Asynchronous Cooperation Support for Distributed Collaborative Information Modeling

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Most standard software suffers from shortcomings in the support of group activities. Even so-called „multi-user"-applications restrict their group support to the ensurance of database consistency and concurrency control. This paper deals with the extension of two standard software applications for process modeling by providing integrated coordination and cooperation functionality. The approach taken is by no means domain-specific, the tool presented could also be used in other areas such as Data Base Management, Computer Aided Design, Word Processing, Project Management, i.e. wherever a decentralised group works on shared artefacts. It will also be shown how a group working on interrelated tasks with different tools and objects can be coordinated by the system.

1 The Extension of „Multi-User"-Applications to Groupware

Standard multi-user software, even though designed for the use by decentralised, networked groups frequently does not deserve its name. Often, it suffers from its historical evolution. Many of these applications have been upgraded from single user versions, preserving the focus of task support for single users. Hence, no assistance whatsoever is given to the user who wonders about the origin of changes to data he previously treated. In this paragraph, different types of collaboration support will be presented and classified in a conceptual framework.

Situated at the core of the model is standard multi-user software for solving individual's tasks. In order to achieve real support for collaboration, coordination and cooperation functionality has to be provided. Software facilitating coordination activities about the work objects can be considered as „teamware". If cooperation is also supported, the term „groupware" is used. Figure 1 depicts the relationship between these levels.

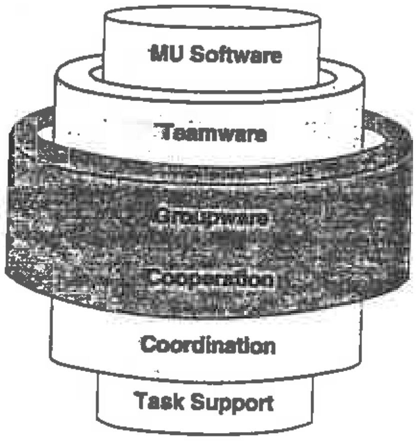

Fig. 1: Three levels of collaboration support

Below, a definition of functions required for these classes is given[1]:

Multi-user software:
- User access restriction to application and data,
- Information sharing (facilitation over networks):
  - data sharing,
  - data consistency enforcement,
  - access concurrency control,
- User monitoring.

Teamware additionally offers coordination technology, i.e.:
- Access to meta-data (i.e. information who changed data and why),
- Information supply:
  - giving the user information about other user's activities,
  - traceability of changes to data,
  - access to procedural models and reference knowledge,
  - shared terminology,
  - mail filtering and information subscription,
- Monitoring:
  - product monitoring,
  - user activity monitoring.

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[1] The approach taken here is general, thus requiring a modification of the original concept (Vessey, Sravanapudi 1995).

Groupware additionally offers cooperation technology, i.e.:

- Communication support (ideally structured and multimedial),
- Time/meeting and project management.

In order to work efficiently, these functions have to be integrated. The mere availability of email or project management software does not mean that users will draw full profit of it (see Markus, Conolly 1990). Below is described how this generic model is realised by ContAct, a collaboration tool offering a simple Application Program Interface (API) to standard software. It permits users to coordinate their work, trace colleagues activities, consult procedural models, establish links between objects of different applications and overcomes a disadvantage of generic email systems, the missing contextual reference of messages. Since we started our work extending two software packages for process modeling with team- and groupware functionality, reference to this application domain will be made frequently. This does not mean, however, that the tool is limited to this area.

2 Introduction to the Application Domain

The time when information models (especially data models) were only used for definition and construction of databases is gone. Today, we are facing many different types of models that are used as a basis for planning, construction, maintenance and decisions in the field of information and communication technologies (see Lehner 1994). Modeling has become a task which is not any more performed by single persons, but in groups, often even distributed over different companies and organisations.

