THE ACTION WORKFLOW APPROACH TO WORKFLOW MANAGEMENT TECHNOLOGY

Raúl Medina-Mora, Terry Winograd, Rodrigo Flores, Fernando Flores

Action Technologies, Inc.
1301 Marina Village Parkway
Alameda, CA 94501
(510)521-6190 rmm@ati.mhs.compuserve.com

ABSTRACT

This paper describes ActionWorkflow™ approach to workflow management technology: a design methodology and associated computer software for the support of work in organizations. The approach is based on theories of communicative activity as language/action and has been developed in a series of systems for coordination among users of networked computers. This paper describes the approach, gives an example of its application, and shows the architecture of a workflow management system based on it.

KEYWORDS

Workflow, ActionWorkflow, Coordination, Coordinator, Business process.

INTRODUCTION

In introducing new technologies into a workplace we are not simply augmenting the work, but are in effect reorganizing it. Technological innovation offers an opportunity for organizational innovation. In providing computer support for cooperative work, we are directly concerned with its potential for business process redesign.

For the past ten years we and our colleagues at Action Technologies have been developing computer software for organizational communication and action, based on a theory of work structure as language action. Previous publications [2][3][10][12] have described the basic elements of the theory and explained its application to computer-supported cooperative work:

- *Language acts*, classified according to a speech-act taxonomy.
- *Conversations*, which are coherent sequences of language acts with a regular structure of expectations and completions.

- *Time tokens* for *completions* in conversations.
- *Explicit mutually-visible* representations of acts, conversations, and times, as a way of facilitating communication in an organization.

This has led us to a new way of characterizing workflow, based on the identification and construction of atomic "loops" of action in which a performer completes an action to the satisfaction of a customer (internal or external). The overall workflow in any organization is an interweaving of these action workflow loops, some of which are highly recurrent (done in a structured way time after time) and others are *ad hoc* (unique to a situation). Our experience with workflow management technology has demonstrated the effectiveness of action workflow analysis in redesigning the action structure in an organization to improve the workflow, along with providing computer support.

BUSINESS PROCESSES

We distinguish three different domains in which to describe activities of an organization:

Materiel processes.

Human activities are rooted in the physical world. Nothing happens without physical things moving and changing state. If we ask "What is happening?" the obvious answer is a description of physical activity.

In the tradition of factory automation this was the relevant domain, in which physical components were transformed and assembled into product unities. Materiel process redesign and technologies have been used to move and process objects more efficiently, from the early analyses of Taylor and the production innovations of Ford, through the sophisticated techniques of modern industrial engineering.

Information processes

With the twentieth-century shift to "information work," the materiel process domain fails to capture what is important about everyday activity. With computer workstations, all of the physical work becomes indistinguishable—talking to people and tapping keys in front of display screens. What is relevant is the nature of what the talk and tapping is about.

Theorists and information technology providers have developed sophisticated ways to analyze and facilitate the flow of information. Current techniques of data flow analysis, database storage and retrieval, transaction processing, network communication, and many more have provided a structure of effective information processing. This is the heart of the applications offered by the computer industry today.

Business processes

What is lost in the information perspective is the recognition that information in itself is uninteresting. Information is only useful because someone can do something with it, and we can't define "do something" circularly as just the handling of more information. What do people do that matters?

Here we find the domain of business processes, in which people enter into language actions that have consequences for their future activities. When a customer hands a supplier an order form, there is a physical activity (transferring a piece of paper) and an information dimension (communicating a form with information about a particular set of goods, delivery instructions, etc.). But the true significance is in the business process dimension: It is a request for the supplier to perform some particular actions, in return for which the customer is committed to perform other actions (e.g., payment).

Our theoretical work has been identifying the basic structure of the business process dimension: workflows, roles, acts and the incompletions they lead to, which constitute expectations for further behavior by the participants. It is important to note that business processes are implemented in information processes, just as information processes are implemented in materiel processes. In moving to a focus on the language/action structure of workflow, rather than on the forms or database transactions used when acting, we are revealing a higher existing level of organization.

