PRACTICAL EXPERIENCE ON WORKFLOW : HIRING PROCESS AUTOMATION BY FLOWMARK

Kwang-Hoon Kim

Collaboration Technology Research Group
Department of Computer Science
University of Colorado, Boulder, CO

ABSTRACT

In recent, there has been an increasing interest in workflow (business process automation) as a way of supporting complex business processes in modern corporations. Because of this increasing interest, about 300 workflow management systems and tools have been commercially developed so far. One workflow product, IBM's 'FlowMark' is very remarkable. The FlowMark workflow management system is appropriate for many typical workflow applications(business processes) such as timesheet, purchase order, engineering change order, return authorization, performance review, product enhencement request, expense reports, product problem report, order entry, vacation/leave request, customer quote request, and intelligent meeting scheduler, etc.

This paper explains about the practical implementation of the workflow application, the Hiring Process at IBM, based on the FlowMark workflow management system which is running on IBM PCs under OS/2 operating system. However, the programs for realizing the behaviors of activities on the hiring process are coded by VX-Rexx user interface design language for OS/2 platform and VX-Rexx APIs provided by the FlowMark workflow management system. In terms of workflow modeling methodology for the hiring process automation, we use ICN (Information Control Nets) which is a business process modeling methodology.

In detail, this paper introduces, as an development environment for business process automation, the IBM's FlowMark and Vx-Rexx user interface design toolkit which is essential to supporting Flowmark for the graphic user interfaces of workflow applications, explains the implementation details - the Buildtime and Runtime of FlowMark - of the hiring process automation, and presents some suggestions for the future implementation including the Internet (World Wide Web) Accessibility.

Finally, we append the user interfaces and the demonstration of the hiring process automation including Buildtime and Runtime of FlowMark as appendix.

Keywords: Workflow Management System, FlowMark, Buildtime, Runtime, Server-Client Architecture, Hiring Process, Business Process Reengineering, ICN(Information Control Nets), Internet(World Wide Web) Access

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Workflow management for business process reengineering is currently a hot technology. Computer industry analysts tout workflow as the 'technology of the 1990's' and predict that workflow will become part of all office applications in the next decade.

The need for workflow software has arisen out of the proliferation of desktop computing and networks. While the amount of computing power and intelligence available on the desktop has grown dramatically in the past 15 years, overall productivity of the office worker has scarcely been affected. As business cope with global recession and global competition, they have been forced to improve productivity. The greatest opportunities for dramatic improvements in productivity lie in improving and streamlining multiperson business processes.

Workflow management provides the infrastructure to design, execute, and manage business processes on a network. End-user productivity is improved by eliminating overhead time spent in 'setting up' and 'tearing down' (e.g. collecting and disseminating the information needed for performing tasks). Lag time spent in routing work from one person to another is reduced. Using workflow, managers are better able to monitor work in process, allocate resources, and receive ongoing feedback about status.

Businesses contemplating adoption of workflow technology take a broad, process-oriented perspective on the costs and benefits. Costs include not just hardware and software costs, but also people costs associated with training, operation, and administration of workflow-based systems. Benefits accrue to all the different types of workflow users - task performers, managers, process designers and administrators, and executives - all of whom participate in the business process. Notice that automation of individual tasks directly affects only one type of user (the task performer). Managers, process designers and administrators, and executives perceive workflow as an information technology(IT), not just an automation technology. As an information technology, workflow provides improved information feedback and tools to monitor, manage, and control business processes, with or without task automation. To get an accurate picture of the business impact of workflow, businesses must add up the costs and benefits across all the different beneficiaries (users) of workflow, and not focus solely on one type of user.

It is important to distinguish today's 'workflow automation' from the 'task automation' that was the focus of early office automation work. The emphasis in workflow management is on using computers to help manage business processes that may be comprised of many individual tasks, not on using computers to automate the individual tasks. The latter may be applied selectively to some tasks, but such task automation is not a prerequisite for using and benefiting from workflow.

Such a process-oriented (as opposed to task-oriented) view of work allows businesses greater opportunities for efficiency and cost reduction. The current business process reengineering(BPR) trend is based on this observation. In many cases, just the act of analyzing business in terms of processes has led to breakthroughs in efficiency without automation. In the context of BPR, workflow management provides a means for enacting reengineered processes and for gathering live information about the actual performance of these processes. This information can be fed back into the BPR activity and used to drive further process redesign and improvement.

Our work done is one of these tries for business process automation to show that workflow provides the right information to the right persons in the right time through the automatic fashion. We model a hiring process, which is almost similar to IBM's, by ICN(Information Control Net) workflow modeling mechanism, and automate it through FlowMark workflow management system commercialized by IBM. The enactment of the hiring process is tested on a network environment set up at IBM (Boulder CO) for FlowMark management system to control data and control flows on business processes developed.

In this paper, we describe about general concepts of workflow and modeling mechanism, detail implementation of the hiring process, experiences from this workflow automation, and demonstration of the enactment of the process.

WORKFLOW MANAGEMENT SYSTEMS

Quite simply, workflow is the automation and management of business processes. Where, the business processes mean a sequence of actions or tasks which must be done to achieve business goals. These tasks are performed in a specific order by specific people (or by an agent - i.e. automated program - that takes the role of a person to complete a task). The order in which these tasks occur, or the determination of which tasks must be done, depends on business conditions or rules. The goal of a workflow management system, like FlowMark, is to ensure that the right information gets to the right person at the right time with the right tools for processing it. That is, workflow is to provide the right technology for business process reengineering.

So far, about 300 workflow management systems, including FlowMark, have been commercially developed, including as shown in the Table 1. These systems fall into two basic categories: Message-based and Object-sharing-based workflow management systems. The message-based workflow management systems can be classified into three types: Conversation-oriented, Form-oriented, and Procedure-oriented workflow management systems.

TABLE 1. EXAMPLES OF WORKFLOW MANAGEMENT SYSTEMS

Category	Classification	Products
Workflow and Coordination Systems by Message Concept	**Conversation-oriented Systems**	Action Workflow, AMS, CHAOS, Coordinator, COSMOS
	Form-oriented Systems	Active Mail, Andrew Message System, ATOMICMAIL, BeyondMail, Imail, JetForm, LIfE, MacRules, PAGES, ProMInanD, WinRules, Workflow.2000, Workman, WorkParty, Safe-Tcl
	Procedure-oriented Systems	AMIGO, DOMINO, ELF, Strudel
Workflow and Coordination Systems by Object Sharing Concept		Action Workflow, Boat, EPIC/Workflow, Factotum, FloWare, Hypnotist, InConcert, KeyFile, Metaphase, OBE, OfficeTalk-D, OfficeTalk-Zero, Omega Sak, POISE, POLYMER, ProcessIT, Staffware, Staffware Workflow, TACTS, Tracker, Workflo, XCP, flowmark

Workflow has the 'Ps' and 'Rs' characteristics. That is, there are three Rs of workflow: Routes, Rules, Roles. And The three Ps of workflow are: Processes, Policies, Practices. The characteristics, three Rs, are related with technical aspects that workflow management systems have to have. The three Ps are invisible and related to human activities (people elements). So these are so important for reengineering business processes.

ROUTES. Routing is probably the first area of business processes that was automated. Workflow management systems allow users to be able to specify the flow of any sort of object. These objects should be able to be routed sequentially (one after another), in parallel routes with rendezvous points (an object can go off on any number of different sequential routes and then reconcile into a single route at a specified point), sent in a broadcast mode (the e-mail model where everyone gets the object at once), or in any another order (as described by the user at the time of processing). Routing needs to take into account more than just the person (or process) to whom the work is routed, It must also include what objects - document, forms, data, applications, etc. - are to be routed.

RULES, A more advanced feature of workflow automation is defining rules which determine what information is to be routed and to whom. This is sometimes called conditional routing or exception handling. Most workflow builders have mechanisms for defining rules.

ROLES, The ability to define roles independent of the specific people or processes that happen to fill that role, is very important to ensure flexibility of a workflow applications. Roles are also vital when a number of different people have the authorization to do the same work. That is, any one will do, just assign it to the next available. Finally, a process or an agent can assume a role. It doesn't need to be a person.