By doing research in enterprise modeling and business process reengineering we recognised that besides the existing tools for the development, analysis and simulation of enterprise models other types of tools are needed, i.e. one which supports process management within modeling projects, tools for the cooperative work during modeling and tools for the multimedial documentation of models.

Based on the ARIS-Architecture which includes different types of models such as data, functions, organisational and process models (see Scheer 1992) we are doing research to improve the construction, use and understanding of information models. Examples of types of models which have a strong relationship but are still developed independently from each other are Business Process Models (BPM) and Workflow Models (WFM). Whereas BPM describe business processes in a semi-formal way from a general, business-relevant and organisational point of view, WFM are formal and describe workflows in much detail and in a technical way (see Galler, Scheer 1994).

This article deals with a coordination concept and a groupware tool for the transformation of BPM to WFM. Therefore, we first describe our understanding of workflow management and then show how a groupware system could contribute to better coordination during the modeling of business processes and their transformation to workflow models.

3 Decentralised Modeling of Business Processes and Workflows

Their usefulness to support the automatisation of standard business processes in offices as well as manufacturing areas has led Workflow Management Systems (WMS) to become very popular during the last years (see White, Fischer 1994). Workflow applications are often chosen as a technological enabler for business processes which involve many employees on different locations and/or need a better system integration, better process control, higher quality and/or improved customer focus.

Process models are the basis for the development of enterprise-specific workflow applications. Whereas the models describe the process structure and logic on an abstract type level the workflow application supports the execution of single processes on the instance level. Tool support for business process modeling requires computer-based means for representing and processing models. It covers functionalities such as model representation and manipulation. Major functions of a model management system are (see Chang et al. 1993):

- model construction and storage,
- model selection/retrieval and analysis,
- model configuration:
    - model integration,
    - model adaptation and modification,
    - model evolution and change,
- model execution and interpretation.

Just as the definition of data structures in a database management system leads to a specific database, the definition of a workflow model in a WMS results in a particular workflow application. In contrast to the generation of program code out of models as was intended in the classical CASE approaches, the development of workflow applications is based on the configuration of existing software building blocks and therefore supports the reuse of software.

Available WMS integrate modeling systems for the graphical definition of process models (i.e. FlowMark, FlowPath, Workparty, Cosa, FloWare etc.). In comparison to existing architectural frameworks for business process modeling the functionality of these systems and their modeling concepts are quite poor. They do not support the construction of models in separate views like data, organisation, function and their integration in a central process view. Each WMS-provider has defined his own method for modeling processes. These methods are in most cases a derivation of Petri-Nets. Currently the Workflow Management Coalition is working on a standardisation for process modeling within WMS (WfMC 1994).

The transformation process can be shortly characterised by the following aspects:

- At the beginning of Business Process Re-engineering projects it is not known which technology would be the most appropriate to support the business process. Therefore BPM are a basis for the identification of the needed information technology.

- The business process analysis on the one hand and the organisational and technical realisation of the determined best-practice model on the other hand is performed by different people with different know-how in strongly overlapping teams. This is shown in figure 2.
- The transformation of business concepts (expressed in BPM) into information systems (for example WMS) is not a simple derivation but a creative process which includes many feedback loops between organisational and technical experts.

