The Integration of Workflow Systems and Collaboration Tools

Nuno Guimarães, Pedro Antunes, and Ana Paula Pereira

Instituto Superior Técnico (IST)
Instituto de Engenharia de Sistemas e Computadores (INESC)
R. Alves Redol 9, 1000 Lisbon, Portugal
email: {nmg,paa,app}@inesc.pt,guimaraesn@acm.org

Summary. The design and development of computer support for work environments must consider both the coordination of individual activities and the collaboration that occurs among individuals in organizations. This paper presents our research efforts towards the understanding, design and implementation of a technological framework designated by "augmented work environments". These efforts build bridges between computational support for formal processes in organizational work (workflow) and computational support for interactive and informal processes (collaborative tools for group facilitation, decision or negotiation).

1. Introduction

This paper presents a particular dimension of our research efforts towards the understanding, design and implementation of a technological framework that we classify as "augmented work environments". These efforts aim at building bridges between computational support for formal processes in organizational work, which we see materialized in current workflow technology, and computational support for interactive and informal processes, which we identify with collaborative tools for group facilitation, decision or negotiation. This is the fundamental motivation for the work presented here.

The concepts, designs, prototypes, and experiments that are reported in the paper were mostly produced in the scope of the Orchestra project [Orchestra97]. The concerns expressed and addressed in this paper were already approached in two other publications related with the project's activities [Antunes95a] and [Guimaraes96].

The next section makes the concerns more explicit and lays a set of theoretical and conceptual arguments that justify our approach. The core arguments are a specialization of fundamental notions related with the design of interactive systems and human machine interaction. The two following sections describe the technological environment were we stand. The first of these two sections addresses workflow systems and technology, while the second overviews collaboration techniques and tools. The fifth section presents approaches to integration of those two independent but unseparable technologies. The core of this section is the report of our previous experience and the presentation of our current thinking on the subject. The final section summarizes the paper and highlights the main conclusions.

NATO Advanced Study Institute Series, Computer and Systems Sciences, vol. 164, pp. 222-245, 1997, Workflow Management Issues and Interoperability, A. Dogac, L. Kalinichenko, M. Ozsu, and A. Sheth, Eds. Berlin: Springer Verlag.

2. Concerns and Theoretical Foundations

The work described in this paper was influenced by a number of theoretical principles. Amongst those notions are the duality between coordinated and collaborative activity, the situated nature of work, and the perspectives of organizational structures and dynamics.

2.1 Coordination versus Collaboration

A frequently used quote in the field of CSCW (Computer Supported Cooperative Work) is a statement of C. Ellis [Ellis94], according to which *Workflow Systems automate a fiction.* The statement highlights the notion that organizational work is seldom a fixed flow of individual actions, but rather includes informal activities and spontaneous interaction between persons as members of a group.

Underlying the above quote is also a dichotomy between two related concepts: *coordination* and *collaboration* (as subclasses of Cooperation). Coordination is understood as a process by which the individual activities of the members of a group become organized (in terms of inputs, outputs and scheduling) by an external entity, in such a way that this organization leads to the predefined goal. Collaboration emphasizes the capability of self organization of those group members, which progress to the final goal through informal and mutual adjustment. Defined as such, workflow systems can be labeled coordination technologies, while tools for informal interaction like group decision and negotiation support systems are better defined as collaborative. A basic assumption in this separation, and in the remainder of this paper, is a rejection of any bias towards one or the other type of systems. Both are adequate in particular circumstances and address complementary issues in the computer support for organizational work.

2.2 The Situated Nature of Work

The title of this subsection points to the foundational notions presented by [Suchman87]. Those notions, presented in the scope of human machine communication, matches particularly well with the dichotomy mentioned above. In the context of group work, the automation provided by traditional workflow systems can be associated to *plans*. Just as for face-to-face or human-machine communication, *plans are inherently vague.* Workflow systems provide plans, as *resources*, for group interaction and work. However, these plans never define the complete details of the interaction, which are ultimately defined by the actual circumstances or situation.

Another important concept in this framework is the concept of *breakdown.* This concept is also central in [Winograd86], and has its roots in reflections on cognition and language. According to these authors, *. . . a design constitutes* *an interpretation of a breakdown and a committed attempt to anticipate future breakdowns.*

The contextualization of the above reasoning to the design and use of workflow systems in organizational settings leads us to the following questions: which resources are made available to groups and group members when prescribed plans breakdown in a workflow environment ? Which alternate courses of action are provided to the group ? Our suggestion is to provide support for informal group interaction, communication and decision.

2.3 Organizational Structures and Flows

A relevant body of theory is presented in [Mintzberg79, Mintzberg93] on organizational structure and dynamics. The general model for the structure of organizations includes five basic parts: (1) the operating core, (2) technostructure, (3) support staff, (4) strategic apex and (5) middle line. Based on the five part structure, linkages between the parts are defined, which characterize the organization as a system of flows: a flow of formal authority; a set of regulated flows; a system of informal communication; a system of work constellations; and a system of *ad hoc* decision processes.

This classification scheme for organizational structures and dynamics, suggests that regulated or formal flows are associated with coordinated actions, and therefore prone to be supported by workflow systems, while informal flows, work constellations and *ad hoc* decision processes, as essentially unplanned or situated, seem to be better suited to profit from collaborative technologies. Once again, and drawing on Mintzberg holistic view of the organizational life, the former cannot exist without the later, a conclusion that reinforces our integrative efforts.

2.4 Empirical Evidence

Another ground for our approach is the evidence drawn from observing workflow systems in use. The observations can be summarized as:

- Workflow systems eliminate paper based forms in standard processes.
- Control becomes easier and awareness of the processes status is increased. However, speed is not a major gain.
- The number of automated processes has a steep growth when a workflow system is put at work. However, the coverage of the workflow automation saturates: obviously automatable processes are no longer available, and the remaining ones are not obviously supported.

This observation leads to the conclusion that coordination-only systems have, in spite of its relevance and usefulness, a constrained space of intervention and therefore a limit to their impact in the organizational activities. A significant amount of group activities is related with the informal collaborative processes.

3. Orchestra : a Testbed Environment

The concepts presented in this paper have been consolidated in the Orchestra project. This project, its rationale, activities, partners, and results are described in [Orchestra97]. Orchestra stands for ORganisational CHange Evolution, STRucturing and Awareness, and was an EC funded project (ESPRIT 8764), involving a large number of partners (12), lead by INESC (94-96).