WORKFLOW

Most current approaches to workflow management are structured around the domain of information processes [9]. They begin with a class of information objects, such as forms or stored images, and define workflow as a sequence of actions to be done on those objects. The primary organizing structure is the "routing" of information objects among users, and the specification of automatic actions to be taken in that routing. In a way, this is very much like the materiel process view, in which parts are passed along from one "station" to another in a factory for processing, and some of the component tasks are taken over by automated machinery.

Traditional work management is well suited to highly structured "heads-down" paper processing, but is not adequate for supporting the realities of work in the 90s, with its emphasis on better educated workers who combine structured work with opportunity-based initiative and individual responsibility for quality and customer satisfaction.

Although our approach also includes capacities for generating and managing forms, these are grounded in the dimension of business process structure, which is constituted of action workflow loops. This provides the basis for allowing individuals to deal directly with the consequences of their work for completion and satisfaction.

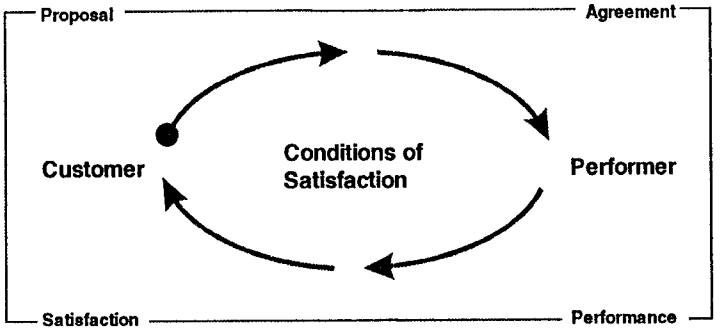

Figure 1. ActionWorkflow Loop

Figure 1 shows the basic sequence of actions in the action workflow loop. There is always an identified customer and a performer, and the loop deals with a particular action that the performer agrees to complete to the satisfaction of the customer.

The loop proceeds in four phases:

1) Proposal

The customer requests (or the performer offers) completion of a particular action according to some stated conditions of satisfaction.

2) Agreement

The two parties come to mutual agreement on the conditions of satisfaction, including the times by which further steps will be taken. This agreement is only partially explicit in the negotiations, resting on a shared background of assumptions and standard practices.

3) Performance

The performer declares to the customer that the action is complete.

4) Satisfaction

The customer declares to the performer that the completion is satisfactory.

At any phase there may be additional actions, such as clarifications, further negotiations about the conditions, and changes of commitments by the participants. (For a more detailed analysis of these possibilities, see [12], p. 65). The structure is defined by the language acts through which people coordinate, not the actions done by individuals to meet the conditions of satisfaction. The key difference in our approach is this shift from the task structure to the coordination structure. In a more traditional workflow approach, actions of coordination are seen as one kind of task or as a flow of information between tasks. In our perspective, tasks are defined by the requests and commitments expressed in the loops. This shift is analogous to moving