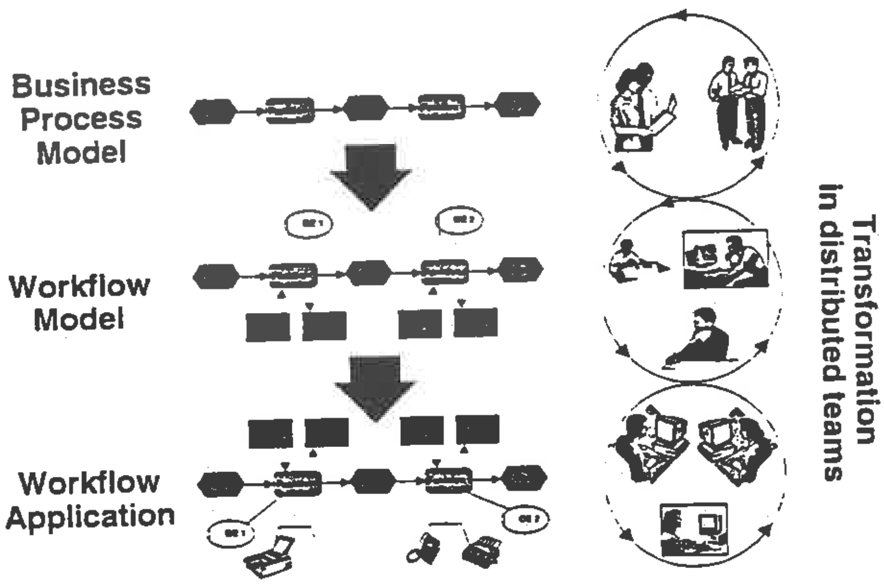

Fig. 2: Transformation of BPM into WFM in interdisciplinary teams

We have accomplished case studies in 17 companies which have implemented or are in the process of implementing company-specific workflow-applications (see Galler et al. 1995). From this empirical research we have figured out different strategic success factors for the development of workflow applications. Each of those 17 companies had engaged consultants to evaluate the state of the art of the business processes and develop alternatives for the reorganisation. Only one out of those 17 companies could directly reuse the results of the consultancy services for the implementation of a workflow application. The main reasons for this poor integration of requirements analysis and the implementation of an appropriate system are:

- Requirements specified through process models could not be reused during the implementation of the workflow application because the developers did not understand the syntactic and semantic aspects of the models and could therefore not transform them.
- The reuse of the process models resulting from requirements analysis during the definition of workflow models could not be coordinated successfully because the project partners (consultancies, software developers and user) where locally distributed.

For the transformation of business process models into workflow models we have to focus on both the methodical and organisational aspects. From the methodical point of view we can separate in general methodical issues and the notation a method has to have for enabling modelers to transform the type of models. General methodical issues are for example whether the method supports modeling in different views (e.g. as in ARIS: organisation, function, data and control) or allows to structure models on different interconnected levels. The notation of a method enables modelers to find out what type of modeling constructs are allowed and can be used to develop a model. Since constructs used for workflow modeling can differ from those used for business process modeling it is important to choose a method carefully.
Hence, this paper primarily deals with the organisational implications for a successful methodical model transformation. From the organisational point of view project organisation, coordination of activities as well as control of results is central. Since the project members are typically working geographically decentralised their collaboration has to be supported by an integrated tool.

4 ContAct: A Groupware System Used for the Management of Modeling Activities

The groupware tool ContAct presented here is integrated in two modelling tools and therefore supports cooperative information modeling. Its functionality focuses on the asynchronous and locally distributed coordination of activities as well as the support of synchronous communication for cooperative work. The basic mechanisms for multi-user access to data are not of its concern. Experiences made in past research and industry projects have led us to specify ContAct together with two companies which develop and distribute modeling tools[2] and are facing coordination problems during information modeling. ContAct has been developed focusing on the stepwise transformation of BPM to WFM but is not limited to this application area. In the following we describe three central working areas for ContAct where the main focus lies on the coordination of modeling activities.
Currently available modeling tools do not provide coordination mechanisms for cooperative information modeling. This leads to a number of problems that increase the cost of modeling projects and which can be reasons for modeling errors and bad quality within big modeling projects. Listed below are some key problems which are the result of several interviews made in research and industry (see Galler et al. 1995):

1. If more than one person is involved in the construction of an information model they have to meet to coordinate their activities. Often a printout of the first version of a model is the basis for such coordination meetings. If meetings cannot be scheduled the printouts are commented on by hand and sent via mail or fax to locally separated modeling partners.

[2] ContAct is developed by the IWi, sponsored and cooperatively specified with IDS Prof. Scheer GmbH which distributes the BPR Tool "ARIS Toolset" (see Scheer 1994) and the IBM German Software Development Laboratory which is responsible for the development of the WMS "FlowMark" (see Leymann, Altenhuber 1994).