3.1 Objectives

The objectives of Orchestra can be interpreted in multiple ways. The conceptual framework of Orchestra was designed with the organizational theories in background and with the concern for organization-centered application of information technologies. Other more pragmatic reasons underlie the definition of the Orchestra project. Previous experience in the development and deployment of office systems, understood as primitive forms of organizational systems, allowed us to identify a set of needs that shaped the project:

- The lack of awareness about the organizational structure and dynamics has to be overcome with the inclusion of knowledge coming from social sciences and management experts.
- This knowledge must be incorporated in the tools provided to the organization, improving flexibility and support for re-organization decisions,
- Office, workflow and corporate information systems must be integrated to provide a seamless interface to the organizational worker.
- Communication must be flexible, both at the infrastructure level and at the user level, integrating the organizational knowledge mentioned above.
- Decision and negotiation tools can not be stand alone tools, but rather integrated in the context of organizational daily work.

The objective of the project was then summarized as: *to design and develop a group work environment that increases organizational effectiveness through better management of organizational information, improvement of the communication among individuals and groups, and support to the group decision and negotiation processes.*

3.2 Participants and Activities

The participants in the Orchestra project were software producers, social sciences experts, research and development institutions and user organizations. The user organizations were departments of large organizations: the administrative department of a Thermal Powerplant in Sines, Portugal, a holding organization for the Telecommunications sector in Lisbon, Portugal, and a department concerned with the planning of the Nuclear Fuel Purchases in Madrid, Spain.

The project as a whole addressed the following areas: organizational analysis, automation of organizational procedures, security, workflow management and information systems integration, interpersonal and organizational communication, negotiation and decision processes. The activities directly related with the purpose of this paper are described below.

3.2.1 Organizational Analysis and Modeling. The task of organizational analysis was undertaken by a social sciences team. This analysis was performed in the three pilot organizations. To guide the analysis, the Stream Analysis Model [Porras87] was adopted. The data collection process, based on semi-directive interviews to the key elements of the organizational units, allowed to capture the work and communication flows.

Given the organizational information, the project approached the problem of modeling workflow in the larger scope of organizational description and modeling. To support organizational and workflow modeling, the Taskon OORAM (Object Oriented Role Analysis and Modeling) [Reenskaug96] tool was used. The result was the production of a significant sample of workflow models (60-80) in computational form.

3.2.2 Workflow System Design and Development. The definition of the workflow functionality based on the initial prototypes, the evaluation of competing products, and the result of the project reviews, led to the design of a workflow system as an open and integratable component. The effort was put in the design and construction of a Workflow Engine, upon which specific applications could be designed and implemented. This design was a precursor of the approach currently promoted by the WfMC (Workflow Management Coalition).

3.2.3 Interactive Negotiation Tools. The construction of interactive negotiation tools or facilitation tools, had two dimensions in Orchestra: the first includes the design of a suite of tools for the specific computing environment of Orchestra. While related tools exist, the requirements for integration with other components, as well as the wish to elaborate on the interaction approaches, led us to these developments. Computer-based tools for three types of group interaction techniques were designed and implemented (Voting, Brainstorming and Nominal Group Technique). The second dimension relates with the problem, which relevance became clearer and clearer along the project, of linking together support for regulated of formal processes (traditional workflow) and support for informal and *ad hoc* decision processes.

4. Workflow Systems and Technology

This section reviews several classes of workflow technology. We first highlight aspects of some existing workflow systems (Flowmark, Staffware, Action and Action Metro) and groupware platforms. The modeling approaches are of particular relevance to us since they provide a departure point for our integration efforts. The proposals of the Workflow Management Coalition are another contribution to consider.

4.1 A Sample of Workflow Systems

4.1.1 IBM Flowmark. Flowmark [IBM96, Ovum95] is a client-server workflow management system based on workflow process models. An enactment service controls the execution of these models, which are linked to application programs using FlowMarks APIs. Application programs support the work to be done in a process activity and are defined by the developer.

Design Concepts The top level element of a FlowMark workflow model is the Process. A process is a sequence of activities that must be completed to accomplish a task. It defines how work is to progress from one activity to the next, who or what performs the activities, nested processes and how these subprocesses are distributed among servers, clients and databases. Activities are steps within a process. A Block is a modeling construct used for reducing the complexity of a process diagram, loop through a series of activities or implementing bundles. Connectors link activities in a workflow model. Control Connectors have transition conditions associated with it that direct the flow. Data Connectors specify the flow of data in a workflow model and Default Connectors specify where control should flow in the case of exceptional events.

4.1.2 Staffware. Staffware is a client-server workflow tool and one of the earliest workflow products. The most significant aspects of Staffware [Ovum95] are its ability to support a distributed workflow environment containing a mixture of platforms and the possibility of installing the server in any number of nodes. A workflow process can span several servers and Staffware ensures the integrity of communications between the servers involved.

Design Concepts Staffware procedures are process definitions of workflow applications and are composed of steps. All data required for a procedure is defined into a case. Each time a Staffware workflow is initiated an individual case is created. Steps are used to model routing conditions and are a placeholder for scripts. Three types of steps are defined: normal steps, require user interaction and appear in the work queue for the user or group; automatic steps are designed into the procedure and invoke external applications that do not need user intervention; event steps are triggered by specific events and can be used to pause or suspend a case, deal with exceptions or change task data.

4.1.3 ActionWorkflow. ActionWorkflow [Action96] is a client-server application that routes forms. Forms are the front end to a Lotus Notes or Microsoft SQL Server database. The Action workflow system is strongly based on a specific methodology. It enacts processes based on *conversation cycles* between entities generically designated as *customers* and *performers*.

Design Concepts ActionWorkflow modeling is rooted on the *speech acts* theory. This theory reduces interactions between people to conversations that are represented graphically as workflow loops. A conversation has four phases (preparation, negotiation, performance and satisfaction), two participants (a customer and a performer) and one objective (the performer must satisfy the customer within a defined period of time). The preparation is the initiation of the dialog. In the negotiation phase, the customer and the performer agree upon unique conditions of satisfaction for the particular instance of work. The performance phase is where the actual work is carried out, and it ends with the report that the work is complete. Finally, the acceptance phase closes the dialog loop, the customer accesses the deliverable and declares satisfaction or refuses to accept. Workflow loops can also include observers, which are not directly involved in the workflow but have access to information and data associated with it.

