Bridging Workflow and Collaboration Tools[1]

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Abstract

This paper presents our research efforts towards the understanding, design and implementation of a technological framework that we classify as "augmented work environments". These efforts are centered around the specific goal of building bridges between computational support for formal processes in organizational work and computational support for interactive and informal processes. The concepts, designs, prototypes and experiments that are reported in the paper were mostly produced in the scope of the ORCHESTRA project (Organizational Change, Evolution, STRucturing and Awareness).

1. Introduction

This paper presents some of our research efforts towards the understanding, design and implementation of a technological framework that we classify as "augmented work environments". These efforts are centered around the specific goal of building bridges between computational support for formal processes in organizational work and computational support for interactive and informal processes. This is the motivation of the work presented here.

The concepts, designs, prototypes and experiments reported in the paper were mostly initiated in the scope of the ORCHESTRA project (Organizational Change, Evolution, STRucturing and Awareness), an Esprit project carried out between 1994 and 1996. Our activities in the project, besides project management and leadership, were focused on organizational modeling on the first hand, and design of collaborative tools for group decision and negotiation on the other. The concerns expressed in this paper were also addressed in other publications [Antunes95a], [Guimarães96].

The structure of the paper is the following: the next section makes the concerns more explicit and lays a set of theoretical and conceptual arguments that justify our approach. The two following sections are a short description of the technological environment were we stand. The first of these two sections addresses workflow systems and technology, while the second overviews collaboration techniques and decision models. The fifth section presents approaches to integration of those two independent but, in our view, unseparable technologies. The core of this section is the report of our previous experience and the presentation of our current thinking. The final section presents the conclusions.

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2. Theoretical and Empirical Background

A known quote in the field of CSCW (Computer Supported Cooperative Work) states that "*workflow systems automate a fiction*" [Ellis94]. The statement highlights the empirical 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, or several overlapping (in time and space) groups.

Underlying the statement is 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 temporal sequence) by an external entity, in such a way that this organization leads to the predefined goal. Collaboration refers to the capability of self organization of those group members, which progress to the final goal through informal and mutual adjustment. Workflow systems can thus be labeled "coordination" technologies, while other tools for informal interaction like group decision support systems (GDSS) [DeSanctis87] are better defined as "collaborative". A basic assumption in the remainder of this paper, is that we should reject any aprioristic bias towards one or the other type of systems. Both are adequate in particular circunstances and address complementary issues in the computer support for organizational work.

2.1 Plans and Situated Actions

The title of this subsection refers to the foundational notions presented by Lucy Suchman in "Plans and Situated Actions" [Suchman87]. The concepts presented in the larger scope of human machine communication match particularly well with the dichotomy we are handling in this paper. In fact, when put in the context of group interaction, or group work, the automation provided by traditional workflow systems can be classified as a strict, or fully specified, plan for group work. However, to quote Suchman's writings, "***plans are inherently vague***, *plans are a constituent of practical action, but they are constituent as an artifact of our reasoning about action, not as the generative mechanism of action*". On the other hand, "*The term **situated action** underscores the view that every course of action depends in essential ways upon its material and social circumstances ...*". Finally, in what concerns the relation of plans to situated actions: "*The function of abstract representations is not to serve as specifications for the local interactions but to orient us in a way that will allow us to exploit some contingencies of our environment, and to avoid others....*".

We argue that workflow systems provide plans, as resources for action in the Suchman's sense, for group interaction and work, but should not aim at defining the complete details of each interaction which are often defined by the actual circunstances or situation.

Another important concept highlighted by Suchman is the one of **breakdown**. This concept is also central in the work presented by Winograd and Flores [Winograd86], and has its roots in fundamental philosophical reflections on cognition and language. From Winograd and Flores, "*... a design constitutes an interpretation of a breakdown and a commited attempt to anticipate future breakdowns...*". The contextualization of this 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 individual group members when prescribed plans breakdown in a workflow-supported environment ? Which alternate courses of action are provided to the group ? An intuitive answer leads us to the support for informal group interaction, communication and decision.