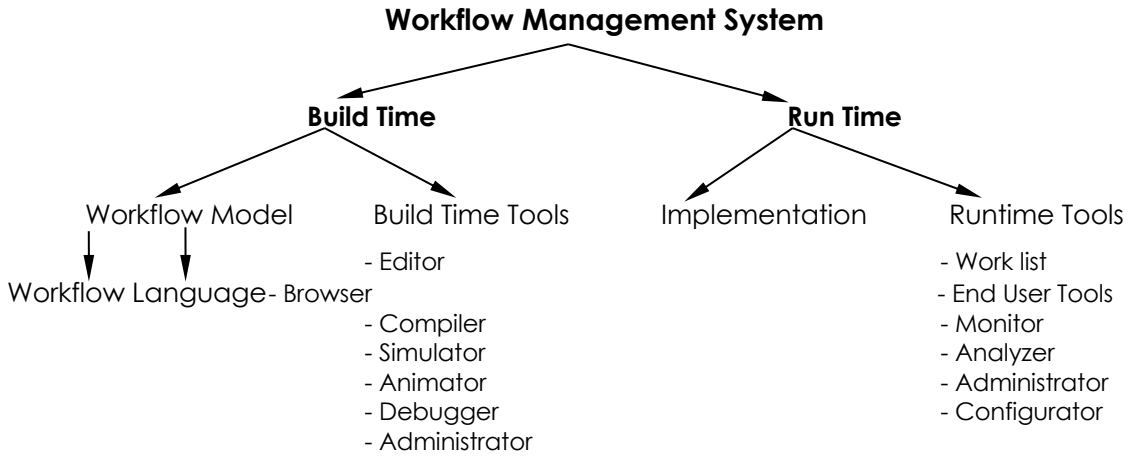
PROCESSES, The processes that have been established to run businesses are as varied and as personal to companies as are the people who take part in them. Often processes aren't designed, but rather are identified after the fact, extracted from common usage. So, one of the biggest of potential and pain is in redesigning existing processes, eliminating the redundancies, identifying the bottlenecks, and understanding why it is you do what you do. This is why the business process reengineeing field has suddenly become a hot area.

POLICIES, Policies are more than just the formal written statements of how certain processes are handled. They are the actual reasons for doing the work - the guidelines that explain how the decision to do things a certain way was made. Formal policies rarely capture this information. Most of it is anecdotal at best.

PRACTICES, The practices are an organization's reflections of its corporate culture and values. They are based on not only the work, but how the actual work experience should feel. Practices include issues such as democratic access to information, responsibility vs. authority, freedom to take risks, etc.

Too often, when automating workflow procedures, the people elements, the three Ps, are overlooked or deliberately ignored. But this is a grave error. The value of taking the time to rethink business processes in light of these three Ps is invaluable.

A workflow management system consists of two parts: Build time and Run time. The build time part allows a modeler to define and maintain all the information necessary to eventually execute workflows. The workflows are finally performed by the run time part of the workflow management system.



The conceptual part, i.e. the logical foundation of the build time part, is the workflow model. It contains all objects and relationships available to describe a particular workflow. The expressiveness of a workflow management system is decided by the content of this model. Thus, the workflow model is mainly influenced by requirements stemming from the application areas. Not only current application requirements but also future application requirements determine the workflow model. Also, the build time tools are necessary. A workflow editor is necessary for the specification of workflows. The language has to be compiled in order to check the integrity of the specified models. Simulator and animator are used to check the pragmatics of specified workflows.

The execution of workflows is the main task at run time. Therefore, an execution infrastructure has to be provided. The selection and configuration of the implementation infrastructure is driven by requirements like reliability, salability, robustness and manageability. So, the efficiency of a workflow management system is mainly determined by its implementation.

Hiring Process Modeling

Before the hiring process is designed and implemented by the FlowMark, it must be modeled and analyzed. The ICN(Information Control Nets) is a graphical representation formalism modeling office and business processes. In this section, the basic ICN and the hiring process are described. That is, the hiring process is modeled by the ICN and analyzed by defining activities consisting of the process, staff on each activity, and roles of each staff. Based on the model, the hiring process will be designed and implemented by the FlowMark in the next section.

ICN(INFORMATION CONTROL NETS)

ICN is a mathematical formalism designed to model graphically office and business procedures. Unlike Petri Nets, ICN was specifically created and designed for business processes. ICN can be represented by ICNL(ICN Language), activity, procedure, actor, mechanism, policy and control flow graph.

ICNL is a collaboration language that allows administrators to dynamically define, describe, schedule, modify their business processes, their inter-relationships, and any organizational information associated with them. ICNL can be specified indirectly using ICN editor, like the one supplied by BULL corporation. It can also be generated indirectly by a computer agent, intelligent, enough to initiate, for example, a change in the procedure.

An activity is a work step of a procedure. The activity can be either an elementary one or a compound one containing another procedure. A set of work steps will depend on many factors such as control, autonomy, cost and other organizational considerations.

A procedure is defined as a set of work steps and partial ordering of these steps. A work step consists of a header (identification, precedence, etc.) and body (the actual work to be done).

An actor is a person or a computer program responsible for fulfilling a set of duties which is necessary for the procedure to continue execution.

A mechanism is a set of components used to implement a set of strategies. In the context of workflow systems, procedures and technology used in the office are considered to be mechanisms.

A policy is a particular strategy that dictates the way that a mechanism is used to achieve specific goals. It provides the necessary tools for explicit control. Policies are both restrictive and permissive at once. They spell out the limits to actions, but at the same time give freedom to act within the limits specified.

An ICN control flow graph is composed of a set of activities represented by large circles, OR control flow nodes represented by small-open circles, AND control flow nodes represented by small-filled circles, and edges to interconnect these nodes. An arc represents precedence among nodes: if activity A leads to activity B (i.e., (A, B) is an edge in the graph), then activity A must be applied to an individual transaction before activity B can be applied to it.

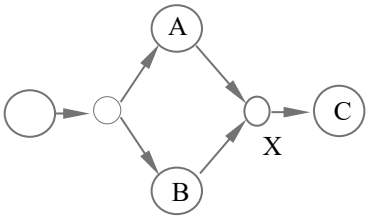


FIGURE 1. ICN OR-NODE CONTROL FLOW

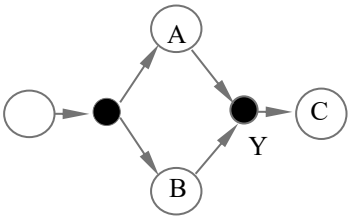
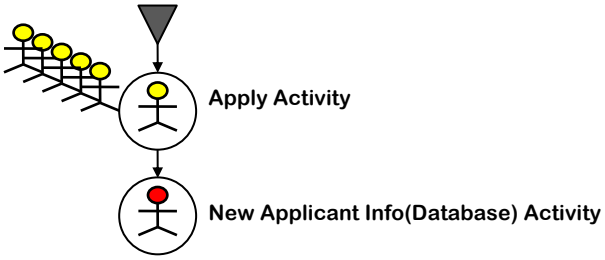


FIGURE 2. ICN AND-NODE CONTROL FLOW

Suppose we have activities A, B, and C. Let X be an OR-node with arcs (A, X), (B, X), and (X, C) in the graph(FIGURE 1); then the activity C can '***fire***' after either activity A or B has been executed on a transaction. An AND-node uses conjunctive flow logic as opposed to the disjunctive logic of the OR-node; if Y is an AND-node and the graph(FIGURE 2) contains (A, Y), (B, Y), and (Y, C), then the activity C can only fire after both A and B have fired. If instead the graph contains (A, Y), (Y, B) and (Y, C), then both B and C can fire after A has fired.