Processes are called business process maps and consist of a hierarchy of linked workflow loops. The first workflow loop to be initiated in a process defines its main objective and it is called the primary workflow. Secondary workflow loops are created when it is necessary to do something that cannot be adequately expressed in the primary workflow, thus replacing a phase of the primary workflow. Secondary workflows can also have secondary workflows and so on.

4.1.4 Action Technologies Metro. Action Metro is a process management solution available for the Internet environment, addressing the needs of organizations that wish to automate their business processes across a virtual enterprise. Action Metro is based on the Action Workflow coordination engine. Action Metro has several components that enable a standard Web browser to participate in an application. The core services of workflow are provided by two components: a personality module that translates data and commands from a Web browser to the Action workflow system and vice versa; and a set of HTML form templates, form responses and WorkBox form lists by which Metro receives information from, displays information to, and solicits responses from users.

4.2 Groupware Environments and Workflow support mechanisms

Recent years have witnessed the widespread use of what has become to be known as Groupware platforms. Two representative examples of this type of systems are Lotus Notes and recent evolutions of Microsoft Exchange. These platforms provide high level communication support, both inter-personal and inter-application, some degree of document management, and tools to build special purpose applications that use the base functionality. As such, workflow becomes one of the obvious directions of evolution.

4.2.1 Lotus Notes. Lotus Notes R4 [Lotus96a, Lotus96b] is a client-server application development, integrating a database and a messaging infrastructure. The Notes Application Development Environment (ADE) enables development of applications that store and route information objects using these database and messaging services.

The document database Notes is comprised of databases of *documents*. A Notes document is defined as an object containing text, graphics, video, and/or audio objects or any other kind of *rich text* data. Notes databases are semi-structured records consisting of basic design elements like Forms (for information entry and storage in the document), Subforms (objects in a Form that can be reused across applications), Collapsible sections (sections within a Form that can be expanded or collapsed depending on the need to view that particular piece of information), Fields (parts of a Form that contain a single type of information), Views (user-defined ways of looking at information), and Navigators (graphical tables of contents for a database).

The messaging infrastructure Notes databases are animated by the messaging infrastructure. Information is not just stored in or retrieved from databases but can be routed between users or even other databases. The Notes messaging infrastructure consists of a transport back-end that runs on almost any wiring topology and/or network operating system.

4.2.2 Microsoft Exchange Server/ Microsoft Outlook Client. Microsoft Outlook'97 [Outlook97] is a workgroup client combined with Microsoft Exchange, that combines messaging, group scheduling, personal information management and a form-design environment.

Outlook enables creation of custom groupware and workflow applications based on customized forms. Typically, custom forms will be stored in a Microsoft Exchange Server forms registry along with forms created using Microsoft Exchange Forms Designer. Outlook Forms can also be included as part of an e-mail message that can be sent across the Internet. The groupware applications can be made richer through the use of the Microsoft Visual Basic programming system, Scripting Edition (VB Script) and ActiveX Controls.

4.3 Workflow Modeling Approaches

The modeling facilities of workflow systems have a fundamental impact on the power and usability of such systems. Just as software programs and systems, workflow as an inherent complexity that grows together with the organizational complexity. Workflow modeling is the process of capturing the work processes and describing them in a machine understable form. Every workflow system tends to have its own modeling component. On the other hand general tools for systems analysis and modeling can be considered as providers of modeling support. Three basic categories of process modeling methodologies are considered:

- Activity based methodologies focus on modeling activities and tasks. Workflows consist of tasks and each one may be comprised from subtasks. This is

the model used by most of the commercial workflow management systems but it does not capture process objectives such as customer satisfaction.
- Commitment based methodologies are based in an interpretation of work as the coordination of actions where the flow of work can be specified through speech acts. An in a workflow is an interaction between a customer and a performer. This is the approach of the Action family of products and systems.
- Object-oriented methodologies model workflow as communicating objects. Jacobsons model is made of actors and use cases [Jacobson95]. The *role model* is the basic abstraction used in OORAM [Reenskaug96]. A role model describes the subject of object interaction, the relationships between objects, the messages that each object may send to its collaborators, and the model information processes. Each object can play several roles in different role models.

  Object orientation provides no explicit support for workflow process modeling. The object designer typically must define workflow model specific objects from scratch (eg, customer, employee, document, step, etc) as it was done in the models described in [Guimaraes96] and [Farshchain96].

The first two types of modeling approaches were illustrated in the previous section. Workflow systems like Flowmark or Staffware reinforce Activity-based modeling methodologies. Action and Metro are the most striking examples of a Commitment based methodologies. The use of object oriented methodologies in modeling workflow systems is an approach that is being pursued in multiple contexts. In Orchestra, we adopted the Taskon OORAM methodology and tool as an open approach to workflow modeling. For further details on the use of this methodology, see [Orchestra97] and [Reenskaug96].

4.4 The Workflow Management Coalition

The Workflow Management Coalition[1] was established in August 1993 as a non-profit international body for the development and promotion of standards for software terminology, interoperability and connectivity between workflow products. A glossary and a framework for workflow systems have been proposed.

4.4.1 Models and Architectures. All workflow systems contain a number of generic components which interact in a variety of ways. The model (fig. 4.1), identifies the major components and interfaces:

- Process Definition Tools are used to analyze, model and describe business processes, as mentioned in the previous sections.
- Workflow Enactment Service is the run-time environment where workflow processes are executed (or enacted). This may involve more than one workflow engine. This service is responsible for reading process definitions, and creating and managing process instances.

[1] http://www.aiai.ac.uk/WfMC

– Workflow Client Applications are the software entities which present work items to the end user, invoke application tools which support the task and the data related to it, and allow the user to take actions before passing the case back to the workflow enactment service.
– Administration and Monitoring Tools can be used to track process status, for control, management and analysis purposes.