2. Persons which have constructed an information model or are responsible for a model are often not aware of changes in these models which are made by third parties. Consequences of such changes are often recognised too late which makes it difficult to maintain a model up-to-date.
3. If someone has to work with an information model which has been constructed by someone else he often can not find out who has developed the model and what the semantic meaning was when the model was constructed.

As a consequence of this findings we have investigated in coordination theory to find coordination mechanisms which could contribute to the development of a problem-adequate groupware system. Following the three-level concept for collaboration, we will describe how cooperation and coordination have been added to the tools.

4.1 Coordination

The coordination of different experts working with common objects is a key functionality of ContAct. This is not limited to a single tool but covers coordination functionality for the definition of BPM in a BPR tool and the refinement of these models in a WMS. The implemented coordination mechanisms integrate aspects of different coordination theories like IBIS (see Kunz, Rittel 1970) and the speech act approach (see Winograd 1988; Medina-Mora et al. 1992). The experience made in other implementations of these theories like the Coordinator (see Ellis et al. 1991), SEPIA (see Haake, Wilson 1992), CoDecide (see Jacobs, Kethers 1994), CONSUL (see Ludwig, Krcmar 1994) and others has also been considered. ContAct is thought to support the coordination of unstructured and semi-structured activities. The asynchronous coordination is based on a coordination cycle similar to the approach shown in the Business Design Language (see Schäl, Zeller 1993). For the synchronous coordination it is possible to leave the coordination cycle and communicate over audio- and video-conferencing.

4.1.1 Control

Coordination control can be seen from various point of views. Following Vessey/Sravanapudi (Vessey, Sravanapudi 1995) coordination control refers to mechanisms which regulate the access rights group members have to the different project models and documents. Most of the available modeling tools already integrate such a log-in mechanism so that ContAct takes the part of supplying a complete organisational model and leaves the access restricting mechanisms to the modeling tools. Rather, it shows which user is working with which model.
For us control is not limited to checking user rights but includes mechanisms enabling the awareness about group activities and modifications in the objects (artefacts) with which the group is working (in our example information models).

4.1.2 Information Supply

Information sharing is essential for team work. This includes information about the ongoing work processes as well as information about probably interesting things in the past or future.

4.1.2.1 Data Sharing

Data sharing can be regarded as a basis to achieve information sharing. In ContAct we differentiate between data about the work items or objects and group work data. Whereas the modeling tools manage and store the data about information models, ContAct manages all the data relative to the work a group performs during the building or modification of information models. To ensure the right association of group work and work objects data ContAct has to be kept informed about changes in the work objects via its API. Each tool is responsible for supplying data-sharing mechanisms.

4.1.2.2 Reference Knowledge

Research in requirements engineering has shown that a development environment must allow the application engineer to proceed according to the way-of-working defined through a given method (see Jarke et al. 1994). ContAct integrates a module for the administration of reference knowledge for shared objects (e.g. information models). The reference knowledge is classified in different topics and can be associated to single actions (e.g. the construction of a function tree, the refinement of a data cluster, etc.) or to object types (e.g. functions, data entities, organisational units, etc.). The use of such reference knowledge shall lead the user to use methods the right way and provide him with online information about:

- what kind of decisions have led to which results in the past,
- approaches to perform modeling activities the right way,
- changes in modeling methods,
- enterprise-specific conventions

and others. The stored reference knowledge can be accessed and modified by each user. If this is done continuously the reference knowledge can become a kind of basis for organisational learning within group work.

