Workflow in Knowledge Work: Promises and Perils

Steven E. Poltrock and Mark Handel

ABSTRACT

Workflow management systems provide efficient means for developing systems that coordinate business activities spanning an organization or multiple organizations. Workflow developers construct graphical models of business processes that the business community is expected to understand and validate. These systems ensure that approved processes are followed consistently, and they provide a detailed history of each instance of the process that can support metrics used both to monitor and audit business processes. These and other benefits should be sufficient to motivate widespread adoption of workflow management systems, but organizations considering their adoption should be aware of potential perils. This paper summarizes some of the key problems we encountered while attempting to implement eight workflow management applications. We conclude by considering ways that organizations can manage the risk of succumbing to these perils.

Categories and Subject Descriptors

H5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interfaces: Computer-supported cooperative work.

General Terms

Management, Human Factors

Keywords

Workflow management, technology adoption

1. INTRODUCTION

The role of *process* in the modern workplace has never been more important. High-visibility trends and requirements such as TQM, ISO9001, and Sarbanes-Oxley (SOX) compliance in the US are built around documenting business processes and ensuring their careful adherence in the day-to-day performance of the business at hand. This increasing reliance on process suggests that workflow technologies should be a natural choice and widely used in the workplace. However, despite many heroic efforts, the river of workflow is lined with the rusting hulks of failed efforts spanning many years. Zuboff [11], Kingbury [7], and Bowers [1] all discuss these less-than-optimal implementations of workflow systems.

In recent years we participated in the development of eight workflow management applications. Our primary organizational role is to conduct research investigating the use and adoption of technologies that support team and organizational collaboration, and our participation in application development was unusual. Our objectives were twofold: (1) to contribute to the success of these applications by applying what we have learned in the research community about user-centered design and workflow automation; and (2) to learn more about the obstacles to successful technology adoption. We played varied roles in these development efforts, including consultant, business analyst, development lead, and project manager, and in every case we approached the work with a healthy skepticism fueled by familiarity with published research about workflow management and by our own limited prior experience. In each of these development projects we had opportunities to learn about (and sometimes influence) expectations regarding the benefits and problems that workflow management systems offer. And we had ample opportunity to observe the problems that emerged, resulting in cancellation of four of the eight workflow development projects. We also observed some of the benefits realized by two workflow applications that were completed and are in production use.

All eight workflow management applications were developed to support a large aerospace program in which supplier companies around the world participated in the design and development of product components. These companies were considered partners in the program, and it was essential that they participate in many of the program's processes. The participants in these processes were all knowledge workers and many of them were engineers. They were all accustomed to using computers to perform the majority of their daily work and accustomed to receiving and responding to information about tasks via email.

We worked in an organization responsible for developing the processes and tools used by this aerospace program, and we followed their well established development practices. We engaged with the intended end users of each application in many ways. We interviewed them and their managers, attended their meetings, and reviewed each phase of application development (requirements, designs, and prototypes) with them. All the workflow management applications were developed using a commercial web-based workflow management system with a graphical process editor, an object model of information objects, and a user interface management system. This system included a CMII compliant change management structure [5]. Three of the eight applications automated portions of the processes required to propose, review, approve, and implement proposed changes to an attribute of the program. A fourth application coordinated all the steps involved in providing information access to employees of the program's partners. A fifth application managed an exchange

of data between engineers, including partners. A sixth application managed the approval of software delivered to partners. The last two applications tracked special components delivered by the partners.

2. Promises and Fears of Workflow

Workflow management applications automate the flow of work from one person to another, thereby ensuring that the work follows a pre-defined and approved process. Early workflow applications were implemented in database systems by embedding process-related code in data validation formulas and using triggers to enforce deadlines and alert participants. Modern workflow management systems were created by separating the process flow from the data. In early workflow management systems the processes were implemented as tables of procedural rules. In current systems they are represented graphically, with each node representing a process step or task and the links between the nodes representing the path from one task to another. Separating the workflow process from the data is an important development because it facilitates inspection and revision of a process and minimizes the risk of unexpected side effects when revising a process. Of course, the clarity and expressiveness of these graphical representations can vary considerably [2].