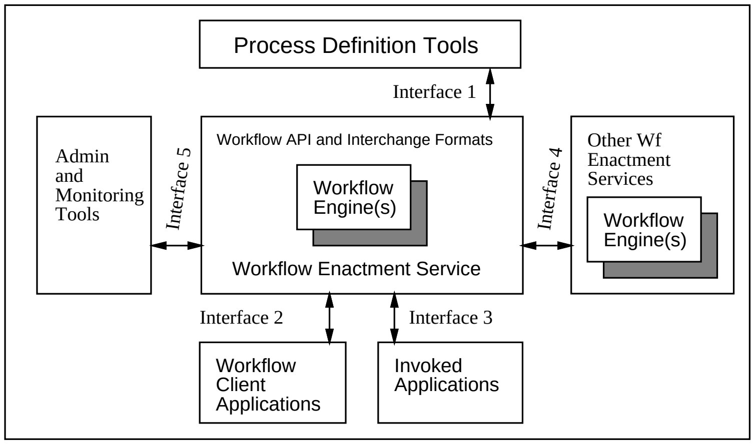

Fig. 4.1. WfMC Reference Model

The standardization efforts of the WfMC is focused on the five interfaces to the workflow enactment service:

– Interface 1: process definition import/ export interface
– Interface 2: interaction with workflow client applications and software for presentation of worklists
– Interface 3: tools and external application invocation
– Interface 4: interoperability between several workflow management systems
– Interface 5: interaction with Administration and Monitoring Tools

4.4.2 Openness and Reusability Directions - WPDL. One of the interfaces being standardized that has, in our perspective a direct impact on the proposals that we make in this paper, is the Process definition import/export interface. This interface normalizes the final format of a work process description. This definition led to a common interchange format, the Workflow Process Definition Language (WPDL), which supports the transfer of workflow process definitions between separate products.

The WPDL definition proposes a set of extensibility mechanisms to support vendor specific requirements. This is based on the definition of a Workflow Meta-Model, a limited number of entities that describe a workflow process definition (the "Minimum Meta Model"). The meta-model identifies a basic set of entities and attributes for the exchange of process definitions: Process Definition, Process Activity, Participant Definition, Transition Information, Application Definition, and Process Relevant Data. These entities contain attributes which support a common description mechanism for processes. Further entities and attributes may be added to the model to create future conformance levels.

The WfMC proposal document includes one representative business case that can be used to verify the feasibility of the implementation of the standard, as well as to constitute a preliminary test of a conformance assessment procedure. The business example describes a fictitious company, FBN Sports Equipment Company, its departments, and business or work processes. The example details the analysis and definition of the work processes, and its further specification in the WPDL format. Just for the sake of providing the reader with a flavor of the language, see extract below.

```
WORKFLOW At the Sales Department
        WPDL_VERSION    1.0
        VENDOR  Vendor:Product:Release
        CREATED 1995-12-06
// <Activity List>
// <Transition Information List>
END_WORKFLOW
PARTICIPANT Tim White
        TYPE            HUMAN
        USERID          tw456
        SURNAME         White
        FORENAME        Tim
        DESCRIPTION     Mail Room Clerk
END_PARTICIPANT
PARTICIPANT Presidents_Secretary
        TYPE            ROLE
        PERSONDESCR     France Baroque
        DESCRIPTION     handles presidents mail
END_PARTICIPANT
APPLICATION scan_document
        TOOLNAME        winscan.exe
        OUT_PARAMETERS  scanned_document
END_APPLICATION
DATA document_type
        TYPE            string
        DEFAULT_VALUE   Sales Order
END_DATA
DATA scanned_document
        TYPE            reference
END_DATA
```

5. Collaboration Approaches and Technologies

This section addresses the support for collaboration in three dimensions: existing collaboration technology, techniques for group decision and interaction, and high level decision models that regulate group interaction. These are the elements of a framework required for effective support to group collaboration, as well as for adequate integration with coordination technology.

5.1 Collaboration Technology

Technology support for informal processes can be associated with a broad range of computer based technologies. Electronic mail has been the technology with broadest dissemination and a large number of studies have been published on the specific issues related with the impact of electronic mail in organizational life. Similarly, teleconferencing and videoconferencing has progressively been introduced to overcome the physical limitations of interpersonal and intergroup communication. These technologies are however limited to the physical dimensions of the communication, either time, such as electronic mail, or space, such as the telephone or conferencing facilities. In particular, no attention is given to the interactive process that may be carried out over those physical supports.

Beyond the above mentioned technology, the most relevant nature of current and emerging collaboration technology is the support for particular styles of group interaction processes. Examples of this styles are argumentative processes that occur for example in collaborative authoring environments [Streitz94], or decision or negotiation processes that can be found as the object of support in multiple GDSS's (Group Decision Support Systems)[Nunamaker91].

Several classification tags exist for collaborative technology. The basic classification divides the possible systems into four (4) classes according to the time-space x same-different combinations. Other aspects that have impact on the classification of collaborative systems include size of the group, types and structure of the groups, process support, etc.

5.1.1 GroupSystems. GroupSystems, from Ventana Corporation[2], is one of the most successful electronic meeting support software systems. The system runs on a generic infrastructure of networked personal computers. The functionality is provided by a set of complementary components that includes: Agenda (supporting electronic brainstorming, idea categorizer, voting tools, topic commenter, and group outliner), People (supporting the management of group's information), Whiteboard (for group interaction through a shared drawing space), Handouts (for structured information sharing), Opinion meter (quick polling), Briefcase (for auxiliary tools), Personal Log and Event Monitor.

[2] http://www.ventana.com

5.1.2 MeetingWorks. MeetingWorks, from Enterprise Solutions[3], is another electronic meeting system that provides tools for managing the several steps of a meeting, with specific support for brainstorming sessions. This support includes idea organization, ranking, voting, impact analysis and other tools. A distinction is made between facilitator (*chauffeur*) and participants.

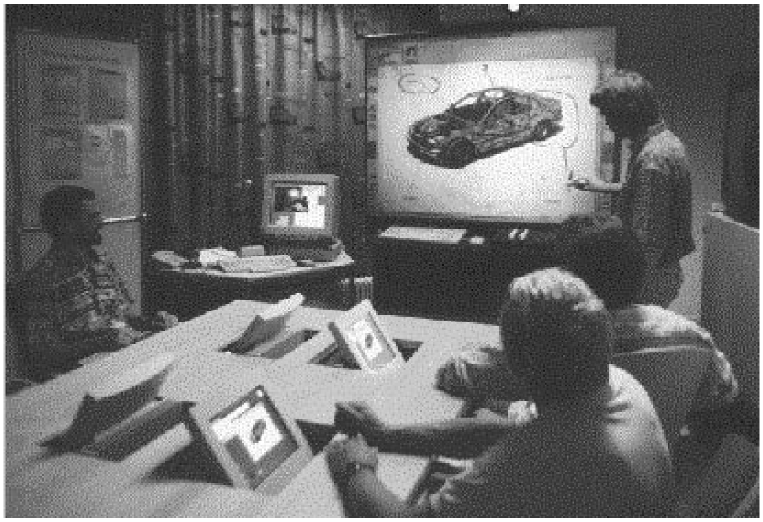

Fig. 5.1. The Ocean Lab at GMD-IPSI - printed with permission.