4.1.2.3 Information Subscription

Information subscription is a mechanism to ensure awareness about group work. Group members or authorized persons can define an information subscription to work objects and they will be continuously informed about changes happening to this work object. Through the integration with modeling tools, ContAct allows the definition of subscriptions on model or information object changes. If the user defines such a subscription ContAct informs him about changes in the model whenever they take place. The information subscription is not limited to one tool but even works with different tools like demonstrated in figure 3. When an object belonging to another tool has been linked to a subscribed object is changed, the subscriber is also notified. This link can be established automatically. If a model has been derived from another method and stored in a second tool, ContAct is informed about the semantic connection of these models. Information subscriptions defined within ContAct take into account both models and modifications in one model will lead to a notification of users which have defined the information subscription.

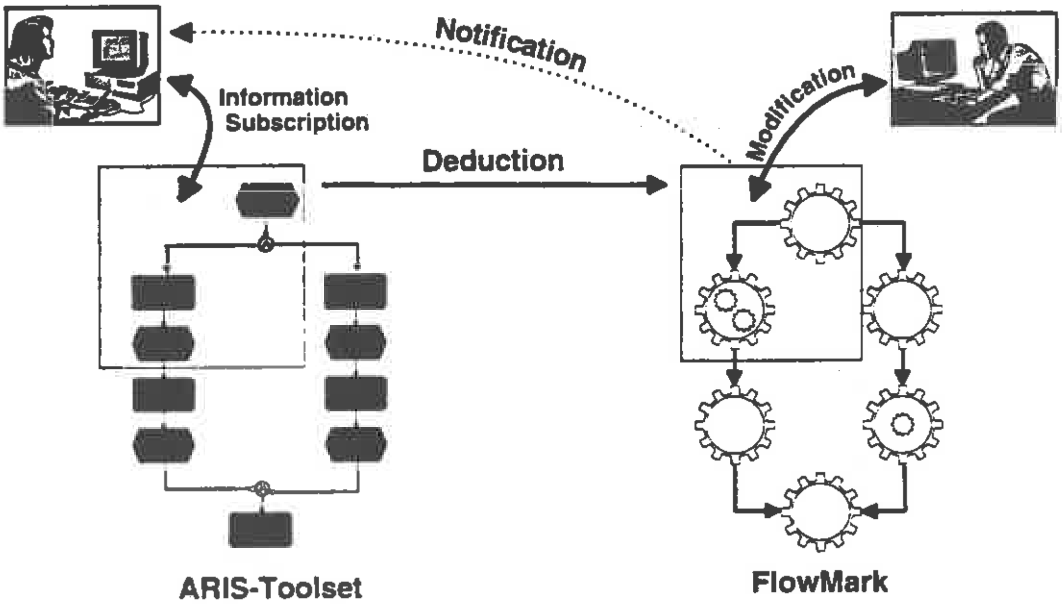

Fig. 3: Staged information subscription

In order to avoid information overload, the user is notified of changes either via graphical representations of the models or text messages. This subscription service can be very helpful to manage the continuous refinement and improvement of information models even if one logical model is physically stored twice in different modeling tools like e.g. a BPR-tool and a WMS-tool.

4.1.2.4 Shared Project Data

If groupware systems are used within projects, they should even provide information about and access to general project data. With ContAct users can define the project organisation and link project documents to this definition. These documents are managed by ContAct and shared with other project members. Such project documents can be the project plan, the project description, project literature and other.

4.1.3 Monitoring

Today the control (in respect to quality and goals) of results from modeling/requirements engineering projects often can only be done by analysing the outcomes of such projects. The process of achievement of these results is not transparent and thus not available for verification. ContAct includes mechanisms to provide the sustainable control of work processes happening in a group.

4.1.3.1 Product Monitoring

The term product monitoring stands for information which results from observing the work items (equal to the product data) and their modifications over time. ContAct stores both: the historical coordination data and modifications in the work items accumulated over time in an archive. This enables users to evaluate and understand single models by analysing the process performed during the construction of the models. The forming of models becomes transparent, single modeling steps can be followed and modeling decisions understood. By comparing the models resulting from a project and the decisions taken in the project it seems to be possible to derive reference knowledge for future modeling projects.