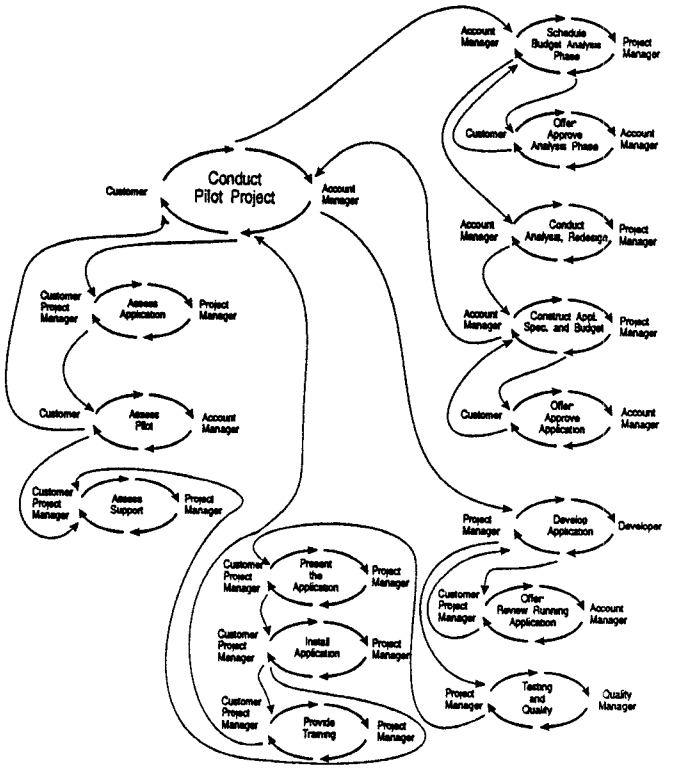

Figure 2. Business process map for pilot projects

from a view of a network as a collection of nodes (with links between them) to seeing it as a collection of links (with shared nodes). Although all the elements are still there, the different starting point leads to different potentials for representing and supporting the activities.

The simple workflow loop structure is both general and universal. It is general in that it occurs whenever there is coordination among people, regardless of what they are doing. The words "customer" and "performer" apply to people within a single organization as well as across boundaries. The loop structure is universal in that it is independent of any culture, language, or communication medium in which it is conducted. There are endless variations in the specifics of how the steps are taken, what other loops are triggered, and how people respond to breakdowns within them, but the basic structure is the same. The action workflow loop is like an atomic element of the chemistry of interactions. By combining these loops, all the complex phenomena of organizations are generated.

Our initial designs, such as The Coordinator™ [1][11][12], based their utility on the universality of this basic structure. They provided tools for creating and managing records of conversations (which correspond to workflow loops) based on the universal vocabulary of speech acts. The research described here follows later developments [2], which expand on this elementary structure as the basis for doing business process design. In place of the sequential tracking of forms found in other approaches to workflow support, we design (and help redesign) a business process as a collection of interrelated loops, each with its own completions and possibilities for breakdown.

Figure 2. shows an example of a business process map that was created to manage the conduct of pilot projects in the Action Technologies development group. The lines connecting loops show dependencies between them, with each connected to the appropriate quadrants of the loop, according to which aspects of the workflow structure they complete. We will examine a smaller example in some detail below.

We approach the task of designing a workflow management system by first analyzing the workflow structure and its possibilities for improvement and new functionality and for new or improved conditions of satisfaction that can be offered to customers. This analysis process, or "work mapping," uses theory-guided observations and interviews to generate explicit representations of the acts, roles, and incompletions that make up the flow of work. We have experimented with more detailed forms of mapping, in which we represent material and information structures in their relationship to the language/action structure [7], but the primary focus in our applied work has been on tools for revealing and highlighting the key elements of workflows and their relationship to completions and incompletions that are vital to the organization.

New opportunities to improve performance come from the ability to identify, observe, and anticipate potential "breakdowns," or failures to reach satisfactory completion. From the maps and associated discussions it is possible to identify places where breakdowns may occur on a recurrent basis and to see what additional steps or workflows can be put into place to anticipate and/or cope with them. The explicit articulation of the structure of customers, performers, and conditions of satisfaction leads to identifying new kinds of offers or requests that can be made. On the basis of these, new workflow structures can be instituted. While "breakdown" (by other names) is a standard concept in other forms of workflow analysis, the loops with their associated completions are unique to our approach.

Finally, we can identify those places where technological support can be valuable:

- Notifying users about actions that need completion.
- Providing users with the specific tools and information to complete a task, in a ready-to-hand way associated with identifying it.
- Managing reminders, alerts, follow-ups, etc. to keep processes moving along.
- Giving users an overview of where their tasks fit into the overall processes, both dynamically and through maintaining records of workflow history and providing structured access to them.