2.2 Organizational Structures and Flows

Another body of theory that underlies our integrative perspective is the the view presented by Mintzberg on organizational structures and dynamics [Mintzberg79, Mintzberg93]. A general model for the structure of organizations, according to Mintzberg, includes five basic parts: (1) the *operating core* is composed by the operators that carry out the basic activities of the organization like

producing products or providing services; the *administrative* component, above the *operating core* is composed by *management*, (2) *technostructure* and (3) *support staff*; the *management* component can be further divided in (4) *strategic apex* and the (5) *middle line*. The former is the top of the management hierarchy, the later completes the chain of command down to the *operating core*; the *technostructure* includes the analysts that support the standardization of the work of others and apply analytical techniques to adapt the organization to the environment; and the *support staff* supports the functioning of the organization indirectly.

Based on the five part structure, linkages between the parts are defined, which characterizes the organization as a system of flows. Organizations can be viewed according to five different perspectives: as a system of formal authority; as a system of regulated flows; as a system of informal communication; as a system of work constellations; and as a system of ad hoc decision processes.

1. The flow of formal authority corresponds to the relations of direct supervision within an organization. It is usually described through the *organizational chart* or *organigram*.
2. Regulated flows are determined by the standardization of the activities within an organization. Three distinct flows are considered: operating work flow; flow of control information and decisions; and flow of staff information.
3. Authority and regulated flows are not the only mechanisms that shape the dynamics of an organization. Another important contribution is given by informal communication. Informal communication is justified on two grounds: First, most activities carried out in modern organizations have a degree of complexity that cannot be fully regulated. Second, organizations are social in nature.
4. Informal communication is often patterned in certain ways. This structuring of the informal communication takes the form of work constellations created due to the aggregation of the individuals.
5. The last perspective on the dynamics of the organization is the consideration of the *ad hoc decision* processes.

Under this classification scheme for organizational structures and dynamics, regulated or formal flows are associated with coordinated actions, and therefore in the scope of workflow systems. Informal flows, work constellations and ad hoc decision processes, as essentially unplanned or situated, seem to be better suited to the use of 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 an integrative effort.

2.3 Empirical Evidence

A final but not less relevant ground for our approach is the empirical evidence drawn from observing workflow systems in use[3]. The observations can be summarized as follows:

• The main effect of the deployment and use of workflow systems is the elimination of the paper-based forms from the traditional processes
• Automated processes, even highly standardized ones, do nor seem, from the user point of view, to increase their speed of "travel" through the organization. Control however becomes easier and user awareness of the processes status is increased.
• The number of processes that become "automated", if observed along the time axis, has a steep growth in the beginning, when the strictly standard, completely formal, processes are chosen to be the subject of automation. However, sooner than later, we observe the coverage of workflow technology becoming to a halt, or at least a much slower growth, due to the fact that the

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[3] At INESC, where the authors work, a groupware system called Elenix is in use for about two years. Elenix incorporates basic workflow functionality, namely electronic forms circulation. This is the mechanism through which some of the standard organizational procedures (travel requests and authorization, internal memos, purchases) were put in electronic format. Elenix (developed and sold by SMD Informatica S.A., a portuguese company) was also the base technology of ORCHESTRA, around which additional prototypes and methodologies were designed and evaluated.

"obviously automatable" processes are no longer available, and the remaining ones are not "obviously" supported by the workflow system.

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

3. Orchestra : An Observational and Research Opportunity

The concepts and proposals presented in this paper have been consolidated in the ORCHESTRA project. This project, its rationale, activities, partners and results are extensively described in [Orchestra97]. ORCHESTRA (**OR**ganisational **CH**ange **E**volution, **STR**ucturing and **A**wareness) was an European Union funded project (ESPRIT 8749), involving a large number of partners, and lead by INESC.

3.1 Objectives

The objectives of Orchestra can be interpreted in multiple ways. The generic conceptual framework of ORCHESTRA was designed with the organizational models and theories in background, and with the concern for organization-centered application of information technologies.

The consolidated objective of the ORCHESTRA project could therefore be stated as:
> **To design and develop a Groupware system that increases organizational effectiveness through better management of organizational information, improvement of the communication among individuals and groups, and support to the decision and negotiation processes.**

The potential products resulting from Orchestra were a toolkit of complementary and integrated technological components and integration expertise that address the multiple dimensions of organizational automation and augmentation through technology, taking into account the intrinsic heterogeneity of large organizations and the existing investments in central information systems.

