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Workflow Systems - An Introduction and Framework

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This document introduces Workflow Systems and explains the role they play as part of an organization's information infrastructure. A framework is described that can be used to contrast different approaches to workflow. We outline some characteristics that distinguish the approaches taken by different systems. This document is intended to help build a vision for workflow systems, and to suggest some challenges that the next generation of workflow systems should tackle.

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1 The Rôle of Workflow

Office software (on PCs) tends to consist of personal productivity tools that are designed to improve an individual's productivity for particular tasks. However, these tasks are generally part of processes that involve groups of individuals, many of whom expend a significant amount of effort to co-ordinate these processes [1].

Workflow Systems offer a complementary, holistic approach that focuses on the needs of the organization rather than those of individuals. They support procedures that require the co-operation of workers to perform related tasks. Their emphasis is on the procedures rather than the constituent tasks.

Workflow Systems support co-operation between individuals when that co-operation can be formalized. They do not support informal co-operation between individuals, such as in collaborating on a script.

Most knowledge work is performed in offices - which can be thought of as places where groups of people co-operate to perform specific functions or procedures. From this perspective it is clear that Workflow Systems should play a major rôle in the office. A recent review of Computer Supported Cooperative Work [2] categorizes Workflow Systems as *Office Automation Procedures*. However, Workflow Systems can be applied to many other areas where a group of people are co-operating to meet a shared goal, such as in hospitals or in factories. A workflow need not be restricted to a single workplace but may be distributed, reflecting the nature of the procedures it supports.

Some examples of applications that might be made of a Workflow System are: routine office procedures such as purchasing or booking travel (between requesters, authorizers and service departments); patient management (between GPs, clinicians and hospital administration); product release (between R&D, manufacturing, marketing and general management).

Many clerical management positions are characterized by assigning paper (and hence the implied tasks) to workers, monitoring and managing the resultant workflows.

Many tasks that make up these procedures may not be automatable. Workflow is about automating the bureaucracy - the routing and tracking of the constituent tasks. A Workflow System may also integrate tools that support the tasks, whether the tasks are automatable or manual.

Pieces of paper are the way in which the state of a procedure is represented within a paper workflow. In a Workflow System we can use a richer variety of media (for example text, graphics, voice, active-forms etc.).

Workflow products call for a new function within organizations, that of procedure administration. This involves the specification and implementation of the business procedures that the Workflow System supports. Hence, a procedure administrator should have an understanding of both the business requirements and the workflow implementation. There are two stages to procedure administration: the implementation of a new procedure, and the maintenance of existing procedures so that they reflect changes in the organization.

The ideal situation would be one where the business professionals with responsibility for a procedure were able to implement and maintain the workflow support for that procedure. Most current Workflow Systems require users to have a fairly sophisticated understanding of

their implementation approach. This acts as a barrier to their use by business professionals, and requires the intervention of specialist procedure administrators.

Procedure processing (as workflow is sometimes called) can be seen as the next step beyond data processing[3] in the application of computers to support knowledge workers. The Workflow Systems that are emerging in the marketplace (such as Staffware[4], Workhorse[5] and ODMS[6] etc.) just hint at the potential of workflow.

2 A Framework for Workflow Systems

This framework provides an abstract view of workflow, that is independent of any particular technology or requirement. The framework describes the variety of approaches that can be taken by a Workflow System and thus provides a basis for the comparison of existing Workflow Systems. It will act as a focus for the analysis of the workflow market-place's requirements, in turn this analysis will help validate and refine the framework.

The framework will help to identify the challenges that face the next generation of Workflow Systems.

Workflow Systems focus on two main classes of objects: Work and Workers. Work consists of a state and a set of tasks to be performed on that state. Workers are empowered to perform and initiate certain tasks.

Similarly there are two classes of services that Workflow Systems provide. The first is Routing, which deals with the allocation of work to workers. The second is Monitoring and Control, which deals with providing access to Case Histories, and to the ongoing Cases which can be modified.

The following sub-sections will examine each of these aspects in turn:

2.1 Work

A piece of work consists of a state and a number of tasks that are to be performed on that state. Each of these tasks can be thought of as producing a transformation on the state (including the null transformation). A task may also have other effects within the organization; that is - it can cause side-effects that are not part of the workflow model.

A Workflow Specification describes how a procedure is implemented by a set of related tasks, for example the processing of a travel request. An individual piece of Work is an instance of a Workflow Specification and is referred to as a Case, for example the John Smith's travel request for a visit to Palo Alto.

- A Case develops a Case History as it progresses, the Case History being a record of the state changes, the tasks performed and the workers who performed them. There may also be other auditing information such as the times and durations of the tasks.
- A Workflow Specification may contain many tasks, which have a variety of dependencies between them. These dependencies may be represented as a graph between dependent

tasks (with a Petri net like interpretation) or in terms of pre-conditions and post-conditions.