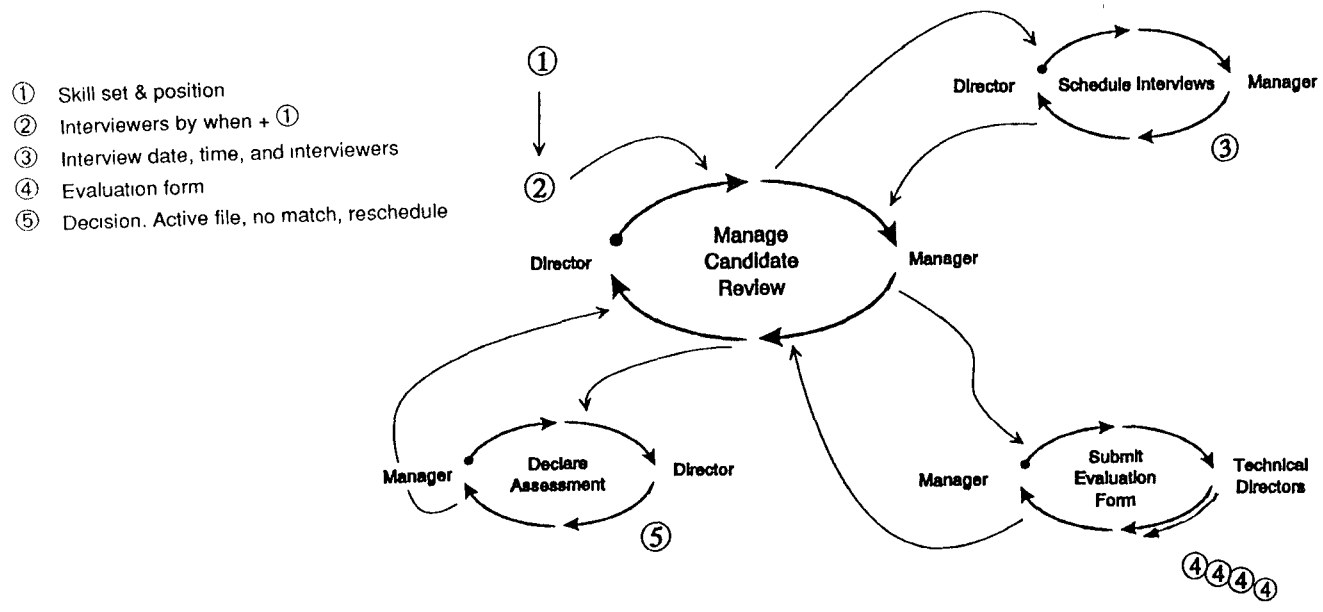

Figure 3. Core structure of the candidate review process

- Giving managers an overview of the status of workflow in the organization, both on demand and through generating regular reports and measures based on workflow structure.
- Automating standard procedures and individualized responses, on the basis of the action workflow structure.

Our methodology for providing workflow support is based on creating a unified conceptual structure and data representation that ties these functions into a coherent whole based on the explicit representation of workflow loops and their interconnections.

AN EXAMPLE

We will illustrate business process analysis and support with an application that was developed for managing the review of job candidates. This process is part of a larger business process for staffing, which is based on several dozen interconnected workflows, including advertising for positions, receiving and evaluating resumes, etc.

The process centers on four central loops, as shown in Figure 3. Each loop stands for a recurrent workflow, with the customer identified on the left and the performer on the right. Lines connecting workflow loops indicate triggering and dependency relationships between them. Numbered circles indicate forms and other external representations that play a role in the process.

The candidate review process starts when the director of personnel makes a request to a personnel manager to manage the review of a particular candidate. The manager starts the process by filling in an on-line form with information such as the interviewers, positions sought for the candidate, required skills, etc., as shown in Figure 4.