5.1.3 Dolphin and the Ocean Lab. Dolphin [Streitz94, Mark95] is the system used in the Ocean Lab[4], at GMD, Darmstadt, Germany. The Ocean Lab is an electronic meeting room designed to study multiple types of computer based support for cooperative work. From the infrastructure point of view, the lab is characterized by the coupling of personal workstations with electronic boards (LiveBoard or Smart Board). Dolphin is the interactive hypermedia system that provides support for private and public interaction, idea and work organization, and multiple levels of sharing. The environment has been used intensively and continuously in the research of the new cooperation modalities [Streitz97].

5.2 Techniques for Group Decision and Collaboration

Techniques for group decision and negotiation are based on the social behavior of people in small groups. This subsection presents a sample of those techniques. The objective is to point out multiple choices for a given group decision situation.

[3] http://www.accessone.com/entsol
[4] http://www.darmstadt.gmd.de/publish/ocean

5.2.1 Brainstorming. Brainstorming is the most known method of idea generation and is in worldwide use [Hwang87]. Webster defines it as: to practice a conference technique by which a group attempts to find a solution for a specific problem by assuming all the ideas spontaneously contributed by its members . The technique employs four basic rules [Patton89]: criticism is ruled out; Free-wheeling is welcomed (the wilder the idea, the better); Quantity is wanted (the greater the number of ideas, the more like-hood of winners); Combination and improvement are sought.

A number of variations of the technique have been devised [Hwang87, Nunamaker91]: anonymous brainstorming, electronic brainstorming, brainwriting, the Trigger Method, the Sil Method. Studies of brainstorming suggest that it produces a wide range of ideas while promoting group enthusiasm.

5.2.2 Delphi. The Delphi process is applied to complex and unstructured problems, in order to develop the strongest pro and con arguments for a set of alternative solutions [Turoff91]. The Delphi process is based on individual and silent generation of suggestions and arguments which are solicited by a facilitator to the group members. The phases followed by the facilitator are [Hwang87]: (1) Initial questionnaire. This questionnaire is intended to collect a broad spectrum of answers to a particular problem; (2) Analysis of the questionnaire. From this analysis, executed by the facilitator, results a list that summarizes the objects identified by answers to the questionnaire. The list is presented to participants, preserving anonymity. (3) Second questionnaire. The facilitator develops a new questionnaire, which allows to identify areas of agreement and disagreement. The participants are requested to present opinions and vote the list of objects; (4) Analysis of the second questionnaire. Votes are counted and a summary of comments is associated to each object; (5) Third questionnaire. A new questionnaire is developed, allowing to identify agreements and disagreements among participants; (6) Final report. The final report allows to summarize the process results and legitimate future actions.

Delphi is based on the anonymity of the group members and is particularly oriented towards avoiding direct confrontation. Decisions with Delphi express opinions rather than facts which requires group members to be experts. One other important characteristic is that Delphi does not require physical presence [Robbins92].

5.2.3 Nominal Group Technique. The NGT is a participative data collection and consensus-forming device [Sink83]. The basic format of a NGT meeting is based on a facilitator which ensures that the group development runs through the following phases: (1) Individual silent generation of a list of ideas; (2) Individual round-robin feedback, where each group member describes one idea from the individual list. A global list is then generated; (3) Group clarification of the ideas in the list, removing overlapped ones and clarifying any inconsistencies; (4) Individual voting and prioritizing of ideas; (5) Discussion of results, perception of consensus and focus on potential next steps; (6) The NGT meetings are designed to generate a high quality list of prioritized ideas but has been found to be very sensitive to the performance of the group facilitator [Hwang87].

5.2.4 Survey. This technique allows managers to ask for information while taking decisions alone. Subordinates may or may not be told about what the problem is [Mitchell87]. The Vroom & Yetton's model describes the situations where this level of participation is appropriate [Vroom88]. One major requirement is that the problem should be structured.

5.2.5 Voting. Voting is a group decision-making method in a democratic society, an expression of the will of the majority. It is a multiple criteria decision making process whenever a voter casts a vote to select a candidate or alternative policy.

There are two basic voting systems: the non-ranked voting in which each voter has one and only one vote, and the preferential voting in which the voter indicates in what order of preference he/she would place the candidates. The first system is indicated when the number of candidates are two, and the second system when the number of candidates are more than two and it is necessary to protect the minorities and the spreading of representation over a reasonably wide range of interests [Ross55].

A large number of other techniques are available for consideration in every group decision making situation, but the above are already an illustration of alternate forms of social techniques that we should consider in designing and developing computer based tools for group work.

5.3 Decision Models

Decision models provide systematic views on how people and groups handle several variables in the course of a decision processes. This subsection outlines specific perspectives of the decision processes that are relevant for the integrative approaches we are presenting.

5.3.1 Contingency view of decision processes. One important model that characterizes decision making processes in organizations and groups is the Thompson & Tuden's contingency model for group decision making [Butler91]. This model is concerned with the understanding of decision making from the intended solution point of view. It considers two criteria related with the problem that asks for a solution, or decision: (1) Uncertainty about ends (the intended outcomes); and (2) Uncertainty about means (the solutions used to achieve the desired ends). Based on this distinction, it maps the combination of high and low scores on these criterias in four types of decision making processes:

- Computation. Well known ends and solutions.
- Judgment. Selection of solutions for well known ends.
- Bargaining. Resolving of disagreement over ends.
- Inspiration. Unknown ends and solutions.

5.3.2 Task view of decision processes. The McGrath's typology of group tasks [Mitchell87] classifies what a group is expected to do: (1) Generate plans or ideas; (2) Execute some task; (3) Negotiate disagreements; and (4) Choose any issues or answers. These four classes are further refined according to the level of required cooperation (cooperation versus conflict) and skills (behavioral versus conceptual).