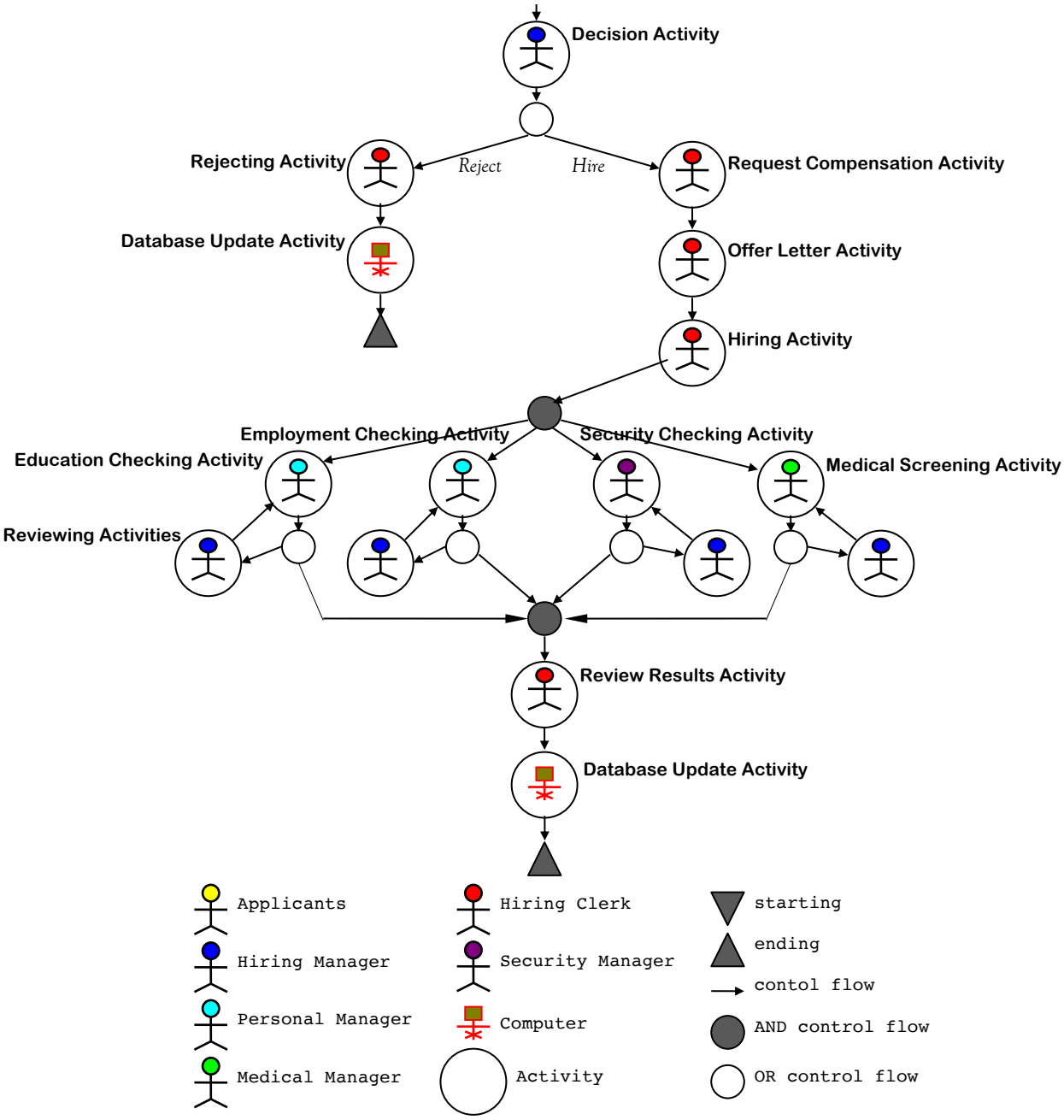


FIGURE 3. HIRING PROCESS MODELING BY ICN

HIRING PROCESS MODELING BY ICN

In general, most hiring processes have some steps of interviews to applicants. But, it is better for the interview steps to be excluded from the workflow automation procedure. Because the interview may happen on several sites according to an organization's policy, as a result, the acceptance rate of interviews has used to be very low. That is, an organization needs not to process for applicants who may fail in interviews. So, this hiring

process is only for officially offering a job to persons, and maintaining their personal information to use internally in the organization. The Figure 3 is to represent the hiring process modeled by ICN.

ACTIVITIES

- The 'APPLY' activity is accessed by an applicant for IBM employment. The applicant fills out an application form through the employment page on the World Wide Web or the employment interface designed by Vx-Rexx on PC. This entails creating an 'instance' of the hiring process and starting the instance. Applicants should give the following information:
  - Personal Data
  - Security Data
  - Affirmative Action Data: Working preference, Education, Employment Experience, etc.
- The 'NEW APPLICANT INFO' activity validates the information written by an applicant, stores it to the database, and prepares and distributes the information for the medical screening, the security checking, and the background checking activities;
  - For the medical screening : Personal Data
  - For the background(Education and Employment) checking : Personal and Affirmative Action Data
  - For the security checking : Personal Data and Security Data

Also, this activity monitors how the applications are being processed, how many applications are in which activity, etc..

- The 'DECISION' activity reviews and evaluates applicant's information, and decides whether he/she is eligible and appropriate for the requirements of a position opened, or not. A decision maker must comment about the decision.
- The 'REJECT APPLICATION' activity receives the applicants who failed in the employment procedure, composes a rejection letter, and send it to them.
- The 'HIRE APPLICANT' activity receives the applicants who passed in the employment procedure, composes a job offer letter, and send it to them.
- The 'DATABASE UPDATE' activity performs updating the employment database automatically after the previous activities are done.
- The 'BACKGROUND CHECKING' activity validates the background information, such as educational background, and employment background, submitted by the applicants. After checking the information out, the actors prepare the checking results with some comments, and send them out to the personal department;
  - Results checked
  - Comments, if needed
- The 'MEDICAL SCREENING' activity does some medical tests, such as drugs, venereal diseases, and geriatric diseases, etc.. After doing it, the actors prepare the test results with some comments, and send to the personal department;
  - Results tested
  - Comments, if needed
- The 'SECURITY CHECKING' activity validates the security information written by the applicants. After checking the information out, the actors send the results out to the personal department;
  - Test results
  - Comments, if needed
- The 'REVIEW APPLICANT INFO' activity reviews the results sent by the previous activities, and decides whether the applicant should be failed, or be passed, based on the organization's employment policy. If the

results of applicants satisfy the policy, then the actors prepare and inform so that the clerks can proceed continuously to the internal hiring procedure.

ACTORS AND ROLES

- Applicant
- Hiring Clerk
- Hiring Manager
- Personal Manager
- Medical Manager
- Security Manager

AUTOMATION OF THE HIRING PROCESS

INFRASTRUCTURE FOR IMPLEMENTATION

In order to realize the ICN model of the hiring process, we need some infrastructures, such as application development environments used to implement programs on each activity in processes, and workflow management system used to control the flow of workcases and data, which are based on distributed computing environment. So, in this section, we introduce these infrastructures.

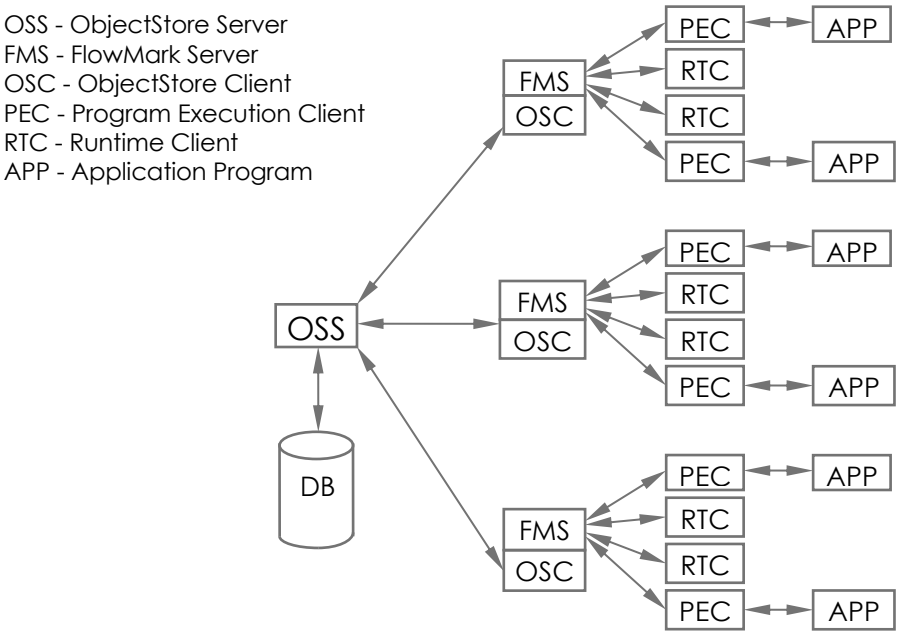


FIGURE 4. FLOWMARK WORKFLOW MANAGEMENT SYSTEM'S ARCHITECTURE

FLOWMARK: WORKFLOW MANAGEMENT SYSTEM

FlowMark is a typical server-client workflow management system developed and commercialized by IBM, runs across different platforms such as AIX, OS/2 and Windows, and supports distribution of most of its components. It is based on a server-client architecture and uses a centralized database to store meta-information about workflows. An object-oriented database management system, ObjectStore, is used. In

particular, the schema definition of a business process and all the runtime information related to active process instances(work cases) are stored in this database.