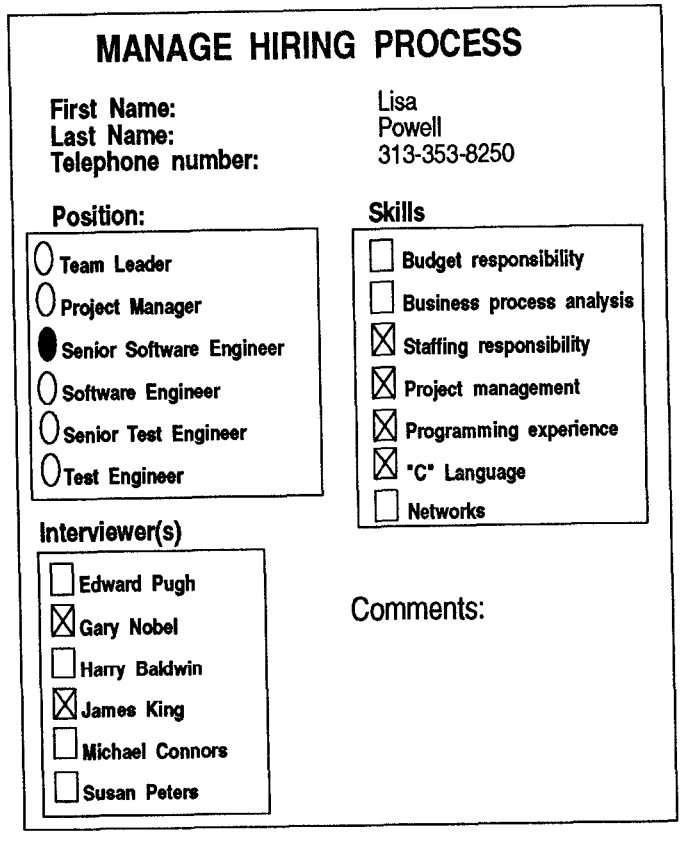

Figure 4. Form for initiating candidate review

This application was developed using the Lotus Notes version of the workflow management system, so the form was defined using the standard facilities for designing Notes forms. Other implementations differ, as described below. The structure of the review process has been defined by the analyst, working with the participants, and is stored in the definitions database maintained by the Workflow Management Server (see below). The server instantiates instances of all the workflows of the process and starts the "Schedule interviews" workflow automatically.

The "Schedule interviews" workflow corresponds to the second phase (agreement) of the main workflow: the manager agrees to do the work as requested by the director once the interviews have been scheduled. By including this scheduling in the agreement phase, a specific completion time can be promised.

Once the review process reaches agreement, the "Performance" phase starts and the "Submit evaluation forms" workflows are automatically started, one for each of the selected interviewers. Again, forms are defined for each of the participants and used in making actions in the workflow.

Once an interview has been scheduled for a particular date, all the workflows for submitting evaluation reports are initiated and directed to the selected interviewers to be completed on the specified date.

Each interviewer can use the workflow database to identify the set of workflows in progress. Figure 5 shows the status of interviews organized by interviewer. The lines showing next actions and times are generated from the action workflow database, using names defined specifically for this workflow.

Candidate	Recommended Action:	By When:
Edward Pugh		
Medina, Raul	Schedule an interview date	03/13/92
Bush, George	Check status of evaluations	0
James, Henry	Check status of evaluations	0
Samson, Dick	Check status of evaluations	0
Frank, Teddy	Thank you for submitting evaluatio	02/29/92
Gary Noble		
[redacted]	[redacted]	[redacted]
James, Henry	Recommit to evaluate	0
Harry Baldwin		
James, Henry	Recommit to evaluate	0
Wilson, Peter	Recommit to evaluate	02/29/92
James King		
Wilson, Peter	Recommit to evaluate	02/29/92
Bush, George	Recommit to evaluate	0
James, Henry	Recommit to evaluate	0
Michael Connors		
Wilson, Peter	Recommit to evaluate	02/29/92

Figure 5. Status display of interviews

By selecting one item, the interviewer brings up the on-line evaluation form for the candidate, which can be filled in incrementally and submitted when completed (this submission of a completed form constitutes a "declaration of completion" action in the workflow action structure). If the interviewer does not submit the evaluation report by a day after the agreed-upon completion date, the definition has been structured to cause the system to send a "follow-up" reminder to submit the report.