5.3.3 System's view of decision processes. The Hwang & Lin's approach to expert judgments/group participation [Hwang87] focuses on decision making from a system viewpoint, regardless of organizational, political and social factors. The model considers four types of problems: (1) Idea stimulation; (2) Issue clarification; (3) Problem structuring; and (4) Problem solving. The model then maps these problems onto four types of facilitation: (1) Creative confrontation; (2) Polling of experts/participant ideas; (3) Systematic structuring; and (4) Simulation. The mapping is based on the following criteria:

- Definition of the problem: well defined, semi-defined or ill-defined.
- Scope of the problem: narrow, medium or broad.
- Time required to accomplish the task: hours, days, weeks.
- Training of participants: needed, not needed.
- Tools required to accomplish the task.

5.3.4 The Participation view of decision processes. The Vroom & Yetton's model[5] addresses the different degrees of group participation in decision making from the manager's viewpoint [Vroom88]: (1) Manager decides alone; (2) Manager asks individually for information but decides alone; (3) Manager asks individually for information and evaluation but decides alone; (4) Manager meets with group to discuss a problem but decides alone; and (5) Manager meets with group to discuss a problem and the group makes the decision.

The decisions suggested by this model are based on the following criteria: (1) Quality requirements; (2) Information available; (3) Problem structure; (4) Acceptance by those affected by; (5) Subordinate implication; and (6) Probability of conflict among members.

5.3.5 The Group Membership and Interaction. The Stumpf et al. [Mitchell87] model focuses on the typology of group processes in two aspects that complement the participants' view: membership and interaction. The model uses the following criteria: (1) Quality of the decision; (2) Acceptance by those affected by; (3) Requirement of a creative or original decision; (4) Span of the decision; (5) Knowledge and information needs; and (6) Probability of conflict among members. Based on the above criteria, it decides on group membership: experts, coworkers, and/or representatives of all relevant

[5] A software tool exists that implements this model and provides aids to a manager.

constituencies. The model also suggests the type of group interaction: face-to-face interchange during the whole process, face-to-face interchange only in evaluation phase, or no face-to-face interchange at all.

The fundamental conclusion from this section is that we have available a large spectrum of knowledge and approaches that provide systematic views on the decision processes. These allow us to conceptualize the computational support to group interaction, and, in turn, relate it with the coordination approaches and technologies presented in the previous sections.

6. The Integrative Approaches

The previous sections presented the scenario for the integrative approaches On the first hand, we have available a significant set of methodologies and technologies for supporting essentially formal and coordinated processes or workflow. On the other hand, we are aware of the existence of models and techniques that characterize group decision as an essentially informal or collaborative process. The issue to be addressed in the design of an integrative approach is the bridge between the multiple models and techniques.

This section identifies the dimensions of this specific problem. First, it summarizes a perspective that considers collaboration tools as a mechanism to handle coordination exceptions. Then, it generalizes the notion of alternate coordination and collaboration. Finally, it explores the idea that some sort of equivalence, or mapping, must be found between coordinated and collaborative work.

6.1 Identifying Exceptions

Exceptions in organizational work are explicitly addressed, for example, in [Saastamoinen95]. It this work, exceptions are classified as follows:

- *Established exceptions* are events where appropriate handling rules exist but they are either incomplete or the exact set of rules to be applied cannot be identified.
- *Otherwise exceptions* are events that lack handling rules but, given the rules for the normal cases, the goal of handling the exception is clearly defined
- *True exceptions* are completely unanticipated events where no preparation exists, and neither the normal situation, nor the specific goal or state that results from handling the exception is defined.

Another dimension of exceptions is the effect that their handling has on the rule base of an organization. In this context, exceptions can have the following types:

- They *do not affect* the rule base.

– Exceptions *cause instance level updates* (e.g. odd invoices are handled specifically, but do not change the way invoices are handled in general)
– Exceptions *cause type level updates* (e.g. general rules for handling invoices are changes due to the occurrence of some kind of relevant exception).

This short classification of exceptions allows us to define the problem space of our initial integrative approach. Some coordination-support systems will be more flexible in handling less dramatic exceptions (the first ones in the above lists), in which case the switch to a collaborative scenario can be minimized. For higher complexity exceptions (the later types in the above lists), collaborative action is the adequate exception handling approach.

6.2 Collaboration as a Handler for Coordination Problems

In Orchestra, the project mentioned in the beginning of the paper, the integrative approach was taken in the design of integration mechanisms between the workflow systems and a set of interactive negotiation and decision tools [Antunes95a].

The Orchestra approach can be summarized as follows: the workflow system must be able to identify situations where formalized solutions do not exist. Once identified, and categorized as a problem to be solved through an informal interaction, several group interaction techniques are available for supporting that interaction. A match between problem characteristics and available group interaction techniques has to be found. As a consequence, an informal process is activated through the execution of the computer-based tool that supports the selected technique [Antunes95b]. The outcome of the informal process is then fed back into the workflow system which progresses with the execution of the formal flow. The concept is illustrated below in fig. 6.1.

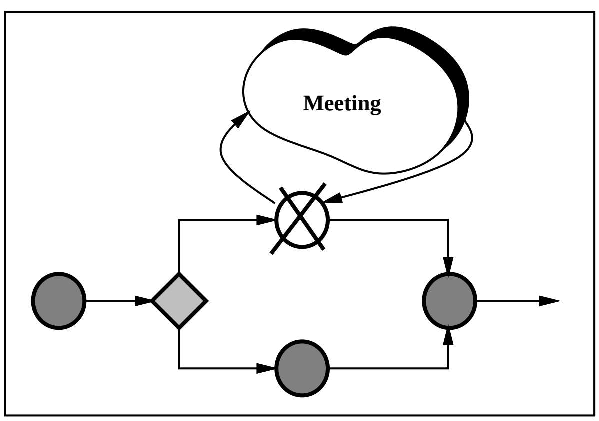

Fig. 6.1. Meetings or informal processes as solutions to breakdowns

6.2.1 The Integration Architecture. The architecture that supports this approach is depicted in fig. 6.2 and performs as follows: first, the Workflow engine detects an exception during the execution of an organizational procedure. Assuming that it is not able to handle the situation, it gathers all the available information concerning the exception and generates a flow interrupt. The interrupt is delivered to the Negotiation system which handles the situation through cooperative techniques and tools. When the problem that raised the interrupt is solved the workflow engine may continue with the execution of the procedure.