Despite the advantages of a workflow management system with a graphical process editor, development of a workflow management application is a substantial undertaking, much like any other application development project. The predicted benefits must be weighed against the cost of development. The investment required to develop an application should achieve the greatest benefits when it involves many people, the process is repeated frequently, and process variation is undesirable. Workflow should reduce the cost of coordinating work performed by many people because workflow management systems provide coordination capabilities intended to coordinate people's contributions in a consistent manner. The coordination benefit may be small for any single process instance, but these benefits will accumulate when a process is repeated many times. Because the process task sequence is controlled by the workflow management system, variation in the process will be limited to process variations intentionally implemented in the workflow and variation in activities outside the scope of the workflow.

Advocates of workflow management applications often point to insurance claim processing to illustrate its advantages; many insurance claims are filed and customers believe that they should obtain the same outcome regardless of which clerks are handling their claims. This application seems to fit the criteria for achieving substantial benefits. As recently as 1997, however, workflow management systems had not achieved much of their expected deployment in the insurance industry [7]. Its slow acceptance in this and other industries provides good reason for caution.

The organization that requested our help wanted to use workflow management to facilitate inter-company coordination. Aerospace programs require systematic regulation and control over development, manufacture, and support of the end product. This regulation and control arises from government oversight and the liabilities faced by the manufacturer in the event of a mishap. As might be expected, the company has a mature set of processes for all its line-of-business work. There are four layers of authoritative process documentation released within the company. Authoritative documents can be used as evidence of compliance in an audit; there are also three more layers of non-authoritative documentation that further flesh out the process details plus more than five additional types of writings that control such things as standards for drawings, metadata, and further interpret process details. Most importantly, there is an expectation that these processes are consistent, repeatable, and reliable across the company. The primary reason for their interest in workflow management was its promise to ensure process compliance even when processes extended outside the company to its business partners.

We found that members of the program had a wide range of other expectations for workflow management. Some were lured by promises of more efficient and flexible processes and others had some fears. We address these promises and fears in this section.

2.1 Automated Coordination

Most of the processes we were asked to implement were not new. Each process constituted a system of human activity aided by software tools, most commonly email and general purpose office tools. Because these were complex processes, many included an explicit coordination function and identified a role that performed this function. These human coordinators accomplished the functions of a workflow management system, but one with human ability to reason, judge, and adapt. Program managers expected the workflow management applications to replace or substantially simplify the work of these coordinators, thereby permitting higher throughput with fewer coordinators.

The functions performed by these coordinators varied from one application to another, but included validating the correctness of data, determining who should receive it, routing it with instructions, reminding people of task deadlines, maintaining status of each process instance, and generating reports of overall process performance. Coordinators had knowledge and skills that exceeded the capacity of any automated system. Coordinators knew the people whose work they were coordinating, and they knew which people preferred email, a phone message, or a visit to their desk. They were respectful of the status of process participants, and they knew about other activities in progress (e.g., program reviews) that might affect people's availability. As circumstances demanded, they could chose to modify the order of tasks, request that tasks be performed in parallel, or make other process adjustments. Human coordinators were expensive, but those who were talented and hard working could provide exceptionally effective support. A workflow management system should be able to perform the coordination functions of many coordinators but is unlikely to achieve the same quality of service.

2.2 Effective, Consistent Processes

As noted, the processes were thoroughly documented, and people were required to follow these processes. Thus, it was expected that the workflow management system would implement the processes as documented, and they would be efficient and consistent.

In every instance, however, the processes themselves were undergoing revision. The circumstances of this program, particularly the scale of the involvement by partners, challenged the existing processes and tools, and motivated adoption of workflow management as a more effective and scalable technology to support global, multi-company collaboration. Of course, the introduction of a workflow management system called

for some re-thinking of the details of the processes. A workflow management system could require adjustments to the assignments of tasks to roles. There may be less need for coordinators, for example, or an adjustment in their responsibilities.

Over time, this expectation evolved. The program expected the workflow management applications to implement effective and consistent processes, but realization grew that changes to both the process and the application should be expected. The adoption process involves some co-evolution of process and tool [8].

2.3 Collective Metrics

Management required metrics showing the collective performance of key processes and identifying any individual tasks or process instances that required special attention. Workflow management systems maintain the status of every instance of a managed process, and management expected the system to provide useful metrics for these processes. The program's human coordinators were responsible for constructing reports of these metrics, and for processes not yet implemented in a workflow management system they tracked the progress of each process instance in a spreadsheet or database, updating this repository at each step in the process. The workflow management system was expected to replace these manually updated repositories. We discovered, however, that the reports required by management often included charts and other presentation materials that were beyond the capabilities of the workflow management system and sometimes required data that were not collected by the workflow management system.