The definition of a workflow structure includes definitions of the forms that are used by customers, performers and observers of each workflow at each phase. When an interviewer accesses the document for the interview, it shows up as an evaluation form to be completed, since the interviewers are the performers of the workflow "Submit evaluation form." Other participants would see the forms relevant to the actions they are able to take, with fields available or protected from editing as suited to their roles.

Once all of the interview workflows have been completed, the system automatically declares the main workflow complete and moves to the fourth phase, where the personnel director declares (or not) satisfaction with the process. The system sends a mail message to the personnel director, as a prompt to act on the workflow for final assessment of the candidate.

At any time the manager can get an overview of the status by examining the workflow database through an appropriate view, as illustrated in Figure 6.

Recommended Action:	By Whom:	By When:
Not in process		
Harris, Mike		
Commence interview process	**Manager**	
Schedule Interviews		
Medina, Raul		
Schedule an interview date	**Manager**	03/13/92
Complete Evaluations		
Bush, George		
Check status of evaluations	**Manager**	0
James, Henry		
Check status of evaluations	**Manager**	0
[redacted]	[redacted]	[redacted]
Check status of evaluations	**Manager**	0
Decision Pending		
Jones, Tom		
Decide on candidate	**Director**	02/29/92

Figure 6. Status overview of workflows

ARCHITECTURE

We have defined a general Workflow Management System architecture for interoperability among different applications and across diverse platforms, integrating the coordination of specific applications along with system enhancements and utilities from users and third-party developers. This architecture has been the basis for several implementations, including a DOS based "Business Process Management" system (BPM1) [2], an extended version of The Coordinator in the Windows environment, and a workflow application development environment in Lotus Notes (from which our example was drawn).

The overall architecture consists of one or more client applications (called *workflow-enabled applications*), and the structures and components that enable them to interact with the workflow management server and receive services from

it. Figure 7 shows the major components of a Workflow Management System.

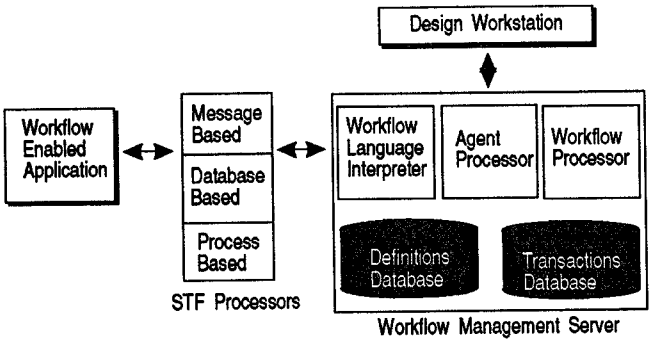

Figure 7. Workflow Management System Architecture

Workflow enabled applications
The goal of the Workflow Management System is to provide workflow capabilities to new and existing computer applications. Adding or integrating an existing or new application is referred to as "workflow-enabling."

Workflow-enabled applications are of three types:

1. Workflow-initiating applications.
An example of a workflow-initiating application would be an existing order-entry application that has been modified to initiate a fulfillment workflow. The task of the order-entry application is complete once the fulfillment workflow takes over and starts a sequence of actions to verify the new order, define customized requirements, alert manufacturing, etc. This level of integration can be done with little or no modification to the existing system.