4.1.3.2 Monitoring of Group Activities

Mechanisms to allow an online monitoring of group activities are included in ContAct. Group members with appropriate rights can observe the activities of the whole group and use that information to identify problems in the project progress. Permanent monitoring of the state of the whole project and even of single project tasks can be done. Through the integration of ContAct with modeling tools project managers can use statistics to identify models or modeling activities which need many resources and have not achieved the planned results. Key figures which can be obtained by using monitoring functionalities of ContAct are: which coordination cycles are still open (not fulfilled), which coordination cycles have been completed successfully, who has know-how in what area, who has participated in what group activities, what kind of tasks need most of the coordination effort, which coordination methods are prefered by whom, etc.
This functionality should not lead to the "big brother is watching you"-syndrome but help the project managers to contribute to solutions for a better project work. Through the monitoring of modeling activities ContAct offers even the possibility of distance-consulting. Consultants can observe in a remote modus (via Internet) the project's progress and take over the position of a know-how supplier by responding to requests from project members. Self-monitoring of the group members is also possible.

4.2 Cooperation

Below, the communication and project management facilities of ContAct are explained.

4.2.1 Communication

4.2.1.1 Structured message exchange

The message structuring functionality of ContAct has been discovered through the analysis of verbal communication and emails sent between information

modellers and the manually documented print-outs of information models as well as the evolutionary development and the testing of prototypes.
For the coordination of modeling activities ContAct allows users to define requests, questions, actions and declarations as well as to give answers and evaluations with respect to models or information objects which are part of a model. In case studies and research projects we have often found the situation that communication between specialist departments and the EDP-department follows a customer-supplier relation. Since the development and transformation of BPM into WFM concerns both sides we have implemented the coordination mechanisms according to this relation. A customer can define a *request* for an activity and a supplier can react to this request through a *reply* and/or *action*. Depending on the type of activity requested through the customer this process can follow the principles of a negotiation. Figure 4 shows the interface for the asynchronous coordination of modeling activities.