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 with emphasis on administrative work : 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 and execution of the Nuclear Fuel purchasing process in Madrid, Spain.

The project, with a duration of two years, was broad in scope and addressed the following methodological and technical areas:
- Organizational Analysis and Characterization, including diagnosis and evaluation
- Automation of organizational procedures, including the enhancement of the user environment, authentication and security, workflow management and information systems integration.
- Interpersonal and Organizational Communication, including electronic mail standardization, and intelligent (or contextual) communication filtering
- Support to Negotiation and Decision processes, in a dual nature, namely through the integration of Management and Executive Information Systems, and through the design and integration of interactive negotiation tools.

The activities that most directly concern the purpose of this paper, and from which we will draw conclusions or inspiration, were the ones shortly described below.

3.2.1 Organizational Analysis and Modeling

The task of organizational analysis was undertaken in ORCHESTRA by a social sciences school. This analysis was performed in the three user, or pilot organizations, mentioned above. The social scientists team opted for the model developed by Jerry Porras [Porras 1987], called Stream Analysis. Further details on this methodology and related tool support can be found in [Carriço97].

The data collection process was based on semi-directive interviews to the key elements of the organizational units and processes under analysis. The main characteristic of this type of interview is the existence of a guideline and a set of topics to be treated. This guideline, although not rigid, allows the collection of information equally adequate to the objective of the work.

With the organizational description at hand, both the general and the specific to the work flows, the ORCHESTRA project approached the problem of modeling workflow in the larger scope of organizational description and modeling. To support organizational modeling in general, and workflow modeling in particular, we decided to use Taskon OORAM (*Object Oriented Role Analysis and Modeling*) [Reenskaug96] (see section 4). The result of the application was the production of a large amount of workflow models (50-100) in computational form.

3.2.2 Workflow System Design and Development

The definition of the workflow functionality based on observation of initial prototypes, the analysis and evaluation of competing products, and the result of the discussions and reviews, can be summarized as follows: The workflow system of Orchestra would not be a standalone tool or system but rather a component with a much closer integration with the remaining components of the groupware environment under construction. The effort was directed to the design and construction of an open and integratable workflow engine.

This decision reflects in fact the realization of the need for an open architecture for workflow systems, an approach that was starting to be promoted by the WfMC (Workflow Management Coalition). As we will observe later in the paper, our approach is very much in line with the WfMC proposals.

3.2.3 Interactive Negotiation Tools

The construction of interactive negotiation tools or, as the perspective grew up, facilitation tools, had two dimensions in ORCHESTRA. The first dimension has to do with the design and development of a suite of tools in the specific computing environment of ORCHESTRA. While related tools exist, the requirements for integration with other components of ORCHESTRA, as well as the wish to elaborate on the interaction approaches, led us to these developments. The second dimension relates with the problem, which fundamental nature became clearer and clearer along the project, of linking together support for regulated of formal processes (a long name for traditional workflow) and support for informal and ad-hoc decision processes. These aspects are addressed in more detail in section 5.

4. Workflow Systems and Technology

This section reviews several examples of workflow technology. We first highlight aspects of existing workflow systems and widely disseminated groupware technologies. The modeling approaches are of particular relevance because they provide a departure point for our integration efforts.

4.1 A Sample of Workflow Systems

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

a complete representation of a process, comprising a process diagram and the settings that define the logic behind the components of the diagram. The activities that make up the process are represented by symbols in the diagram and possible ways that work and data can flow through a model are represented graphically by control connectors. Flowmark includes a comprehensive set of devices for modeling organizational structure, user skill levels and roles.

Staffware is another client-server workflow tool and one of the earliest workflow products that helped to shape the market. The most impressive aspects of Staffware [ovum95] is its ability to suport 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. A Staffware workflow is created by linking a set of steps that make up a case. Each step can have a related form which is sent to a different users for information or completion. When a user completes a step then subsequent steps can be processed. Forms are optional: a step can directly invoke an external application.