2. Workflow-participating applications.
In the order-entry example discussed above, the participating applications are those that perform the details of the fulfillment process. The order-entry application first initiates a workflow to verify credit, for example, by sending an e-mail form to a credit manager to which she or he can respond by checking Yes or No. The addition of those buttons to an existing e-mail form, plus the work of defining Yes or No as they are to be understood in this case by the workflow processor are the only steps required to workflow-enable this aspect of the application.

3. Workflow management applications.
Workflow management applications provide managerial views and actions in addition to the operational ones needed to conduct the work. In the above order-entry example, an application that had workflow management built in could be used to keep track of fulfillment cycle times, sources of breakdown, etc. The candidate review example includes workflow management.

STF processors
STF Processors translate between an application's native data format and the Standard Transaction Format of the Workflow Language Interpreter. STF Processors isolate the Workflow Management Server from the interface used by the application and provide a layer for integrating different protocols and technologies. By providing an appropriate STF Processor, any existing database, messaging, or networking system can be incorporated into a workflow management network. If an application communicates by writing to a database, for example, the STF Processor will read the database and look for the records that hold STF transactions.

This architecture makes it possible for existing line-of-business applications, databases, networks, and protocols to be orchestrated by the ActionWorkflow system. Organizations already have tools in place to manage parts of tasks, and parts of workflows. It is an important requirement of a workflow system to integrate with the existing infrastructure, or the benefits will not outweigh the costs of moving to it.

There are three types of STF processors:

1. Message-based.
Message-based applications interact with the Workflow Management System by sending and receiving messages. The STF Processor receives the messages from applications and interacts directly with the Workflow Management Server. Similarly, it constructs messages to be sent back to the application. Message-based STFs are independent of the message transport. Our current implementations use MHS as the messaging system.

2. Database-based .
The client application writes and modifies records in an external database that is concurrently accessed by an STF Processor that has been built for the particular database platform. Applications initiate and participate in workflows by modifying records in this shared database. The STF Processor monitors changes to the database and interacts with the Workflow Management Server for recording and updating transactions. Applications can manage workflows and business processes by querying this shared database to obtain reports about the status of the workflows. We have implemented transaction databases in Lotus Notes and on SQL servers.

3. Process-based.
In the inter-process communication STF interface, a client application receives services from a server by making a process-to-process service request (a remote procedure call, for example). In this case, the STF structures are embedded in the parameter blocks of the service request and service result calls.

Workflow Management Server
The Workflow Management Server uses stored definitions of the workflow structure and of the history of transactions

to interpret and initiate acts. It comprises a number of interacting components:

a) Definitions Database
This database describes the workflow of the organization. The definitions include several basic structures. The core is the set of loop types and act names, with associated forms For example, the loop type "Manage candidate review" would have an associated form as shown in Figure 4, and an "accept candidate" act as one of its ways of reaching completion. The definitions database also specifies the linking relationships connecting the different loops, and the actions to be taken automatically by the agent processor.

The linking relationships are used to generate the appropriate sets of "next actions" for each participant as the workflow proceeds, and for automation. They can be of several kinds:

1. Subordinate workflow loops:
In order to complete a part of one workflow it is necessary to initiate and complete a subsidiary one. For example, in order to do the review it is necessary to schedule interviews.

2. Independent triggered workflow loops:
An action in one workflow triggers the initiation of another, which proceeds independently. For example, in a sales workflow the selling of an item from stock may trigger reordering, but the reordering is not a part of completing the sale that triggered it.

3. Resolving workflow loops:
The decision as to which action to take in one workflow requires the initiation and completion of another workflow. For example, a credit approval must be received before accepting or rejecting an order.