- Within a Workflow Specification one may wish to represent tasks at different levels of abstraction. For example as part of a financial transaction one may wish to represent a task 'producing a cheque'. However, a clerical accounts worker may need to deal with the task as two dependent subtasks: drawing up a cheque and then signing it. This highlights the requirement for being able to decompose a task into its constituent subtasks and vice versa.
- A task may be formal or informal. A formal task is one where the entire task is described in the model. An informal task is one where parts of the task are not described in the model. For example, in the general case authorizing a loan is an informal task that may depend on a customer's relationship with the bank manager. However, under specific circumstances (for fixed amounts on special accounts) authorization can be formalized according to some rigid credit rating.

2.2 Workers

A worker may be empowered to perform and initiate tasks. The initiation of tasks is likely to result from the decomposition of a high level task into its constituent tasks.

- Workers may be humans performing manual tasks or agents performing automated tasks. Only formal tasks can be automated, although workers performing manual tasks may be provided with tools that support those tasks (for example a word processor or a phone).
- Workers should be both identifiable as individuals and as members of classes. For example, sometimes one needs to deal with a specific project manager (yours) and sometime any project manager will do (for example, for low level authorization).

2.3 Routing

Routing is a service provided by the Workflow System; it routes tasks to workers. There are two stages to routing: the selection of eligible tasks for execution, followed by the assignment of those tasks to workers.

Tasks are selected from the set of current (active) Cases. Tasks are deemed to be eligible for execution if their dependencies on other tasks have been satisfied. In order to identify eligible tasks, the state of a Case must be interpreted with respect to the Case's Workflow Specification.

Assignment is based on an 'assignment algorithm' that matches available resources (workers) to the tasks that need to be performed. The algorithm could be an implicit part of the Workflow System, or it could be configurable by a procedure administrator.

- The assignment algorithm may be completely generic, or it may contain domain knowledge. The difference can be examined in the context of an example such as the authorization of purchase requisitions. If the amount is \$1000 or less a project manager

may perform the authorization; if more than \$1000 a department manager is required. This knowledge may be represented in the task and in the appropriate worker's enablements, thus the assignment could be generic. Another approach would be to have the assignment algorithm aware of the appropriate authority levels and decide accordingly. Yet another approach may be to have specialized workers who can perform domain dependent assignment for complex tasks.

- The assignment can be active or passive to different degrees. The passive end of the spectrum can be characterized by a system that decides who should perform a task, mails it to them and then waits for it to be returned in a completed state. This has some obvious disadvantages given the way that human workers behave, take holiday etc. At the active end of the spectrum the system may manage queues of work, which workers are directed to as they become available. This is likely to be more efficient in terms of managing throughput, but has a much more centralized feel.
- Because a Workflow System is likely to be dealing with several Cases at once, more than one task may be eligible for execution at the same instant. Similarly, a worker may be assigned more than one task at the same time.

Depending on the Workflow System's approach to parallelism and to task assignment (active or passive), it may be required to schedule the assignment of tasks to workers. Ideally any scheduling of tasks should correspond to their respective priorities; this would necessitate the system being able to associate some measure of priority with tasks.

2.4 Monitoring and Control

Monitoring and Control are services that a Workflow System provides across Cases. These functions are available as a means of monitoring and controlling the work, and as such are 'meta' to the tasks being performed by the workers. Although some of the functions may be available to the workers to help them introspect about their current tasks, many of them are mainly for use in a management rôle.

- Monitoring should provide access to both past and current Cases, where current Cases are ones that are not yet complete. Past Cases would be available in a Case History database that should be able to meet most of the organization's auditing requirements.
- The system should allow managers to monitor metrics of their choice. These metrics could be shown in a variety of ways, for example attached to dials, shown in reports or alarmed.
- Ad hoc query of the database of Case Histories would be a valuable facility that would help knowledge of past cases to be applied to the present, as well as meeting auditing requirements.
- On the control side, some classes of user should be provided with access to current (or active) Cases, and have the ability to modify the Case or the way in which the system would deal with it. Examples of such modifications are: undoing and re-submitting a task; adding, deleting or modifying outstanding tasks on a piece of work; directing a task to a specific worker; changing the enablement of specific workers; introducing new tasks into a procedure etc.

Uses which could be made of the control facility range from quality assurance to load balancing and evolution of the supported procedures.

3 System Characteristics

There are a number of characteristics of Workflow Systems that distinguish the approaches taken by different systems.

These characteristics have been grouped into the following three categories :

System Capabilities

- by the classes of work that it can manage - the types of media that can be dealt with and the types of task that can be performed on them.
- by the complexity of the procedures that can be (conveniently) supported - the expressivity of the system in handling the complexity of tasks, dependencies, decomposition, abstraction etc..
- by the responsiveness of the system - how it can respond to the dynamics of the workplace.
- by the ease with which existing applications can be integrated with the system.

User Skills

- by the skills required by a Procedure Administrator in order to develop a system - skills in modelling and in implementing the models in the required manner. Skills in the domain are assumed.
- by the adaptability of the system - the skills required in order to maintain such a system as the workflow requirements change.