ActionWorkflow is a client-server application that routes foms. Forms are the front end to a Lotus Notes or Microsoft SQL Server database. ActionWorkflow System is a product that comes with a methodology: tt enacts processes based on conversation cycles between customers and performers that represent a commitment to do the work. The conversation moves towards completion as the participants choose from a set of possible acts. The system operates at a higher level of abstraction than classical workflow systems: what flows between participants is not work but rather responsibility [ovum95, Action96].

Action Technologies's Metro is a business process management solution available for the Internet, enabling companies to automate their business processes across a "virtual" enterprise. It optimizes the efficiency of organizations by capturing, routing and tracking requests as well as the commitments made to fulfill them. Metro has the full power of the ActionWorkflow work coordination engine behind it.

4.2 Groupware Environments

Recent years have witnessed the widespread use of what as become to be known as groupware systems. Two of the most representative of these types of systems are Lotus Notes and Microsoft Exchange. Essentially, these platforms provide high level communication support, both inter-personal and inter-application, some degree of document managements, and a set of tools to build special purpose applications that profit from the base functionality. As such, workflow became an obvious directions of evolution.

Lotus Notes Release 4 [Lotus96] is a client-server application development platform that integrates with relational databases and supports cross-platform development. Notes is composed of document database, integrated with an enterprise messaging infrastructure. The Notes Application Development Environment (ADE) enables rapid development of strategic business applications that store and route information objects using the database and messaging services. It includes LotusScript, a structured programming language that provides a programming environment in Notes.

Microsoft Exchange Server/ Microsoft Outlook Client [Outlook97] Microsoft Exchange Server has become available and disseminated in a large number of organizations. On top of this server, messaging and scheduling tools have evolved. These systems are based on open standards such as the messaging application programming interface (MAPI) and MIME. Microsoft Outlook™ 97 is a workgroup client that combines enterprise messaging, group scheduling, personal information management and a form-design environment.

4.3 Modeling Approaches - Several Levels and Targets

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 understandable 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 candidates for providers of modeling support.

We consider three basic categories of process modeling methodologies:

- **Commitment based methodologies** - It is based in [Winograd86,Georgakopoulos95] interpretation of work that stands that the coordination of actions and the flow of work can be tracked through speach acts. It reduces every action in a workflow to a four-phase cycle based on communication between a customer and a performer. The business process map of the organisation is made of a network of such cycles, where its easy to see areas of confusion, incompleteness, inefficienty or ineffectiveness.
- **Activity based methodologies -** Focus on modeling the work instead of modeling commitments among humans. Workflows consist of tasks and each one may be composed of subtaks. This is the model used by most of the commercial workflow management systems but it does not capture process objectives such as customer satisfaction. Limitations often arise at the level of the structuring, encapsulation and reuse mechanisms.
- **Object-oriented methodologies -** Different parts of a workflow are modeled as objects which comunicate with each other. This is an application of the general object oriented approach to workflow modeling. The immediate advantages are the intrinsic power of structuring, organization and reuse that object oriented tools provide in a modeling task. On the other hand, object oriented tools do not provide explicit support for workflow process modeling. The modeler has to build a set of classes that constitute the specific domain of workflow.

The first two types of modeling approaches were illustrated in the previous section. Workflow systems like Flowmark or Staffware reinforce Activity-based methodologies. Action and Metro are the most striking example of Commitment based methodologies.

The use of object oriented methodologies in modeling workflow systems is an approach that is being pursued in multiple contexts. Jacobson´s model is made of actors and "use cases" [Jacobson95]. An actor represents something that interacts with the business, whereas a use case represents the flow of events that a particular actor wants performed in the business.

In ORCHESTRA, we adopted the Taskon OORAM methodology and tool as an open approach to workflow modelling [Farschain96, Guimarães96]

OORAM - Object Oriented Role Analysis and Modeling Taskon/OORAM [Reenskaug96] is a software engineering tool that provides an environment for object-oriented analysis, design and implementation in areas such as enterprise modeling and information management systems. The tool is based on a pure object-oriented concept. Role models are the central construct. They describe how objects collaborate in a structure in order to perform some function of the overall system. 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.

4.4 The Workflow Management Coalition[4]

The Workflow Management Coalition 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 has been proposed [WfMCGlossary96].