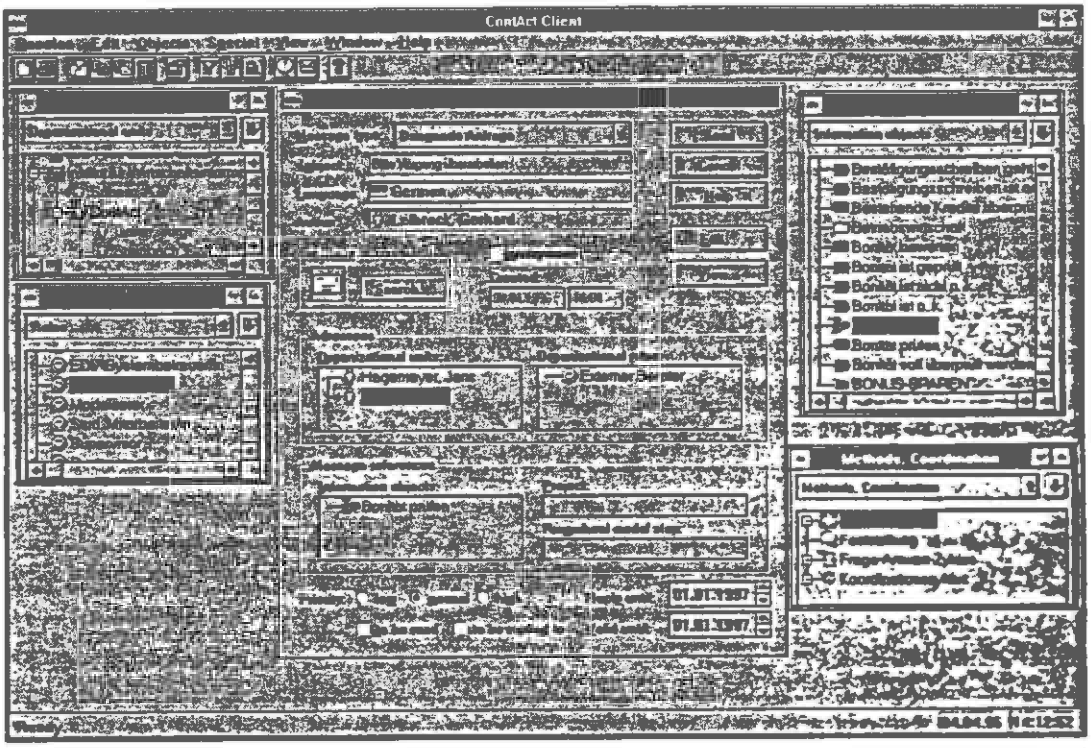

Fig. 4: Graphical user interface of ContAct

4.2.1.2 Definition of Communication Structures

All above mentioned coordination methods can be used for different tasks and projects. They are predefined in an extendible library. Through the definition of an open meta-model the coordination structure and the used message types can be changed by the user. Should the necessity arise, other coordination cycles can be implemented, the order of messages changed or additional reactions to messages defined.

4.2.1.3 Multimedia Communication

Since standard text-based email messages are at times not sufficient for communicating information efficiently, we have included the possibility to exchange messages of different media types. An example of this is a scanned drawing of a process model, sent to a modeller. Synchronous communication via an off-the-shelf video conferencing system is also possible.

4.2.1.4 Discussion Groups

Colleagues working in the same area can define discussion groups in order to exchange information detached from particular models, i.e. about modeling techniques, procedural models, management decisions, continious improvement processes etc. A fundamental concept is the openness of these forums to everybody without any restriction.

4.2.2 Project Management

4.2.2.1 Project Member Roles

Workflow projects involve persons from the company where the workflow application will be installed, but often also from external organisations like consultancies and workflow technology providers. Case studies have shown that a successful workflow project requires the task-based integration of such persons, defining the roles each project participant has to fulfil. Normally, we differentiate between the following roles: project leader, project members, application developer, user, consultant, technology provider.