Besides the database server, FlowMark is organized into four other components: FlowMark Server, Runtime Client, Program Execution Client, and Buildtime Client.

- The **FlowMark Server** acts as the workflow engine,
- the **Runtime Client** acts as the worklist handler,
- the **Program Execution Client** acts as the application-agent, and
- the **Bulidtime Clients** acts as the process-definition tool.

A single database usually acts as a repository to several workflow servers. The connections among the runtime components are shown in Figure 3. Workflow servers are connected to a centralized database. Connected to each workflow server, there can be several servers simultaneously. Communication among components takes place through TCP/IP, NetBIOS or APPC, except for the database and the workflow servers that function as ObjectStore client-servers and use their own internal protocol.

VX-REXX: GRAPHICAL USER INTERFACE DESIGN LANGUAGE

Wacom VX-Rexx is an application development system for OS/2 REXX that provides visual design and programming tools to create OS/2 applications that have a graphical user interface. An application can be saved as an executable file so that others can use the applications without requiring a copy of VX-Rexx. The development system can be used to create macro or script files to be used with other applications.

The FlowMark workflow management system is running on OS/2 environment. Also, it supports the APIs for VX-Rexx design and programming language. So we use the language to create the programs for the hiring process automation.

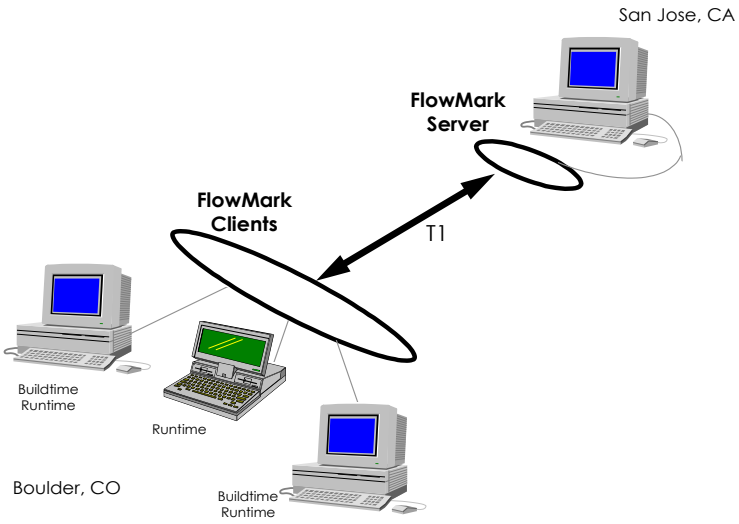


FIGURE 5. FLOWMARK SERVER-CLIENTS NETWORKING FOR THE HIRING PROCESS

FLOWMARK SERVER-CLIENTS DISTRIBUTED COMPUTING ENVIRONMENT

The figure 5 is showing the networking environment of the FlowMark workflow management system for the hiring process automation. A server of the FlowMark is located as San Jose in California, and clients are in the lab of Boulder in Colorado. They are connected through T1 Line which supports 1.5 Mbps rate of data

transmission. The network is controlled by Token-ring protocol. Two of the clients run the buildtime and runtime of FlowMark, the other is only for the runtime.

BUILDING THE HIRING PROCESS BY FLOWMARK

Business processes are modeled by FlowMark as acyclic directed graphs in which nodes represent steps of execution and edges represent the flow of control and data among the different steps. The main components of a workflow model of a business process are:

- **Process**, a description of the sequence of steps involved in accomplishing a given goal. The hiring process is an example of a process. The process is represented as a graph.
- **Activity**, or each step within a process. Activities are represented as nodes in the process graph. They can be program activities or process activities. A program activity has a program assigned to it that is executed when the activity is started. A process activity has another process associated with it, so an entire process is nested and executed when the activity is started. Process activities are used for nesting and modular composition. Each activity has an input container from which it takes its input, and output data container where it places its output. This applies to both program activities and process activities.
- **Block**, very similar to a process. The only difference is that a process has a name and therefore can be used in different places, while a block has no name and can only be used in one place within a single process. Blocks also have input and output data containers. The analogy between blocks and processes can be drawn from programming languages. A block is similar to a piece of code between *begin* and *end*, while a process is similar to an external library or procedure.
- **Control connector**, specifies the order of execution between two activities. Control connectors are directed edges in the process graph.
- **Data connector**, defined between an output data container and an input data container, specifies the flow of information from one activity to another. Data connectors are also expressed as directed edges in the process graph.
- **Conditions**, which specify the circumstances under which certain events will happen. There are three basic types of conditions.
  - *Transition conditions* are associated with control connectors and specify whether the connector evaluates to true or false.
  - *Start conditions* specify when an activity will be started: either when all incoming control connectors evaluate to true - AND condition - or when at least one of them evaluate to true - OR condition.
  - *Exit conditions* specify when an activity is considered to have terminated. After the execution of an activity, the exit condition is checked. If true, the activity has terminated, if false, the activity is rescheduled for execution. In the case that a container value is not set, then any condition testing on that value is set to false.

When the modeling of the ICN hiring process is done by the Buildtime FlowMark, we have to define the followings through the components of FlowMark workflow management system, before enacting(running) process instances through the Runtime FlowMark:

- Staff Definition: People, Roles, Organizations, Levels
- Program Definition: Programs used in each program activity must be registered.
- Data Structure Definition: Data structures used in the input data containers and output data containers in each program activity, process activity, or block activity must be registered.
- Process Definition: We have to define the process that we develop, to link activities to staffs, to link activities to programs, to link input and output data containers of activities to data structures, and to set transition, start and exit conditions on activities.

- *Process definition*: the hiring process modeled by ICN is represented by FlowMark's process definition editor which provides 8 symbols - data source, data sink, program activity, block activity, process activity, data connector, control connector, and default connector.
- *Link activities to staffs, data structures, and conditions*: this is done on each activity through interactive user interfaces by linking to staff and data structures that are already defined in the previous Bulidtime works, and by typing some conditions on the entry fields or by choosing a radio button, for exit, transition and start conditions.

- Server Definition

A. Hiring Process Definition

FIGURE 6 and FIGURE 7 are to represent the ICN hiring process modeled by the Buildtime of FlowMark. As shown in the figures, the process consists of 18 program activities and 4 block activities each of which has a resource and a sink data repository that are the input and output data container of the block activity, respectively. All activities are connected each other through control and data connectors connectors including 5 transition conditions. And each block activity has an exit condition to break the end-less loop of internal activities.

