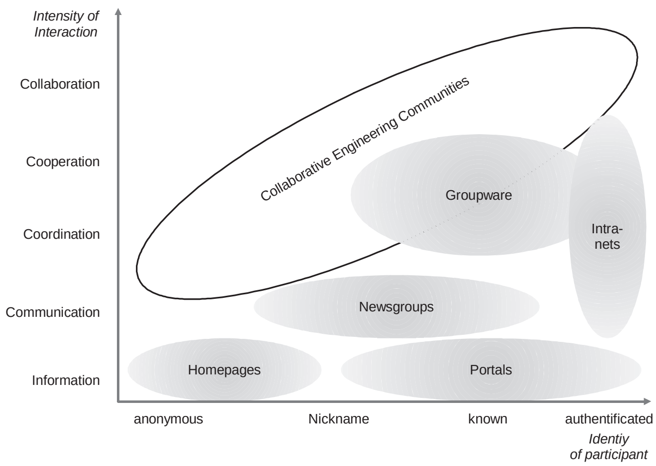
Communities are one kind of loosely organized groups discussed in the field of internet economy. Lechner and Schmid (1999) define communities as an association of singles (agents) which share a common language, values and interests and which communicate with each other in roles using electronic media. The members of a community can share the same or complementary interests. Frequently the equality or complementarity of interests is only a question of the degree of abstraction or of the wording of the interests. In a society which produces a good all members have the same interest to produce the good and to maximize their individual profit. On the other hand the interest of agents which belong to exchange relations is complementary. In this case supplier and buyers of parts or customers and vendors can be distinguished. These groups define themselves nearly completely by a common interest in a special topic. Members of communities identify themselves with a nickname, but provide much more information about them, depending on the kind of community. Earlier communities are used only to communicate or to exchange information. Therefore only a few rules exist how to behave in a community. If a moderator exists who supervises the posting of articles of community members and who purges unallowed articles from the discussion area of the community, it can be supposed principally that a heterarchical coordination of topics discussed in the community exists (cf. Corsten and Goessinger 2001).

2.1 Typology of communities

Precursors of communities are newsgroups widely used in the internet and extranets in the area of business to business communications. Another kind of group creation different from communities are groups of persons which are summarized belonging to a common work context. Here groups are not individually generated but ordered by management or pretended by business processes. Frequently these groups are working together using internet technologies, too.

Communities and the other mentioned groups can be put in order into a grid which differentiates between the anonymity of the users and the mechanisms of interaction (fig. 1). The differentiation using mechanisms of interaction is described in the following section.

Fig. 1: Differentiation of groups using interaction and identity



2.2 Mechanisms of interaction

A descriptive property of distributed systems is the concerted fulfillment of the task. Formal mechanisms of interaction with different degrees of intensity are communication, coordination, cooperation and collaboration. All mechanisms of interaction base on information exchange.

Communication

Communication is defined as the exchange of information. Information are defined as purpose or target oriented data in the field of business information systems. An equation of information and knowledge which can be found in literature sometimes is however wrong because knowledge needs human beings as knowledge bearers. Of course it is possible to change knowledge into information during explication (Gronau and Kalisch 2002).

Specially in engineering it can be seen that the task fulfillment does not become more efficient with access to information only. Orientation knowledge is rather necessary to be able to put the information in order, to value them and to determine their profit. Information does not contribute more to the design of task fulfillment in an distributed context than the exchange of data. Specially information does not structure or priorize task sequences.

Coordination

Mechanisms are needed to handle complex economic systems and to fulfill the system's purpose which provide a guiding influence on the system's elements and the processes running in the system. The main task of these mechanisms is named coordination. The aim of coordination is to integrate the actions of elements and subsystems to reach the goals of the whole system (Fischer 1994). Coordination has therefore an integrating and tuning function during task fulfillment in distributed systems. It does not describe the distribution of actions between elements of the system while working together on a common task.

Cooperation

Cooperation can be defined as the shared production of goods or services between distributed agents, organizational units or organizations (Schmidt 1997). If the cooperation is supported by appropriate media it is called telecooperation (Reichwald et.al. 2000). The degree of spatial or temporal distribution can be pictured using the so called „Anytime-Anyplace-Matrix" (OHara-Devereaux and Johansen 1994).

Collaboration

Communication, coordination and cooperation describe tasks which are fulfilled by single elements of distributed systems. A special case of cooperation is the common execution of an action or a set of actions at the same object by distributed task agents. This shall be named as collaboration. Examples for collaboration in the field of engineering are the common distributed edition of a document or the common definition of product properties. The cooperation mechanism has to be supplemented with features securing a consistent, unified and reusable work result. With coordination the work tasks are fulfilled uniquely by task members 1,2 or 3 (persons or groups) which exchange start and end dates, task descriptions and take over conditions to assure a common work result. With collaboration an integration of work fulfillment takes place. The task members work together to fulfill the task to that a dissolution of partial actions is no longer possible. Therefore the information on tasks must be shared and supplemented by a version management, field and data set locks and different access rights..