4.4.1 Models and Architectures

All workflow systems contain a number of generic components which interact in a variety of ways. The model illustrated below, identifies components and interfaces:

- Process Definition Tools - are used to analize, model and describe business processes, as mentioned in the previous sections.
- Workflow Enactment Service - is the run-time environment where workflow processes are executed. This service is responsible for reading process definitions, and creating and managing process instances.
- Workflow Client Applications - present work items to the end user, invoke application tools that 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.
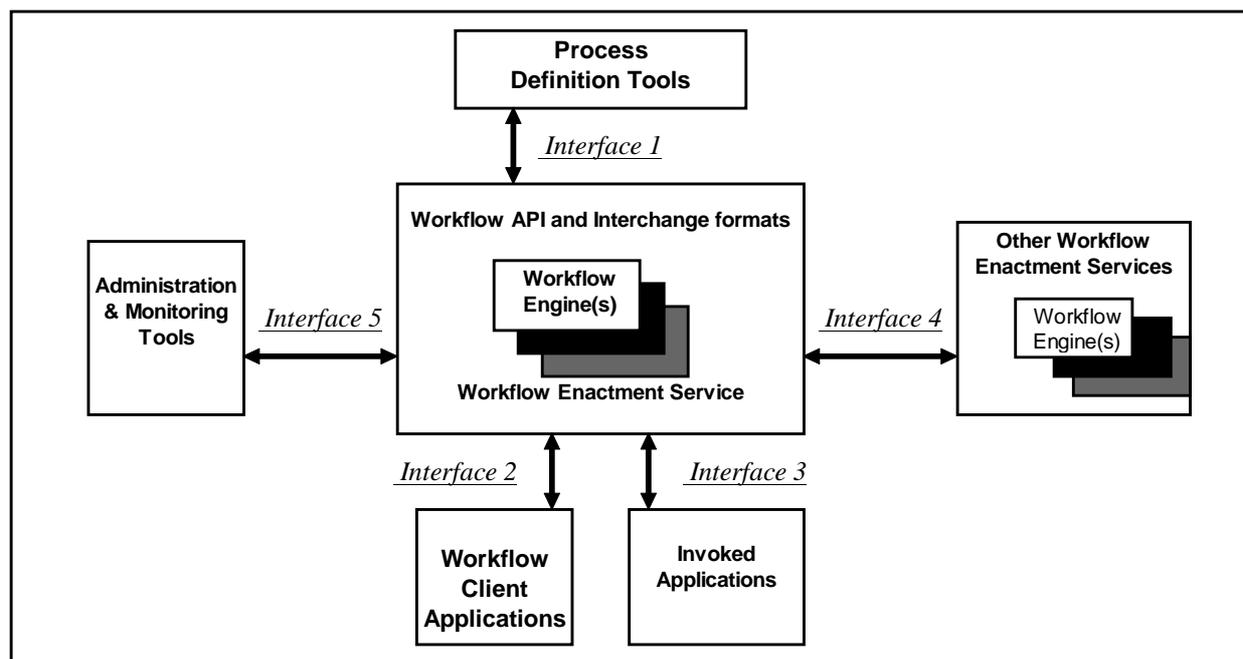
Fig. 1 : *Workflow Reference Model*

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

- interface 1 [WfMC96Interface1]: process definition import/ export interface
- interface 2 [WfMC95Interface2]: interaction with workflow client applications and software for presentation of worklists
- interface 3: tools and external application invocation
- interface 4 [WfMC96Interface4, WfMC96Interface4a]: interoperability between several workflow management systems
- interface 5 [WfMC96Interface5]: interaction with Administration and Monitoring Tools

4.4.2 Openness Directions - The Process Definition Language[5]

One of the interfaces being standardized that has a direct impact on the proposals that we make in this paper, is the "Process definition import/export interface". This interface normalizes the format of a work process description. This definition leads to a common interchange format, the Workflow Process Definition Language (**WPDL**), which supports the transfer of workflow process definitions between separate products. As stated in the quoted WfMC proposal, "this format describes a formal documentation of a workflow process, which focuses the information content of build-time definitions".