- **Program Activities**

- *Apply* : Apply activity
- *ReviewInfo* : Review New Applicant Information activity
- *Decision* : Decision activity
- *Rejecting* : Reject Applicant activity
- *Compensation* : Compensate with Accepted Applicant activity
- *OfferLetter* : Write an Offer Letter activity
- *Hiring* : Internal Process for Hired Applicant activity
- *EduCheck_s* : First Educational Background Checking activity
- *EmpCheck_s* : First Employment Background Checking activity
- *SecCheck_s* : First Security Background Checking activity
- *MedScreening_s* : First Medical Screening activity
- *TransitEdu* : Transition Activity from Checking to Reviewing of Education
- *TransitEmp* : Transition Activity from Checking to Reviewing of Employment
- *TransitSec*: Transition Activity from Checking to Reviewing of Security
- *TransitMed* : Transition Activity from Checking to Reviewing of Medical Result
- *ReviewResults* : Review All of Checking and Reviewing History and its Results
- *DBUpdateRej* : Update the Hiring Database to Rejecting Status of Applicant
- *DBUpdateHire* : Update the Hiring Database to Hiring Status of Applicant

FIGURE 6. THE HIRING PROCESS MODELED BY BUILDTIME OF FLOWMARK

- **Block Activities**
  - *EduCheckReview* : Supporting Communication of and Maintaining the History of Checking and Reviewing that are Results of Communication between Checkers and Reviewers. This consists of two program activities, a source and a sink data repository.
    - *EduReview* : Reviewing the results of Educational Background Checked
    - *EduCheck* : Checking the Educational Background Based on Reviewer's Comments
  - *EmpCheckReview* : Supporting Communication of and Maintaining the History of Checking and Reviewing that are Results of Communication between Checkers and Reviewers. This consists of two program activities, a source and a sink data repository.
    - *EmpReview* : Reviewing the results of Employment Background Checked
    - *EmpCheck* : Checking the Employment Background Based on Reviewer's Comments

FIGURE 7. THE BLOCK PROCESSES MODELED BY BUILDTIME OF FLOWMARK

- *SecCheckReview* : Supporting Communication of and Maintaining the History of Checking and Reviewing that are Results of Communication between Checkers and Reviewers. This consists of two program activities, a source and a sink data repository.
  - *SecReview* : Reviewing the results of Security Background Checked
  - *SecCheck* : Checking the Security Background Based on Reviewer's Comments

- *MedCheckReview* : Supporting Communication of and Maintaining the History of Testing and Reviewing that are Results of Communication between Testers and Reviewers. This consists of two program activities, a source and a sink data repository.
  - *MedReview* : Reviewing the results of Medical Screening Tested
  - *MedCheck* : Testing the Medical Screening Based on Reviewer's Comments

B. Staff Definition for the Hiring Process

- **Roles:**
  - Applicant
  - Hiring Clerk
  - Hiring Manager
  - Personnel Manager
  - Security Manager
  - Medical Manager
- **People (Password):**
  - Kwang-Hoon Kim (kwang)
  - Sri Kosaraju (password)
  - Pradeep Ravi (password)
  - Barbara Roberts (password)
  - Ken Turnipseed (password)
- **Organization:**

- Personnel Department

- **Level:**
  - level 9 : Applicant
  - level 8 : Hiring Clerk
  - level 6 : Hiring Manager
  - level 7 : Personnel Manager
  - level 7 : Security Manager
  - level 7 : Medical Manager

- **Mapping Roles to People**

TABLE 2. MAPPING ROLES AND PEOPLE

Role	People	User ID	Password	Organization	Level
Applicant	Applicant	applicant	password		9
Hiring Clerk	Kwang-Hoon Kim	kwang	kwang	personnel	8
Hiring Manager	Ken Turnipseed	ken	password	personnel	6
Personnel Manager	Barbara Roberts	barbara	password	personnel	7
Security Manager	Pradeep Ravi	pradeep	password	personnel	7
Medical Manager	Sri Kosaraju	sri	password	personnel	7

C. Data Structure Definition for Input/Output Containers on the Hiring Process

- **_STRUCT ApplicantInfo:**
  - applName **String**
  - applNumber **String**
  - applEmail **String**
  - applDate **String**

- **_STRUCT BouncedInfo:**
  - applBounced **Long**
  - applInfo **ApplicantInfo**
    - applName **String**
    - applNumber **String**
    - applEmail **String**
    - applDate **String**

- **_STRUCT CommunicationInfo:**
  - sendToManager **Long**
  - applInfo **ApplicantInfo**
    - applName **String**
    - applNumber **String**
    - applEmail **String**
    - applDate **String**

- **_STRUCT DecisionInfo:**
  - applDecision **Long**
  - applInfo **ApplicantInfo**

- applName **String**
- applNumber **String**
- applEmail **String**
- applDate **String**

- **_STRUCT ApplyResult:**
  - applResult **Long**
  - applNo **String**

D. Mapping Activities and Roles

TABLE 3. MAPPING ACTIVITIES AND ROLES

Activity	Role
Apply	applicant
ReviewInfo	Hiring Clerk
Decision	Hiring Manager
Rejecting	Hiring Clerk
DBUpdateRej	Hiring Clerk
Compensation	Hiring Clerk
OfferLetter	Hiring Clerk
Hiring	Hiring Clerk
EduCheck_s	Personnel Mgr.
EmpCheck_s	Personnel Mgr.
SecCheck_s	Security Mgr.
MedCheck_s	Medical Mgr.
Activity	**Role**
EduCheckReview	Non.
EmpCheckReview	Non.
SecCheckReview	Non.
MedCheckReview	Non.
EduCheck	Personnel Mgr.
EmpCheck	Personnel Mgr.
SecCheck	Security Mgr.
MedCheck	Medical Mgr.
EduReview	Hiring Manager
EmpReview	Hiring Manager
SecReview	Hiring Manager
MedReview	Hiring Manager
TransitEdu	Personnel Mgr.
TransitEmp	personnel Mgr.
TransitSec	Security Mgr.
TransitMed	Medical Mgr.
ReviewResults	Hiring Manager
DBUpdateHire	Hiring Manager

In the Appendix C, these works building the hiring process by Buildtime of FlowMark are shown. Additionally, the Buildtime of FlowMark has an animation feature to show how the process modeled is working properly. Especially, the Buildtime doesn't allow cycles of the control flow in process model, because the model is an acyclic graph in terms of control flows. Cyclic models can be detected by a syntax checking feature at the build time.

DESIGNING GRAPHICAL USER INTERFACES AND PROGRAMS

All of program activities in the FlowMark Buildtime model of the hiring process have their own graphical user interfaces which are designed by the VX-Rexx user interface design language. The instance(workcase) of the hiring process is initiated by an applicant on the Apply activity through several application forms. So, the user interfaces of the activity have some graphical application forms which are exactly same to the paper application forms in terms of items and styles on where applicants have to fill out.

At the same time, all of the programs have coded by the Rexx programming language. Also, FlowMark provides several APIs for getting and putting data, for controlling processes, and for monitoring processes in different programming languages, such as C++, VX-Rexx, C, COBOL, MS Visual Basic. The programs for the activities on the hiring process use APIs in VX-Rexx to get data from input data containers and to put data to output data containers. Also, they use APIs to get some system information about monitoring program status interacting with a FlowMark server.

TABLE 4. ACTIVITIES, EXECUTABLE PROGRAMS, AND INPUT/OUTPUT DATA CONTAINERS

Activity	Program Name	Input	Output
Apply	apply.exe	Default	ApplicantInfo
ReviewInfo	ReviewInfo.exe	ApplicantInfo	ApplicantInfo
Decision	Decision.exe	ApplicantInfo	DecisionInfo
Rejecting	Rejecting.exe	DecisionInfo	ApplyResult
DBUpdateRej	DBUpdate.exe	ApplyResult	Default
Activity	**Program Name**	**Input**	**Output**
Compensation	Compensation.exe	DecisionInfo	ApplicantInfo
OfferLetter	OfferLetter.exe	ApplicantInfo	ApplicantInfo
Hiring	Hiring.exe	ApplicantInfo	ApplicantInfo
EduCheck_s	EduCheck.exe	BouncedInfo	CommunicationInfo
EmpCheck_s	EmpCheck.exe	BouncedInfo	CommunicationInfo
SecCheck_s	SecCheck.exe	BouncedInfo	CommunicationInfo
MedCheck_s	MedCheck.exe	BouncedInfo	CommunicationInfo
EduCheckReview	Non.	CommunicationInfo	CommunicationInfo
EmpCheckReview	Non.	CommunicationInfo	CommunicationInfo
SecCheckReview	Non.	CommunicationInfo	CommunicationInfo
MedCheckReview	Non.	CommunicationInfo	CommunicationInfo
EduCheck	EduCheck.exe	BouncedInfo	CommunicationInfo
EmpCheck	EmpCheck.exe	BouncedInfo	CommunicationInfo
SecCheck	SecCheck.exe	BouncedInfo	CommunicationInfo
MedCheck	SecCheck.exe	BouncedInfo	CommunicationInfo
EduReview	EduReview.exe	CommunicationInfo	BouncedInfo
EmpReview	EmpReview.exe	CommunicationInfo	BouncedInfo
SecReview	SecReview.exe	CommunicationInfo	BouncedInfo

MedReview	MedReview.exe	CommunicationInfo	BouncedInfo
TransitEdu	Transition.exe	CommunicationInfo	ApplicantInfo
TransitEmp	Transition.exe	CommunicationInfo	ApplicantInfo
TransitSec	Transition.exe	CommunicationInfo	ApplicantInfo
TransitMed	Transition.exe	CommunicationInfo	ApplicantInfo
ReviewResults	ReviewResults.exe	ApplicantInfo	ApplyResult
DBUpdateHire	DBUpdate.exe	ApplyResult	Default

In the Appendix B, all of the user interfaces for the hiring process automation are shown. And The Table 4 represents the programs and their data structures on their input and output data containers on each activity.