3. ENGINEERING AND LIFECYCLE MANAGEMENT

The term engineering combines all actions in the process of product development, which are design, work planning, NC programming and the handing over of results to manufacturing and assembly. The life cycle management approach covers also the collection, processing and archiving of all product relevant data in the whole life cycle of a product. This life cycle begins at development and goes from manufacturing, productive use, collection of quality data during usage till the scrapping of the product concerning recycling aspects.

In this paper specially the integration of vendor independent distributors and consumers in the cycle of product life time is described. Main questions in this approach are the integration between separately working information systems and the generation of a feedback loop to the early stages of product life cycle. The business aim is to collect data only once and then use often to minimize change efforts. With a content oriented viewpoint it is the aim to use knowledge from the usage of a product during the development of its successor. This could not be done systematically in the past because a complete set of usage data was only available in special cases (e.g. with documentation obliged assets) and no suitable interface between the different systems collecting life cycle data existed.

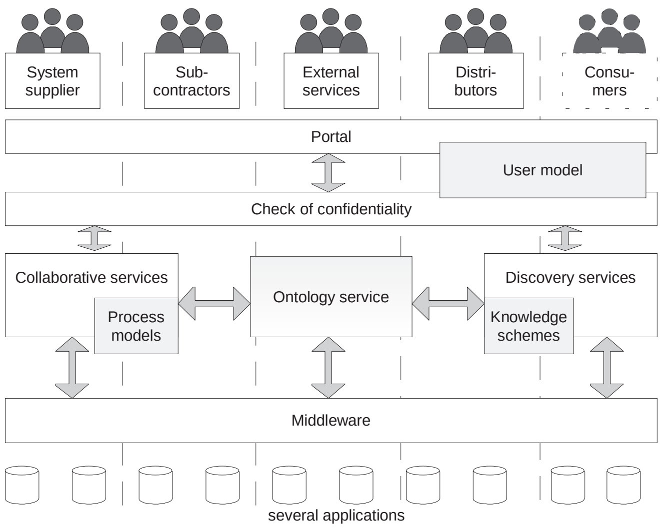
4. REQUIREMENTS FOR COLLABORATIVE ENGINEERUNG COMMUNITIES

The further development from working groups in the field of engineering to communities is supported by the following trends:

- The rapidly growing bandwidth of the internet, specially of the WWW, now allows next to communication, information and cooperation a spatial distributed collaboration.
- Because of the increasing importance of life cycle management the communication with (possible) product users in all stages of the product life cycle becomes more important.
- Communities, actually used for exchange of opinions mostly are enriched with collaborative elements like the judgment of articles written by other community members or the signing of shares which are recommended in the community. It can be expected that new impacts for electronic business processes can be generated by the idea of communities (Truscheit 2000).
- The stronger systematization and segmentation of sourcing instead of manufacturing (establishing of system suppliers with far-reaching responsibility for product development) produce a heavy need for cooperation between firms.
- Because the market claims for shorter development times, customer requirements and consumer reactions are to be integrated more efficiently into the engineering process.

Collaborative engineering communities need a lot of organizational and technical flexibility to reach fast and efficient changes in the configuration of partners participating in the development phase and in the process models of product development with a low effort of hierarchical interventions, if possible.

Fig. 2: *Proposal of an architecture for collaborative engineering communities*



Their information systems architecture, which is defined as a planned cooperation of technical, organizational, cost-related and social aspects during development and usage of business information systems, needs a high ability of self-organizing and partial decision autonomy to be able to integrate new cooperative partners into the engineering community very fast. For that appropriate coordination mechanisms are to be delivered to differentiate between certain levels of confidentiality on the one hand and to develop a common understanding (contents and semantics) for facts on the other hand.

5. PROPOSAL FOR AN ARCHITECTURE

Basing on the considerations in the past sections an architectural model for collaborative engineering communities was developed (fig. 2).

Different groups of users and other participants in the engineering process form the collaborative engineering community. As a rough classification of the different roles and perspectives the following scheme can be used:

- *System supplier*, which are responsible also for development and cost against a contract awarder. A system supplier typically is responsible for the delivery of complete modules. He manufactures these modules in cooperation with his contract awarder and other supplier (Luczak and Eversheim 1999)
- *Subcontractors*, which deliver material and parts defined by the contract awarder, but are not system supplier.
- *External services*, which supervise the project course (in the area of construction known as project steerer). They are less interested in technical parameters of material and parts but more interested in parameters of the process model (dates, budgets, capacities).
- *Distributors*, which sell the product to the final customers and which are first contact for product properties (during purchasing and if quality defects are occurring)
- *Consumers*, which play a part in some stages of the process or are related to some components and which are not covered by one of the other roles.

5.1 Description of the architectural building blocks

It was detected as useful to grant access for all types of users by a common portal. A portal not only indicates the unified access but at the collaborative engineering community it also delivers the personalization after an appropriate authentication.