While standardizing on a core set of concepts, 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"). 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.

```
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
```

Fig. 2 - An illustration of the WPDL for the FBN business example

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[5] This WPDL - Workflow Process Definition Language is thoroughly described in WfMC document Workflow Management Coalition Interface 1: Process Definition Interchange, Document Number WfMC TC-0020

The WfMC proposal document includes one representative business case that can be used to verify the feasibility of the implmentation of the standard, as well as to constitute the 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 table above.

5. Collaboration Techniques and Decision Models

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 writing environments or electronic meeting rooms [Streitz94], or GDSS's [Kraemer88, Nunamaker91].

5.1 Group Techniques and Processes

Undelying the support for collaborative processes in the scope of decision making are a number of techniques for group decision and negotiation. These techniques are based on the social behavior of people in small groups. This subsection presents a small set of those techniques, not necessarily homogeneous.

Brainstorming is the most known method of idea generation and is in worldwide use [Hwang87]. It is defined in the Webster's international Dictionary 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 modified brainstorming techniques have been devised [Hwang87, Nunamaker91].

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 [Turoff91Computer]. 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. 2. Analysis of the questionnaire.3. Second questionnaire. 4. Analysis of the second questionnaire and voting. 5. Third questionnaire and identification of agreements and disagreements. 6. Final report.
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 characteristic is that Delphi does not require physical presence [Robbins92].

The Nominal Group Technique 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. 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].

The **Survey** technique allows managers to ask for information but make 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.

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 has been reported but even a short description of them would not fit in this paper. In particular decision contexts some of these reported techniques may prove adequate for enactment through computer supported tools.

5.2 Models for Decision Processes

Decision models provide systematic views on how do people and groups handle several variables in the course of a decision processes. This subsection presents a particular perspective of the decision processes that will be of relevance in the next section.

The Thompson & Tuden's contingency model for group decision making [Butler91Designing] is concerned with the understanding of decision making from the intended solution point of view. It considers two criteria related with the problem: Uncertainty about ends (the intended outcomes); and Uncertainty about means (the solutions used to achieve the desired ends). The model maps the combination of high and low scores on these criterias in four types of decision making processes: (1) Computation: Well known ends and solutions; (2) Judgment: Selection of solutions for well known ends; (3) Bargaining: Resolving of disagreement over ends; and (4) Inspiration: Unknown ends and solutions.

The **McGrath's typology of group tasks** [Mitchell87] attempts to classify what a group is expected to do: (1) Generate plans or ideas, (2) Execute some task, (3) Negotiate disagreements, (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).

The **Hwang & Lin's system approach** to expert judgments/group participation [Hwang87] focus 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; (4) Problem solving, and it maps these problems with the following types of facilitation supported by the system: (a) Creative confrontation; (b) Polling of experts/participant ideas; (c) Systematic structuring, and (d) Simulation.

The **Vroom & Yetton's** model identifies the possible different degrees of group participation in decision making from the manager's point of view [Vroom88]: Manager decides alone; Manager asks individually for information but decides alone; Manager asks individually for information and evaluation but decides alone; Manager meets with group to discuss a problem but decides alone; Manager meets with group to discuss a problem and the group makes the decision. The model is normative and bases its decision on the following criteria: Quality requirements; Information available; Problem structure; Acceptance by those affected by the decision; Subordinate implication; Probability of conflict among members.

The **Stumpf et al.** [Mitchell87] model focus on the typology of group processes in two of its aspects that complement the participants' view: membership and interaction. The model uses the following criteria: Quality of the decision; Acceptance by those affected by it; Requirement of a creative or original decision; Span of the decision; Necessity of knowledge and information; Probability of conflict among members. The model suggests decisions on the group membership (experts, coworkers, representatives of all relevant constituencies), and on the type of group interaction (face-to-face interchange during the whole process, face-to-face interchange only in evaluation phase, face-to-face interchange).

The fundamental conclusion 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 layed out the scenario for an integrative approach. On one hand, we have available a significant set of methodologies and technologies for supporting essentially formal and coordinated processes, a more general name for workflow. On the other hand, we are aware of the existence of models and techniques that characterize and support group decision as an essentially informal or collaborative process. The core issue that has to be addressed in the design of an integrative approach is how to build the bridge between the multiple models and techniques. This section raises the issue of exceptions, presents a solution that was designed in the scope of the ORCHESTRA project, and proposes a generalized approach to this integration.