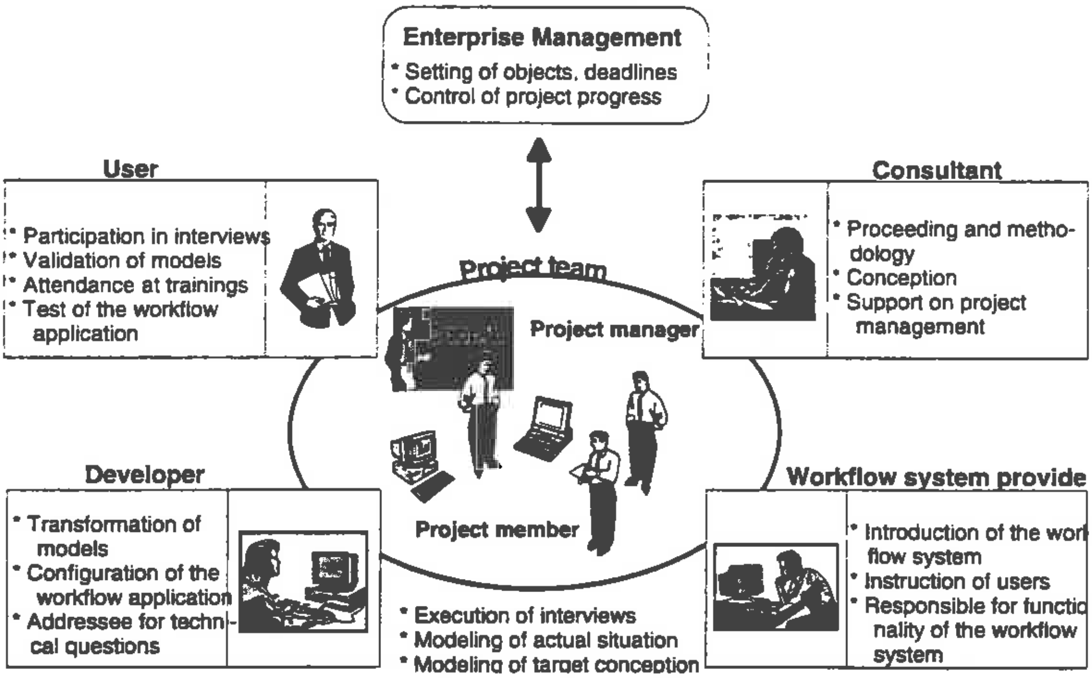

Fig. 5: Roles of the project participants

Furthermore it is a frequent problem in large, multinational companies to find the right person to talk to when looking for the solution to a problem. Although we consider it to be the task of standard software to supply information about the roles and tasks of its members no adequate assistance was found. So ContAct offers the functionality to organize the project team by defining the project structure, specifying roles and assigning them to persons. It administrates data to persons and organisations following the X.400 standard specification. The organisational information stored and administrated in ContAct is further used by the tool for the coordination of modeling activities and control of the project status.

4.2.2.2 Project Organisation

Modern organisations are organised in project teams, gathering experts in their specific areas to solve work tasks on a limited time basis. Our tool facilitates the possibility to address (possibly constantly varying) project members in messages or information subscriptions. The progress of such groups can be monitored, e.g. by checking the number of completed and uncompleted coordination cycles.

5 Implementation

ContAct is divided into one server and one or many clients. The ContAct server offers all mechanisms needed to fulfil the requests which reach him from the ContAct clients. For the storage of data the server has access to a relational DBMS. This database is implemented following the SQL-2-Entry-Level standard which ensures good portability to different platforms. The ContAct server runs permanently on a central computer with the operating system MS Windows NT. SQL-Calls for data retrieval can only be sent to the database from the ContAct server. The ContAct client communicates with the server over an ORBIX interface which is CORBA- (Common Object Request Broker Architecture) conform. We have chosen this approach because it facilitates communication between applications running under different operating systems and because it allows communication over heterogeneous networks which ensures very simple access of ContAct clients to the ContAct server via the Internet. The multimedial data objects linked to ContAct-messages are stored in OLE documents in the database.
To integrate ContAct standard software products have to implement a defined interface. Changes in the product data has to be communicated asynchronously to the ContAct server via a data queue. This happens without user interaction. The standard software product notes changes in the work items and communicates these to the ContAct server. All activities which regard group work are performed through the user interacting with a ContAct client. He uses ContAct to communicate, coordinate or cooperate. Therefore the integrated software has to communicate with the ContAct client, to inform ContAct about the selected work item, etc. This is done by synchronous communication over an normal C function call interface.

One of the challenges for ContAct was that it has to integrate tools from different platforms (ARIS Toolset under Windows and FlowMark under OS/2) and that its DBMS is only working on Novell Netware. This has increased the development effort, but does not influence the system architecture negatively. ContAct is designed to be portable over different platforms and even though it is a research prototype, an important effort has been made to ensure its further evolution into a product.
This is achieved by porting the original prototype which had been developed in a 4GL (GainMomentum) to C++, using a SQL-database (Oracle) and a GUI class library (StarView). The asynchronous data transfer will be implemented using PIPES by PeerLogic which is available for different operating systems.

6 Conclusion

In this paper we presented a generic model for groupware by enhancing the functionality of multi-user software with coordination and cooperation technology. These concepts are actually implemented in a prototype. The partners for which the prototype is being developed produce typical multi-user applications designed for use in locally distributed project teams. The generalised approach taken in the project has resulted in a prototype which can be used in connection with a broad range of applications on a number of different platforms.
Particularly interesting is the possibility to link objects belonging to different applications by the staged information subscription mechanism. Once an object has been changed all subscribers of change information for related objects are also notified. An example of this is the change of a requirements definition document and the subsequent automatic notification of the process modeller.

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