RUNNING THE HIRING PROCESS BY FLOWMARK

A Runtime process maintained in the Runtime processes folder consists of model and its instances(workcases). The instances have associated with one of 5 states which are showing the status of the runtime process. Model and its instances are represented by 6 different process icons:

- *Model*, used to instantiate a process,
- *Ready*, displayed for an instance of the model which has not yet been started,
- *Running*, displayed for an instance that is currently in execution,
- *Suspended*, shown for an instance that has been interrupted,
- *terminated*, shown for an instance that has been canceled, and
- *finished*, shown for an instance that has completed normally.

An activity under control of the Runtime(Work Lists on each people's account) of FlowMark has a state associated with it. The state is identified in the Runtime work lists folder by different shapes of activity icons:

- *ready* when it can start to execute,
- *running* when the associated program or process instance is executing,
- *finished* when execution has completed and the exit condition is satisfied,
- *disabled* when it has been started by another user, and
- *suspended* when the process instance to which it belongs is suspended.

From the ready state, activities can be started either manually or automatically. Within a process, those activities without incoming control connectors are considered to be the starting activities of the process, and are set to the ready state when the process is started. Once an activity finishes, its exit condition is evaluated. If it is false, then the activities reset to the ready state. Otherwise, the activity state is set to terminated and all the outgoing control connectors from that activity are evaluated. When the start condition for an activity is met, the activity is set to ready. If an activity will never be executed because its start condition evaluates to false, the activity is marked as terminated and all the transition conditions of the outgoing control connectors from that activity are set to false. This, in turn, might cause other activities to be marked as terminated. Such recursive procedure is called *dead path elimination*. A process is considered finished when all its activities are in the terminated state.

An important feature in FlowMark is the use of conditions. Transition conditions provide a great deal of flexibility in designing the flow of control since avoid the need for the system having to traverse some branches of the control flow and implement control structures similar to if-then-else, or case. Exit conditions can be used to implement loops by using blocks or process activities within another process. When the exit condition of an activity is not satisfied, the activity is rescheduled for execution. Thus, by setting the appropriate exit condition, a group of activities within a block or a process activity, can be executed any number of times. In general, conditions increase the power and expressibility of the model.

The runtime of the hiring process is now fully operational. It tested on the FlowMark networking environment. A coordinator, who creates instances of the hiring process, is an applicant. That is, an applicant

applies for the employment through the user interfaces of the activity, Apply, which are exactly same to the forms in the appendix A. After that, the work case goes through the activities on the hiring process up to the activity, DBUpdateRej or DBUpdateHire.

One of the FlowMark's novel features is to monitor the instances on running. Through the feature, the coordinator is able to see how the instances of the process is going on, which activity the instances are in, and what status of the activities is, through the graphical icons. The runtime of the hiring process is in the appendix D.

CONCLUSIONS AND FUTURE WORKS

Quite briefly, workflow, which is a typical collaboration technology, is the automation and management of business processes which are a sequence of actions or tasks which must be done to achieve a business goal. According to recent reports on magazines related to business and technology, companies sometimes spend $1 billion on workflow automation and technology to improve customer services, to reduce costs, and to increase benefits. In terms of terminology, it is critical to distinguish the 'workflow automation' from the 'task automation'. The emphasis in workflow management is on using computers to help manage business processes that may be comprised of many individual tasks, not on using computers to automate the individual tasks. The latter may be applied selectively to some tasks, but such task automation is not a prerequisite for using and benefiting from workflow.

This work is one attempt at business process automation to show that workflow provides the right information to the right persons in the right time through the automatic fashion. We model a hiring process by ICN(Information Control Nets) workflow modeling mechanism, and automate it through the FlowMark workflow management system commercialized by IBM. The enactment of the hiring process is tested on a network environment set up for the hiring process management and automation.

After developing the hiring process automation, we felt frequently during the implementation period that workflow application developers have to do too much work until a process is ready to enact through the run time part. So, workflow management systems should receive the needs of workflow application areas, and evolve and expand for successful workflow implementation as the requirements and the needs arise.

Here are listing, commenting, and requiring for the commercialized workflow management systems and the future works for the hiring process automation.

- STREAMLINING FROM BUSINESS MODELING TO WORKFLOW IMPLEMENTATION:

  The problem is that there is no way for the ICN model to be automatically transformed to the FlowMark's buildtime model. On the top of that, the ICN model is not able to be straightforwardly transformed to the FlowMark's buildtime model, because the FlowMark doesn't allow cycles on a model. So, workflow application developers pay another efforts. That is, the linkage of the business process modelers and the workflow management systems is so critical.

- DEFINITION OF A PROCESS BY IMPORTING A BATCH FILE: Most of current commercial workflow management systems define processes including staff(roles, people, etc.), programs, data repositories, etc., through an interactive user interface facility which is sometimes uncomfortable when developers are engaged in some large applications.

- GRAPHICAL REPRESENTATION AND TEXTUAL REPRESENTATION AS WELL FOR BUSINESS PROCESSES

- ARCHITECTURAL ISSUES: Workflow architecture is an execution infrastructure for workflows which is deeply related with performance issues such as reliability, salability, manageability, and robustness. Most of commercial workflow management systems have a server-client architecture. Finally, the server might become a bottleneck of the performance in larger scale application domains. We experienced in the hiring process enactment that the workflow sometimes didn't work correctly as the network traffic or the server's load fluctuate. We need some advanced architectures for workflow management systems.

- TRANSACTIONAL WORKFLOW: All of activities must not be done by human being. For example, in TABLE 1, the activity TransitEdu, DBUpdateHire, etc. need to be associated with not a person but a software system. The transactional workflows are the application of transaction concepts to activities that involve coordinated execution of multiple tasks over different processing entities.

- RECOVERY MECHANISM FOR WORKFLOW APPLICATIONS

- MERGING BUILD TIME AND RUN TIME: The requirement to the integration of build time and run time in workflow management systems is associated with the organizational structures which affect the way work is internally carried out in organizations. That is, the organizational structure is dynamic and continuous changing, e.g. exceptional cases. While on the other, most of the current commercial workflow management systems are static, because of the separation of build time and run time. So, it is hard to completely implement the organizational requirements and needs (DYNAMIC) through the conventional workflow management systems(STATIC) without integrating those two parts.
- MERGING WORKFLOW AND GROUPWARE: Some workflow application domains need the concept of town meeting in decision making activities. Most of current commercial workflow management systems support three kinds of activities, such as program, block, and process activity, at the build time. By adding a group activity to the process definition tool, by implementing it on the run time architecture, workflow management systems could provide the novel feature.
- DYNAMIC CHANGES: How are the workflow management systems able to support dynamic changes in organizations? The answer is to integrate the build time with the run time. The flexible process definitions and the graceful handling of exception situations are realized. Those workflow application developers who have engaged in the application domains should be eager to get the workflow management systems supporting DYNAMIC CHANGES.
- INTERNET/INTRANET ACCESSIBILITY: This is a crucial feature for the hiring process automation. Because applicants should access to the process through the outside of the organization. So, this Internet accessibility is the right way to support the application for the employment. It is able to be accomplished by the CGI mechanism or Java approach.