In each of these cases, there may be several triggered loops of a given kind instead of just one, with concurrency relationships among them. In the candidate review example all workflow loops for interviews are started in parallel at the moment the agreement is reached in the main loop. The definition of the process indicates that the performance phase of the main loop is completed once all the interview loops are complete.

b) Transactions Database.
This database contains the history of completed workflow loops and workflows-in-progress. It is accessed both for carrying out transactions and for providing status reports and overviews.

c) Workflow Language Interpreter
The Workflow Language Interpreter receives service requests from STF Processors in the form of workflow language constructs: workflow declarations, workflow actions, and requests for workflow management services. It instructs the workflow processor to calculate workflow states and next actions based on specified criteria (such as the current state of the workflow and the role of the person taking an action). It takes actions and makes reports based on the calculations of the workflow processor and the logic of the workflow definitions.

d) Workflow Processor
The workflow processor generates and manages transaction records in the transactions database, which keep track of the current state and history of the workflow, organized according to the component loops and associated completion times.

e) Agent Processor
The agent processor maintains a queue of events and times to trigger workflow actions that have been specified in the definition. We have taken the approach of *incremental automation*, initially assuming human action at each point, and then introducing a program-determined action at any point where rules can be effectively specified. Agent code is written in the workflow definition language and initiated on the basis of the workflow type and act that triggers it. It can take actions both within the workflow structure (making acts and initiating new workflows) and in other functions (printing reports, sending email messages, running other applications, etc.).

There are three ways in which agents are triggered:

1. Triggering act.
For example, a cancellation in a particular workflow initiates a request to a manager to deal with problems caused by cancellation.

2. Status changes in a workflow.
For example, a workflow moving to the state "completed" may trigger actions to cancel all of the subsidiary workflows in progress, whether or not the termination resulted from a cancellation, success, failure, etc.

3. Incompletion times.
For example, a follow-up request to a performer may be initiated when the time for completion of a loop has been reached without a declaration of completion.

Design Workstation
The design workstation is a separate application that is used to generate, modify, and maintain the definitions. We have developed a graphical notation for high-level workflow maps, and have implemented interactive structured drawing tools for creating and manipulating those maps, which can used for business process redesign, both with and without workflow management system development.

CONCLUSIONS

The approach and architecture described here have been developed in a number of prototypes and products. In addition to the development of computer support systems, the theory and analysis methodology has been used as the basis for consulting about redesign of business processes in a number of organizations (For a general discussion of business process redesign, see [5][6]. Kukla [8] describes a case study in a chemical plant, using earlier versions of our approach).

Our experience has demonstrated the effectiveness of business process redesign and computer support based on an ActionWorkflow analysis. The theory provides a starting point that is very different from conventional approaches to workflow. When an analyst first asks people in an organization "What is the work here?," the natural response is to start looking at the forms and procedures. We explicitly reject this, ignoring the forms and asking "What are you actually *doing*?" Without the action workflow structure, this question might seem meaningless, but with it there is a specific direction to move. Who are the customers and performers? What are the conditions of satisfaction in each loop? How is each of the four stages is carried out? How are the loops related to one another?

This questioning leads to identifying those places where gaps and confusions lead to incomplete workflows, misunderstanding of results, and ineffective information flow. This can then lead to new forms and procedures, rather than simply automating the old ones. Traditional methods have been *production-centered*, focusing on efficiency (as measured in standard output for input) and control. Our approach is *satisfaction-centered*, with a central focus on commitments, conditions of satisfaction, and timely completion.

In a significant way, this new methodology corresponds to the shift of concerns in business as we move into the 90s. Guiding concerns of productivity and efficiency have been replaced with others, such as quality (how are conditions of satisfaction set, met, and declared by customers; responsiveness (how are cycle times related to the completion of the structure of loops and how can they be systematically reduced); and customization (how can secondary loops be designed and managed to effectively tailor conditions of satisfaction in the main loops).

Our current efforts are to provide a general platform for action workflow management, which can be incorporated into existing information systems in an incremental way, providing the basis for new understanding of the business processes, and facilitating business process design on a larger enterprise-wide scope. Our goal is to open up the potential to radically improve the functioning of the workflow-enabled organization.

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