Benefits

- Efficiency - allows the organization to increase its efficiency (responsiveness) with regard to certain procedures.
- Costs - allows an organization to perform procedures more economically.
- Flexibility - allows an organization to be flexible in the way it deals with procedures or allows an organization to change the way it performs a procedure.
- Accountability - allows an organization to audit certain procedures.
- Quality - allows an organization to make QA an integral part of procedures.

Each product will strike its own balance between the characteristics that are described above. It is this profile of characteristics that describes the system's position in the marketplace.

4 Some Reservations about Current Approaches

The current approach to Workflow is analogous to current information management practices, where a business analyst produces a model of the business requirements, which is replaced by an implementation.

This means that in order to modify a system one has to be able to understand an implementation and infer the model that it implies.

Information systems have become a source of inertia in business - businesses become inflexible (and hence vulnerable) because they cannot afford the costs of changing their information systems.

Current Workflow Systems are in danger of introducing the same inertia into the field of procedure automation. Because current products deal with an implementation rather than a specification they are rather inflexible. This means that they tend to emphasize routine procedures and well structured tasks. They also require the application to have a high degree of stability.

In contrast most manual systems have a large degree of inherent flexibility and adaptability, together with a mixture of structured and informal tasks.

A Workflow Architecture should address this issue by supporting specifications that focus on the business requirements. Such specification-driven Workflow Systems would then be usable by the business professionals, allowing those with responsibility to take control of the way in which their organization is supported and can evolve.

5 Workflow - the Next Generation

Before Workflow Systems can address a significant portion of their potential market they must meet a number of challenges:

Adaptability The first generation products are not going to be very easy to maintain in environments where there is any change. They are going to introduce a source of inertia into the organization.

What is needed are Workflow Systems that can be maintained by someone 'on the ground', preferably a business professional with responsibility for the workflow. In order for this to be plausible the Workflow Systems must move away from representing procedures as implementations, and towards representing them as specifications that are closer to models that users understand.

Procedure Complexity If Workflow Systems are to address the implementation of any but the simplest procedures they must be able to represent complex procedures in a comprehensible manner. There are two aspects to this: firstly the representation language must be able to deal with complex dependencies between tasks and secondly the system needs to support different levels of abstraction to make large models manageable.

Responsiveness As well as developing the expressive power of a Workflow Specification, Workflow Systems should be more responsive in their execution of Cases. The main

area where responsiveness manifests itself is in the dynamic assignment and scheduling of tasks.

Media and Tasks Current Workflow Systems are oriented around forms. The tasks are generally confined to field-filling in the form. Some systems allow forms to contain static images.

In order to deal with a broader range of procedures this set of media and tasks needs to be expanded. There is no reason why any computer-based media or task should not form part of a valid Workflow Specification. Indeed one need not be restricted to computer-based media and tasks, as a Workflow System can manage the relationships between tasks that are performed on external media (eg phone conversations).

Integration There is a tendency for current tools to be all-encompassing, so that the only facilities that are available to users are the ones provided by the Workflow System. Ideally the Workflow System should allow users to perform tasks using any tool that is available and preferred by the user.

A Comparison with Dataflow

Some familiarity with basic dataflow modelling is assumed.

The pieces of work that flow between tasks in workflow are similar to the data flowing between processes in a dataflow. However, there are the following differences:

- A Workflow Specification would be incomplete by dataflow standards.
A Workflow Specification may be incomplete in that it allows informal tasks, that is tasks which may not have all of their inputs and outputs specified. This allows a Workflow Specification to include tasks that would be difficult (if not impossible) to describe in a dataflow context. It also allows the Workflow Specification to focus on the core of the procedure that is of interest to the organization and which requires explicit management.
- In a Workflow Specification the place of processes are taken by tasks. The worker who should perform a particular task is not specified when the workflow is defined but is assigned at the time that the task is performed. This contrasts with the execution of a dataflow where one provides a specific implementation for each process specification. A Workflow System requires one to describe the capabilities of workers who can perform the required tasks, and to provide a strategy for assigning tasks to workers.
- Much of the utility of Workflow Systems stems from the powerful monitoring and control functions across 'work cases'. These functions are 'meta' to the workflow and would be to an equivalent dataflow. They do, therefore, form a considerable extension of the basic dataflow ideas.

B References

- [1] Gartner Group, Inc. *Workgroup Computing* Personal Computing, March 28th 1990.
- [2] Paul Wilson *Key Research in Computer Supported Cooperative Work (CSCW)* EU-TECO'88 conference in Vienna, 22nd April 1988
- [3] Carl Hammer. *Beyond the Data Processing Horizon* Education and Computing 1, 1985.
- [4] Financial and Corporate Modelling Consultants plc. *Staffware*. 46 Chagford Street, London, NW1 6EB.
- [5] Workhorse Systems Limited. *Workhorse*. Bank House, 142 Terenure Road North, Terenure, Dublin 6W.
- [6] Odesta Corporation. *Odesta Document Management System*. 4084 Commercial Avenue, Northbrook, Illinois 60062.