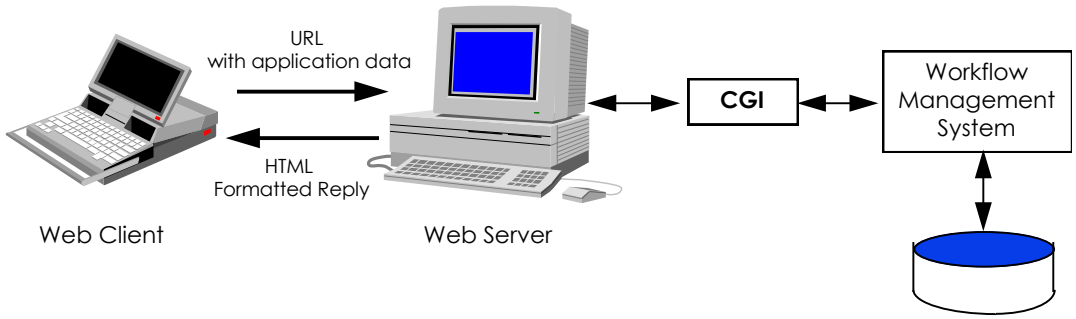


FIGURE 8. CGI APPROACH FOR INTERNET ACCESSIBILITY

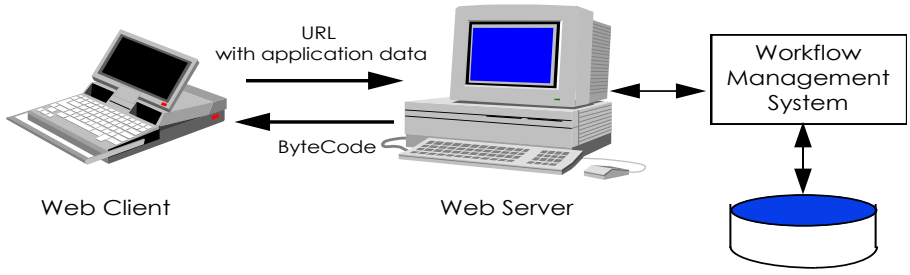


FIGURE 9. JAVA APPROACH FOR INTERNET ACCESSIBILITY

REFERENCES

[1] "Managing Your Workflow", IBM FlowMark, Version 2 Release 2, 1996

[2] "Programming Guide", IBM FlowMark, Version 2 Release 2, 1996

[3] "Modeling Workflow", IBM FlowMark, Version 2.1, 1996

[4] "Programming Guide", IBM FlowMark, Version 2.1, 1995

[5] Kelly Trammell, "Work Flow Without Fear", BYTE, April 1996

[6] "VX-Rexx Programmer's Guide", Watcom International Corp., Version 1, 1996

[7] Ian S. Graham, "HTML SourceBook", John Wiley & Sons, Inc., 1995

[8] Jonathan Magid, R. Douglas Matthews, and Paul Jones, "The Web Server Book", Ventana Press, 1995

[9] Kenneth R. Abbott and Sunil K. Sarin, "Experience with Workflow Management: Issues for the next Generation", Proceedings of ACM 1994 Conference on CSCW, pp.113 ~ 120, Oct. 1994

[10] Jun Huang, "SMART System: A Case Study of Workflow System Modeling", Master's Thesis, The Department of Computer Science, University of Colorado at Boulder

[11] Akhil Kumar & J. Leon Zhao, "A Framework for Dynamic Routing and Operational Integrity Controls in a Workflow Management System"

[12] Yvonne Lederer Antonucci, "Workflow As an Instructional Technology: Enabling Business Strategy with Information Technology"

[13] "The Business Imperative for Workflow & Business Process Reengineering", A Special Advertising Section, Fortune, Feb. 1996

[14] Venkatraman, "IT-Enabled Business Transformation: From Automation to Business Scope Redefinition", Sloan Management Review, Winter 1994

[15] Mark Turrell, "Researching the Deployment of Groupware", Virtual Workgroups Magazine, May/June 1996

[16] Ronni T. Markshak, "Buyer's Guide: Taking the Mystery Out of Workflow Automation", Virtual Workgroups Magazine, May/June 1996

[17] David Coleman, "Interview: Groupware and the Future of Organizations: A Conversation with Bob Johansen", Virtual Workgroups Magazine, May/June 1996

[18] Clarence A. Ellis, J. Gibbs, and G.L. Rein, "Groupware: Some issues and Experiences", Communication of the ACM, Vol. 34, No. 1, Jan. 1991

[19] Steven E. Poltrock and Jonathan Grudin, "Computer Supported Cooperative Work and Groupware", Tutorial Notes, ECSCW '93, Sep. 1993

[20] Steven E. Poltrock and Jonathan Grudin, "Computer Supported Cooperative Work and Groupware", Tutorial Notes, ECSCW '93 Conference, Sep. 1993

[21] Steven E. Poltrock and Jonathan Grudin, "Computer Supported Cooperative Work and Groupware", Tutorial Notes, CSCW '94 Conference, Oct. 1994

[22] Steven E. Poltrock and Jonathan Grudin, "CSCW, Groupware and Workflow: Experiences, State of Art, and Future Trends", Tutorial Notes, CSCW '96 Conference, Nov. 1996

[23] Tom Brinck and Ralph Hill, "Designing Groupware for Realtime Collaboration", Tutorial Notes, CSCW '94, Oct. 1994

[24] Joel Snyder, “Mac Groupware: A Collaborative Effort”, LAN Magazine, Mar. 1994

[25] David Garlan and Mary Shaw, “From Programming Language To Software Architecture: Introduction to Software Architecure”

[26] Clarance A. Ellis, “Workflow Technology”, Tutorial Notes, 1995

[27] Volker Wulf, “Special Issue on Groupware for Self-Organizing Units”, ACM SIGOIS Bulletin, Apr. 1996

[28] Ronni T. Marshak, “IBM’s Business Modeling Tool: BPR Methodology from the Customer Point of View”, Workgroup Computing Report, Vol. 18, No. 6, Jun. 1995

[29] Mohan, Dick Dievendorff, “Recent Work on Distributed Commit Protocols, and Recoverable Messaging and Queuing”, Data Engineering, Vol. 17, No. 1, Mar. 1994

[30] Christoph BuBler, Stefan Jablonski, “Policy Resolution for Workflow Management Systems”

[31] Stefan Jablonski, “MOBILE: A Modular Workflow Model and Architecture”

[32] Miller, A.P. Sheth, K.J. Kochut and X. Wang, “CORBRA-Based Run-Time Architectures for Workflow Management Systems”

[33] Amit Sheth, “Workflow Automation: Applications, Technology and Research”, Tutorial Notes, SIGMOD Conference, May 1995

[34] Nina Burns, “Ebb and Flow”, LAN Magazine, May. 1993

[35] Lawrence G. Tesler, “Networked Computing in the 1990s”, Scientific American, Sept. 1991

[36] James H. Bair, “Contrasting Workflow Models: Getting to the Roots of Three Vendors”

[37] Aidong Zhang, “Impact of Multimedia Data on Workflows”

[38] Keith D. Swenson, “Visual Support for Reengineering Work Processes”, ACM COOCS ‘93 Conference Proceeding, Nov. 1993

[39] Jonathan Grudin, “Groupware and Social Dynamics: Eight Challenges for Developers”, Communications of the ACM, Vol. 37, No. 1, Jan. 1994

[40] Valerio Pinci, Robert M. Shapiro, “Work Flow Analysis”

[41] Clarence A. Ellis, Gary J. Nutt, “The Modeling and Analysis of Coordination Systems”, University of Colorado/Dept. of Computer Science Technical Report, CU-CS-639-93, Jan. 1993

[42] Gary J. Nutt, “Using Workflow in Contemporary IS Applications”, University of Colorado/Dept. of Computer Science Technical Report, CU-CS-663-93, Aug. 1993

[43] Diimitrios Georgakopoulos, Mark Hornick, “An Overview of Workflow Management: From Process Modeling to Workflow Automation Infrastructure”, Distributed and Parallel Databases, 3, pp. 115-153, 1995

[44] Dimitris Karagiannis, “Special Issue on Business Process Reengineering”, ACM SIGOIS Bulletin, Vol. 16, No. 1, Aug. 1995

[45] Doug Barrholomev, “Workflow Software: A Better Way to Work”, Cover Story of Informationweek, Sept. 1995

[46] Clarence A. Ellis, “Formal and Informal Models of Office Activity”

[47] Clarence A. Ellis, Robert Gibbons and Peter Morris, “Office Streamling”, July 1979