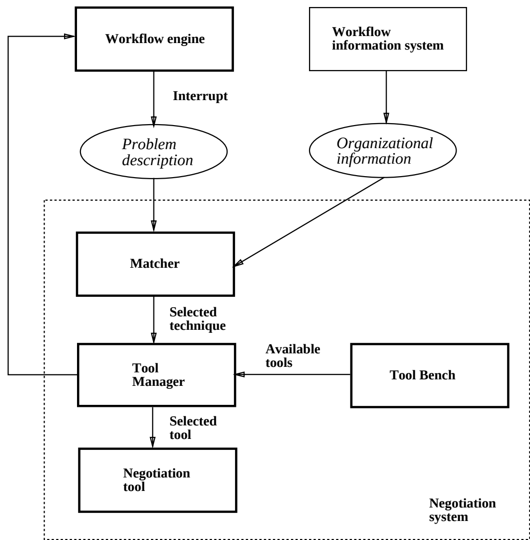

Fig. 6.2. An architecture for the Integration of workflow systems and GDSS tools

The Negotiation system is composed by the Matcher, the Tool Bench and the Tool Manager. The Matcher receives interrupts from the workflow engine and gathers relevant information. Based on this information, it classifies the problem, identifies the agents to be involved in a group decision process, and the most adequate technique solve the problem. This results in the selection of one group interaction technique and the delivery of that information to the Tool Manager. The Tool Manager instantiates a tool from the Tool Bench and connects the agents with the tool.

6.2.2 Criteria for Problem-Matching Techniques. The decision models described above were considered in the design of the Matcher functionality : Thompson and Tuden's contingency model for group decision making; Hwang and Lin's systems approach to expert judgments and group participation; McGrath's typology of group tasks; Vroom and Yetton's contingency model of participation; and the Stumpf, Zund and Freeman's contingency model for group decision making.

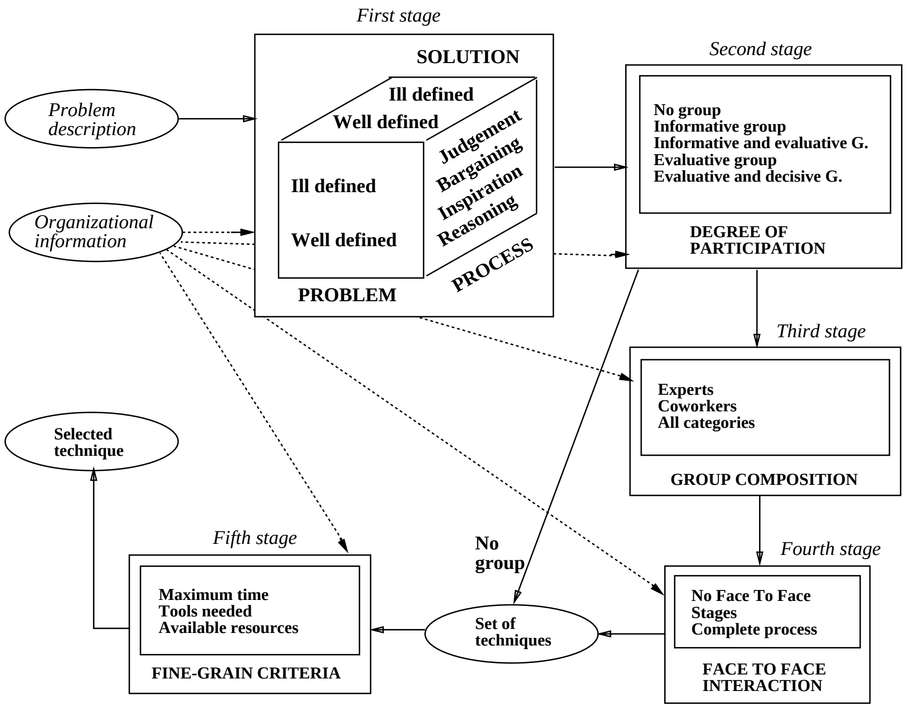

Fig. 6.3. The Matching Criteria

The Mapping from Problem to Technique The mapping from problem to technique is made by the Matcher in the following five stages (see fig. 6.3):

– First Stage: the first stage deals with fundamental and general criteria. This stage considers different values for three basic aspects of:
  1. Problem - Ill defined or well defined;
  2. Solution - Ill defined or well defined;
  3. Process - judgment (selection of solutions), bargaining (resolving of disagreement over solutions), inspiration (search for inspired solutions) or reasoning (rational approach).

  The output of this stage corresponds to the selected subset of techniques that results from crossing the values for Problem, Solution and Process. One can argue about how appropriate values for Problem, Solution and Process are assigned. This assignment can be based on several attributes which should be extracted from the Workflow system or otherwise requested to a human agent.

– Second Stage - Degree of Participation: the degree of participation needed to solve the problem is identified. The major concern is the formation or not of a group or committee to make the decision. The degree of participation of the members of this group in the final decision is also defined, since its members may act as simple consultants or as more active participants. The possible degrees of participation follow the guidelines of the Vroom and Yetton model. When there is no need for a group, the Matcher will jump over the third and fourth stages, which are dedicated to group oriented techniques. Some of the techniques identified in this stage require a facilitator. The output of this stage will specify the need and qualification of this manager. The Matcher will also suggest a name of a person who could act as the manager.
– Third Stage - Group Composition : at this stage, the Matcher has already identified the need for a group or committee. It then decides on the qualification of the group. This decision is based on the Stumpf et al. model. The names of people who could be part of the group are also provided.
– Fourth Stage - Face to Face Interaction : at the fourth stage, the need for face to face interaction is considered. The output will be a subset of the group of techniques which fulfill the requirement established in the stage about the face to face interaction. The possible requirements were extracted from the Stumpf et al. model.
– Fifth Stage - Fine-Grain Criteria : in this last stage the Matcher assigns values to fine-grain criteria, in opposition to the other more formal criteria considered in the previous stages. The output of this stage will designate a single selected technique, without discarding the previous selections notwithstanding.

The complete output of the Matcher is the following:

1. A subset of techniques selected by the first stage.
2. The need or not for a group to solve the problem.
3. If needed, the qualification of a human facilitator and, optionally, the name for this facilitator.
4. If needed, the qualifications of the group members and, optionally, their names.
5. A subset of techniques complying to the required face to face interaction.
6. A single technique complying with the above and the fine-grain criteria.