The results of personalization and authentication determine the possibilities for the members to move inside of the collaborative engineering community. The results are represented by the view models in the user model. Here it is defined, which information is accessible by a certain group member in a certain role. The accessibility is defined for objects, process steps and competitive relevance. A user in the role of a system supplier sees these parts in the object area, which are delivered by himself and surrounding parts to be able to check assemblies.

In the process area the accessibility of certain process information is defined. The role external service perhaps does not need information from the usage stage of product life cycle. On the other hand user groups as cooperation partner should only be able to see product properties from the stage of product definition and then be integrated highly into the results of field surveys.

Crosswise to these aspect definitions basing on objects or process stages the degree of confidentiality is defined for sets of information. The resulting view of users on the collaborative engineering community is determined by the totality of restrictions and releases.

A block layer between portal and system functionality supervises during all activities of the users, that the maximum valid view is not exceeded. To log accesses and access trials and to canal accesses the block layer is formed as a separate software module. This makes the protection easier against security holes.

On the next layer of the architectural model of the collaborative engineering community services are provided. It is stated that the most users need the discovery services, which allow a supply with information or reports about process steps or objects. In the discovery services a realization is possible of

- search engines
- information warehouse technologies
- life time tracing systems (Anderl 2000)

and other on digital past data basing information procurement tasks. As a supporting element the discovery services use a meta model of the information sources available in the community, which is named as a collection of knowledge schemes. This kind of meta modeling can be compared with the representation of repositories in data warehouses (Mertens and Wieczorrek 2000) and contains:

- descriptions of knowledge sources
- time data (dates of creation and of input into the system)
- source descriptions
- classifications
- key words
- format information and
- links between the knowledge sources

The collaborative services provide tools for the joint distributed design and engineering. Today available systems allow joint viewing, digital mockup and joint editing. These functions will be enlarged with rising bandwidth on the internet. Process models are used here in the same function as the knowledge schemes of the discovery services.

A central element to assure a common understanding between different groups of users is the usage of a common world of terminology. Independent term contexts are defined in the different user groups at first, because special and local networks of terms and meanings are used. In the process of communication with other user groups terms are interpreted in a different manner, which impairs the efficiency of communication and any collaboration based on that communication. A solution for this problem is the usage of ontologies (Maedche 2001). This task is fulfilled from a component called ontology service. A proposed task of the ontology service is the standardization of different term usage and the generation of hints if not solvable conflicts occur. Then a manual solution of the problem is necessary to extend the taxonomic knowledge.

The access to the applications reachable via the collaborative engineering community is delivered by a middleware building block. The middleware provides appropriate functions or applications for every user according to the user model with the permitted set of data and information. Possible applications are

- business administration and information systems (Gronau 1999)
- production engineering tools
- product data management systems and

Tab. 1: ***Collaborative functions of common CAD systems (Ibelings 2001)***

System	Manufacturer/ Distributor	collaborative functions
CATIA V4 R. 2.4	Systemes Dassault	File-Sharing and Locking, Web Conferences
One Space Version 5a	CoCreate	Virtual real time conference room
SwissPrecision Manager	Precisionsoft	Accesses during release process
DIG-CAD 4.0	LLH Software	Joint Viewing
Windchill	Parametric Technology	Visualization in the Internet
SolidWorks 2001	SolidTeam	Concurrent Environment
CADRA 11.5	SofTech	Project management, right management for groups and users
Xbrioso	Tecoplan	Virtual project room
Unigraphics V 17	Unigraphics Solutions	Viewing and Application Sharing
Solid Edge	Unigraphics Solutions	Automatic messaging mechanism

- CAD systems

CAD systems are a possible class of applications because they support collaborative work at least a little (tab. 1).

5.2 Presentation of a process example

A process example for the use of a collaborative engineering community is described as following:

The consumer, a customer of a truck rental company, wants to criticize the operating lever of the windshield wiper. Using the portal he gets access with the role „occasional user of the product". From the provided truck models he chooses that one he rented. Three-dimensional views and other product defining properties are gathered from the product data management or ERP system of the truck manufacturer, as far as the information is released for his role. In this process it is possible to state that the user's critic does not only concern one truck model but a whole family of trucks.

The consumer chooses one from a list of released aspects and is also able to describe the part he wants to criticize. The ontology service now tries to create a corresponding link between the description of the user and the part name in the manufacturer's ERP system. This can be done interactively if no clear identification is possible.

Now the consumer enters his text about the insufficient usability of the part and stores his article. If he is a registered user of the platform he can see and judge entries of other users. If the manufacturer has defined and stored design targets and if they are released for his role the user can read these targets, too.

This process example shows how life cycle management can be enriched by information from the consumers view, while permanently the product model of the manufacturer is used. Additionally it is possible to gain relevant information for the customer relationship management.

6. CONCLUSIONS

One of the critical success factors for the integration of collaborative engineering communities into life cycle management is the availability and accessibility not only of data but also of related knowledge. One possible solution path could be the integration of specialized knowledge management systems, which link knowledge bases with product data management systems. Another key task will be the integration of the heterogeneous data stocks. Middleware solutions seem to be able to realize this in the framework of a collaborative engineering community.

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