[48] David Chazin, “An Architecture and Transaction Model for Large Federated Databases”, Ph. D. Thesis, University of Illnois at Urbana-Champaign, May 1996

[49] John A. Miller, Amit P. Sheth, Krys J. Kochut, Xuzhong Wang and Arun Murugan, “Simulation Modeling within Workflow Technology”

[50] Marek Rusinkiewicz, Amit Sheth, “Specification and Execution of Transactional Workflows”

[51] Alonso, D. Agrawal, A. El Abbadi, M. Kamath, R. Gunthor and C. Mohan, “Advanced Transaction Models in Workflow Contexts”, IBM Research Report

[52] Mansoor Ansari, Marek Rusinkiewicz, Linda Ness and Amit Sheth, “Executing Multidatabase Transactions”, Proceedings of the 25th Hawaii International Conference on Systems Sciences, Jan. 1992

[53] Mohan G. Alonso, D. Agrawal, A. El Abbadi, M. Kamath, and R. Gunthor, Exotica: A Project on Advanced Transaction Management and Workflow Systems”, ACM SIGOIS Bulletin, Vol. 16, No. 1, Aug. 1995

[54] Kuo-Chu Lee, William H. Mansfield Hr. and Amit Sheth, “A Framework for Controlling Cooperative Agents”, IEEE Computer, July 1993

[55] Clarence A. Ellis and Gary J. Nutt, “Multi-Dimensional Workflow”

[56] Kawalek, “An Introduction to a Process Engineering Approach and a Case Study Illustration of its Utility”

[57] Clarence A. Ellis and Carlos Maltzahn, “Chautauqua: Merging Workflow and Groupware”, Jun. 1996

[58] Kelly Trammell, “Work Flow Without Fear”, BYTE, April 1996

[59] “FlowWorks, The Bull Workflow Product: Architectural Design and Functional Specification”, BULL L.P.M., Oct. 1991

[60] “Workflow and Process Automation in Information Systems: State-of-the-Art and Future Direction”, Proceedings of the NSF Workshop, May 1996

[61] Mohan, “Tutorial: state of the Art in Wofkflow Management System Research and Products”, Tutorial Notes, 5th International Conference on Extending Database Technology, March 1996

[62] Kamath, G. Alonso, R. Gunthor and C. Mohan, “Providing High Availability in Very Large Workflow Management Systems”, IBM Research Report RJ9967, July 1995

[63] Kamath, G. Alonso, R. Gunthor and C. Mohan, “Providing High Availability in Very Large Workflow Management Systems”, 5th International Conference on Extending Database Technology, March 1996

[64] Alonso, D. Agrawal, A. El Abbadi, M. Kamath, R. Gunthor and C. Mohan, “Exotica/FMQM: A Persistent Message-Based Architecture for Distributed Workflow Management”, Proceedings of IFIP Working Conference on Information Systems for Decentralized Organizations, Aug. 1995

[65] Alonso, D. Agrawal, A. El Abbadi, M. Kamath, R. Gunthor and C. Mohan, “Failure Handling in Large Scale Workflow Management Systems”, IBM Research Report RJ9913, Nov. !994

[66] Stef M.M. Joosten, “A Method for Analysing Workflows”, Tutorial Notes, ECSCW ‘95 Conference, Sept. 1995

[67] Dimitrios Georgakopoulos, “Realizing the Workflow Paradigm in Products, Methodologies, Infrastructure, and Current Research”, Tutorial Notes, Dec. 1995

[68] Dimitrios Georgakopoulos, “Workflow Management Concepts, Commercial Products, and Infrastructure for Supporting Reliable Workflow Application Processing”, GTE Technical Report TR-0284-12-94-165, Dec. 1994

[69] Dimitrios Georgakopoulos and Mark F. Hornick, “A Framework for Enforceable Specification of Extended Transaction Models and Transactional Workflows”, International Journal of Intelligent and Cooperative Information Systems”, Vol. 3, No. 3, pp. 225-253, 1994

[70] Dimitrios Georgakopoulos, Mark F. Hornick and Frank Manola, “Customizing Transaction Models and Mechanisms in a Programmable Environment Supporting Reliable Workflow Automation”, IEEE Transactions on Knowledge and Data Engineering, April 1996

[71] Jacques Wainer, Mathias Weske, Gottfried Vossen and Claudia M. Bauzer, “Medeiros Scientific Workflow Systems”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[72] D. Palaniswami, J. Lynch, I. Shevchenko, A. Mattie and L. Reed-Forquet, “Web-based Multi-Paradigm Workflow Automation for Efficient Health-care Delivery”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[73] Barbara J. Vivier, Ira J. Haimowitz and Jacqeline Luciano, “Workflow Requirements for Electronic Commerce in a Distributed Health Care Enterprise”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[74] Walter Scacchi, “Modeling, Integrating, and Enacting Complex Organizational Processes: Approach and Experience”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[75] Nuno Guimaraes and Ana Paula Pereira, “Workflow Modeling, Automation and Augumentation”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[76] William N. Robinson, “Goal-oriented Workflow Analysis and Infrastructure”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[77] William Riddle, “Fundamental Process Modeling Concepts”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[78] Gail E. Kaiser and Wenke Lee, “Pay No Attention to the Man Behind the Curtain”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[79] Jonathan E. Cook and Alexander L. Wolf, “Discovery and Validation of Processes”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[80] Naser Barghouti and Selma Arbaoui, “Process Support and Workflow Management with Improvise”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[81] Jeanine Weissenfels, Dirk Wodtke, Gerhard Weikum and Angelika Kotz Dittrich, “An Overview of the Mentor Architecture for Enterprise-wide Workflow Management”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[82] Friedemann Schwenkreis, “Workflow for the German Federal Government”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[83] Kurt Wallnau, Fred Long and Anthony Earl, “Toward a Distributed, Mediated Architecture for Enterprise-wide Workflow Management”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[84] Roshan Thomas and Ravi Sandhu, “Task-based Authorization: A Research Project in Next-generation Acitive Security Models for Workflows”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[85] Masahiro Morita, Takeya Mukaigaito and Haruo Hayami, “HFBP: A Hierarchical and Functional Business Process Model for Describing Distributed Autonomous Business Environments”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[86] Vijay Vaishnav, Stef Joosten and Bill Kuechler, “Representing Workflow Management Systems with Smart Objects”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[87] Patrick Harker and Lyle Ungar, “A Market-Based Approach to Workflow Automation”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[88] W.M.P. van der Aalst, “Petri-net-based Workflow Management Software”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[89] Anthony Bonner, Adel Shruf and Steve Rozen, “Database Requirements for Workflow Management in a High-Throughput Genome Laboratory”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[90] Gustavo Alonso and Hans-Joerg Schek, “Research Issues in Large Workflow Management Systems”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[91] Mohan Kamath and Krithi Ramamritham, “Bridging the Gap Between Transaction Management and Workflow Management”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[92] Clarence A. Ellis and Gary J. Nutt, “Workflow: The Process Spectrum”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[93] Jarir Chaar, Ram Chillarege and Santanu Paul, “Virtual Project Management for Software”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[94] Dewayne Perry, Adam Porter, Larry Votta and Mike Wade, “Evaluating Workflow and Process Automation in Wide-Area Software Development”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[95] Leon J. Osterweil and Stanley M. Sutton Jr., “Using Software Technology to Define Workflow Processes”, Proceedings of NSF Workshop on Workflow and Process Automation in Information Systems: State-of-the-Art and Future Directions, May 1996

[96] Thomas M. Koulopoulos and Nathaniel Palmer, “INTRANETS: A New World Order”, Virtual WorkGroup Magazine, Sept./Oct. 1996

[97] Christine Perey, “Stop Comminicating and Start Collaborating!”, Virtual WorkGroup Magazine, Sept./Oct. 1996

[98] Paul Smart, “Novell GroupWise 5”, Virtual WorkGroup Magazine, Sept./Oct. 1996

APPENDIX A: IBM'S EMPLOYMENT APPLICATION FORMS

APPENDIX B: USER INTERFACES OF ACTIVITIES ON HIRING PROCESS

APPENDIX C: FLOWMARK BUILDTIME FOR HIRING PROCESS

APPENDIX D: FLOWMARK RUNTIME FOR HIRING PROCESS