6.2.3 The Tool Manager and the Tool Bench. The description of the functionality of the Tool Manager is of particular interest here, since it directly mediates the operations of the Workflow with the group negotiation processes.

The Matcher does not select a tool for executing a particular negotiation process but rather identifies a set of techniques and a set of actors. The Tool Manager is responsible for selecting and launching a tool that will execute the selected technique. It is also responsible for returning control to the workflow system when the group interaction is finished.

The Tool Manager selects tools according to a catalog provided by the Tool Bench. First, the Tool Manager inquires the Tool Bench on the availability of tool support for the single selected technique. If the technique is not implemented, the alternative techniques indicated by the Matcher are inquired in order: face to face interaction, group composition, degree of participation and, finally, the first stage of the Matcher. As new tools are implemented and incorporated to the Tool Bench, the Tool Manager should be able to select them and the Matcher should be able to discriminate them. If not, the Matcher has to be upgraded with new criteria in the second level.

The Tool Bench is the repository of tools implementing group interaction techniques. Only a small number of the identified techniques has presently been selected for implementation and inclusion in the Tool Bench. At this moment, the intention is to achieve a minimum coverage of the possible selections of the first stage of the Matcher. Five techniques have been selected: Delphi, Nominal Group Technique (NGT), Brainstorming, Voting, and Survey.

6.3 Beyond Exceptions

The view of work as a cooperative and group interaction process suggests a generalization of the computational support that encompasses formal-coordinated actions and informal-collaborative meetings as equal contributors for the efficacity of organizational work. This perspective is depicted in the figure 6.4(a) below. Coordinated steps are defined as complementary to informal meetings.

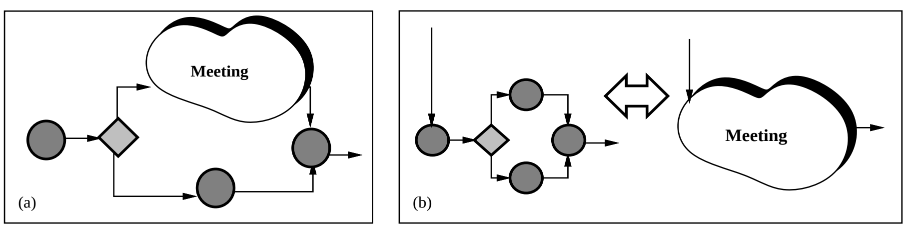

Fig. 6.4. (a) Meetings (informal processes) as steps is real life work; (b) Meetings and Flows as equivalent forms of work.

This view is not currently supported by most of the available workflow technology. Some systems, specially the ones we classified as Commitment-based methodologies, may have an advantage in this context. In fact, the foundation provided by a conversational model allows a level of abstraction that encompasses both formal and informal interaction. The problem, however, is that the commitment based approach (in particular, the Conversations-for-Action models) is hard to extend to groups of participants, and we would still be left with a wide range of undefined parameters, namely the ones addressed by the Orchestra integration approach (Matcher) and described above.

If we consider coordination and collaboration as particular sub-classes of cooperation, then we should search for higher level models that allow the mapping of a given cooperative process onto a given coordination or collaborative system. This further level of abstraction is even more relevant, insofar it opens the possibility of transformations between coordinated processes and collaborative processes, which in fact translates to transformation, at the level of the computational support, between formal and informal processes (see fig. 6.4(b)).

We believe that this is the fundamental progress to be sought, given its relevance to the integration of cooperative technology with the organizational change and transformation processes (the so called reengineering). Much of the reenginering processes affect the formality degrees in several places in the organizational structure. This bridge enables what we designate as *reengineering for participation*.

The design of the transformation mechanisms is currently under research. The initial approaches consider the following baseline:

- The recent progresses in the structuring of the workflow systems and technologies, namely the Worflow Management Coalition models and interfaces, provide an important framework for the identification of the different components and types of information that have a role in coordination systems. In particular, the Workflow Process Definition Language (WPDL) is an example of a structuring tool that can be used to other ends than just the enactment of a process through a workflow engine. WPDL descriptions are descriptions of coordinated work processes and include much of the information (recall the WPDL example) required to refine an integrative approach such as the Orchestra one.
- The framework developed in Orchestra, that associates group interaction tools with the requirements of group decision techniques, is another departure point for the analysis of the relation between those tools and the descriptions of work mentioned above.

The missing links in the integration, which we are currently seeking, are:

- A fine-grained set of criteria that allows to encapsulate a work process is such a way that it can be generalized as a group process, independent of its coordinated or collaborative nature.
- A significant amount of empirical studies, made on information concerning real work processes of a wide range of organizations. This effort is capitalizing on the Orchestra data, but requires further contributions.

7. Conclusions

The concepts and approaches presented in this paper address the problem of improving work environments. Work environments are understood as scenarios for cooperation among people that participate in group and organizational activities. The cooperation has two fundamental facets: a coordinated and a collaborative one. After defining this dual nature, the paper demonstrated that there are both theoretical and empirical grounds to define this separation. Moreover, we stated that, in what concerns computer-support, workflow systems are coordination support systems and tools like electronic meeting rooms or conferencing tools are designed to support collaboration.

In both areas, workflow and collaboration tools, we are faced with a growing dissemination of technologies, standards, methodologies and models. The paper has presented some examples of those, and pinpointed the relevant areas where integration between these two types of systems can be sought.

One of the main conclusions of the paper is the design of viable approaches to the integration of workflow systems and collaborative tools. The first approach was designed and prototyped in the Orchestra project. It essentially links the functionality of a workflow engine with a set of interactive discussion and negotiation tools. The collaboration tools take the role of an exception handler for the workflow system. The innovation lies in the concepts upon which the "linking" mechanism is built namely, a clear knowledge of the purpose of the several collaboration techniques, and a computational integration of hints provided by organizational decision models.

The experience with the design of this first approach led us to the proposal of a more generalized and challenging approach which tries to integrate coordination and collaboration as alternative forms of cooperation. The design and implementation of the mechanisms for this type of integration is an open question. However, based on the theoretical foundations, on the empirical data, and on the experience with our own projects and prototypes, we believe that this type of integration carries a significant added value and will become an enabling factor for what we have coined as "reengineering for participation".

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