6.1.1 Exceptions in organizational work

Exceptions in organizational work are explicitely addressed in [Saastamoinen95]. It this work, exceptions are classified as follows: (1) Established exceptions are events where appropriate handling rules exist but they are either imcomplete or the exact set of rules to be applied cannot be identified; (2) 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; (3) True exceptions are completely unanticipated events where no preparation what so ever exists, and neither the normal situation nor the specific goal or state that results from handling the exception is defined.

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

6.1.2 Collaboration as the Exception Handlers for Coordination Problems

The ORCHESTRA approach can be summarized as follows: the workflow system identifies exceptions. 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. Once this match is found, the informal process is activated through the activation 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 is then able to progress with the execution of the formal flow.

The architecture that supports this approach is depicted in figure X 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.

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, the Matcher identifies or 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 group interaction tool from the Tool Bench and connects the agents with the tool. The Matcher identifies the problem and chooses the most appropriate agents and techniques based on a set of decision criteria.
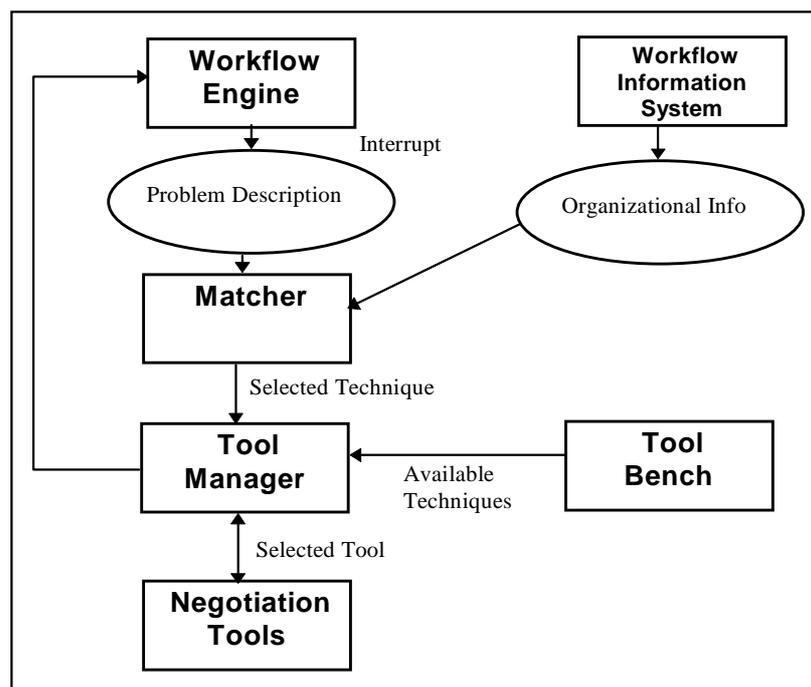

Fig. 3 - An architecture for the Integration of workflow systems and GDSS tools

Criteria for Problem-Matching Techniques. The models described in section 5, were considered in the design of the Matcher functionality. The mapping from problem to resolution technique is made by the Matcher in five stages that are designed according to the decision models presented above.

First Stage: The first stage deals with criteria which were identified as elementary to the specification of the Matcher. This stage considers different values for three basic aspects of: Problem - Ill defined or well defined; Solution - Ill defined or well defined; and Process - Judgment (selection

of solutions), bargaining (resolving of disagreement over solutions), inspiration (search for inspired solutions) or reasoning (rational approach).

Second Stage: Degree of Participation: In the second stage the Matcher tries to identify the degree of participation needed to solve the problem through the application of a technique. Its major concern is the formation or not of a group or committee to make the decision.

Third Stage: Group Composition : At this stage, the Matcher has already identified the need for the formation of a group or committee and decides on the qualification of the group.The Matcher will also provide names of people who could be part of the group.

Fourth Stage: Face to Face Interaction : At the fourth stage, the Matcher considers the need of a face to face interaction. 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.

Fifth Stage: Fine-Grain Criteria : In this last stage the Matcher will assign values to what we have called fine-grain criteria, in opposition to the other more formal criteria considered in the previous stages.

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.

The Tool Manager

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. The mapping is scalable in the sense that it is possible to select alternatives depending on the tools available in the Tool Bench while maintaining a degree of consistency with the models for group interaction. 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 capable to discriminate them. If not, the Matcher has to be upgraded with new criteria in the second level.

The Tool Bench 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.

Two prototypes of tools supporting the Voting and Brainstorming techniques were developed. The principles underlying those tools are drawn from multiuser interface architectures and experience has been gained addressing several issues: multiuser interaction modes, concurrency and concurrency control, and awareness of cooperative work [Antunes95b].

6.2 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 eficacity of organizational work. Informal meetings, or collaborative actions, must be defined as complementary to workflow steps, or coordinated actions.

This view is not currently supported by most of the available workflow technology. Some systems, specially the ones that consider what we have classified as Commitment-based methodologies, may have an advantage in this context. In fact, the foundation provided by a converstational 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 in the previous subsection.

If we consider coordination and collaboration as particular sub-classes of cooperation, then we should search for higher level models that will 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. X).
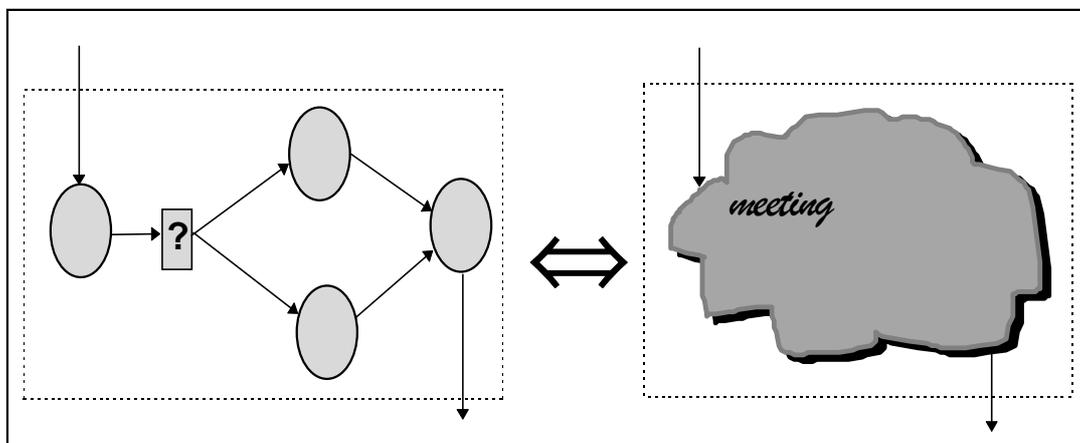

Fig.4 - "Meetings" and "Flows" as alternate forms of work

We believe that this is a fundamental progress to be sought, given its relevance to the integration of cooperative technology with the organizational change and transformation processes (the so called "reenginering"). Much of the reeginering processes affect the formality degrees in several places in the organizational structure.

The design of the transformation mechanisms is currently under design. 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 corodination 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 fig. X with the WPDL example) that is required to design and implement and 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 main conclusions that we can draw from our research and experience, and which summarize what has been presented in this paper, are the following:

- The theoretical frameworks that have been proposed in the broad scope of human-machine interaction and design of interactive systems support the notion of complementarity between coordination systems, or workflow, and collaborative systems, like meeting support systems, or group decision support systems. The experience in the observation and use of workflow technology leads to the same conclusion.

- Workflow technology and systems is becoming more and more disseminated. Moreover, efforts are being made in the direction of openess and modularity. This is the fundamental advantage of proposals like the ones of the Workflow Management Coalition. In our specific context, the consolidation of an approach to Workflow Process description is of great relevance.

- A large body of knowledge exists in the area of group interaction techniques, as well as group decision models. This knowledge is available for integration in computer based tools that provide a richer support to those processes. Moreover, this integration is feasible as the ORCHESTRA approach demonstrated. However, usability issues must be further studied.

- The integration of coordination systems and group interaction technologies can follow several approaches. The first is based on the perspective that group interaction tools are "exception handlers" for workflow systems. In this situation, we assume that control is owned by the coordination support. The second approach is based on a more horizontal notion that coordination and collaboration are essentially equivalent (not equal), and that a systematic mapping between both can be achievec. This is the research question we are currently trying to answer.

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