2.4 Auditable Processes and History

As noted earlier, regulation and control of processes is a primary reason for implementing a process in an application. These processes are subject to audits, and the workflow management applications were expected to support these audits. The system should provide a complete history of all actions taken with respect to a particular information object, including who did it, when it was done, and why. Not only does the workflow management system provide the history of each instantiation of the process, but by using it, it ensures that the same process is followed each time. In the context of a process audit, these two features provide evidence of both past and future compliance with the process. It should also support security audits of all the information accessed by a specific person or group of persons. Of course, audits are performed rarely, and the technical knowledge required to obtain the data to support an audit is not widely available. No formal audits have yet been done, but we anticipate that an administrator or someone with comparable knowledge of the technology would be required to extract the audit data.

2.5 Flexible Revisions

Processes inevitably evolve as a program matures, and workflow applications must be revised to implement these changes. Both management and technical leaders were impressed by vendor demonstrations of how easily workflow management processes could be constructed using their graphical process viewer and editor. Key program managers expected that this tool would enable workflow applications to be developed and revised quickly and inexpensively. The program soon discovered, however, that development of workflow management applications required special skills that were not readily available and were costly to acquire. The workflow management system provided an infrastructure for developing workflow applications that reduced the time and cost of development. Nonetheless, each application required a software development project, and standard software change management practices were followed for all changes to the application.

2.6 Developed by Domain Experts

Domain experts write and maintain process documentation, and domain experts with computing skills expected to be able to develop, or at least maintain, the workflow process model. It is, after all, a viewable and editable graphical depiction of the process. One of the major selling points of the system was its flexibility and customizability. The domain experts expected to be able to adapt the workflow to the needs of users. But, as noted above, development of workflows required special skills and experience, and not simply technical skills. We found, for example, that domain experts were unaccustomed to considering all possible outcomes of each step in a process. They considered the primary outcomes and did not think about exceptions that might occur. Our experienced workflow developers insisted on considering all possible outcomes and developing the necessary logic to handle all these outcomes.

2.7 Easy to Learn and Use

People were already performing most of the processes we were expected to implement with the support of a human coordinator, email, and their general office software tools. They received and responded to task information sent by email with attached office documents. Everyone knew how to use office applications, and they feared that the workflow management applications would make their work more difficult. Much of the development work focused on addressing this fear by providing a consistent user interface, clear instructions, and simple tasks.

The workflow management system sent email to process participants describing the task they were to perform with a link to the workflow management system. In the simplest case a participant could click the link, log into the system, select a response from among a set of radio buttons, and conclude by clicking a button indicating that the task was complete. Other tasks were more complex, requiring entry of data in fields. Reviews with end users were held frequently to obtain feedback about data entry forms and task structures, and the end result was generally but not universally well received by users.

Limited integration with existing office tools was perhaps the largest challenge in terms of ease of use. Prior to the development of these applications, office documents were routed by email, and a document could be sent to anyone with an email account. The workflow management applications controlled who could view data based on their roles and the state of the data. People who lacked an application account and those in an excluded role could not view the data. This policy provided stronger information protection, but at the cost of considerable difficulty when participation from other people was desirable. This situation occurred far more frequently than one might expect. We discovered that some participants in the process routinely asked for input from other people who were not formally members of the process.

2.8 Automated Nag

Although people were accustomed to receiving tasks via email, most were overwhelmed by the volume of email messages, like knowledge workers everywhere today. Many had created rules to help manage this flood of messages. Workflow management applications were expected to become another source of messages with task information and warnings about approaching deadlines. Everyone recognized that email from the workflow management system was an essential feature, but many people did not welcome it. While most expectations were benefits, this was viewed as an unfortunate consequence, and one with considerable importance to some people.

We were surprised to learn that some people kept all these email messages, using them as a form of queue. The workflow management system creates and maintains a queue or work list for each person, and we anticipated that people would use the system queue. In retrospect, it is not surprising that they would prefer to use their email as the queue. Many people use their email inbox and folders to manage their work. Many of their tasks are not included in the processes implemented in the workflow management system, and they are not likely to have the workflow management application queue visible throughout the day.

3. Perils of Workflow

During development of eight applications we encountered problems or circumstances that stopped development of some applications and inhibited deployment of others. Many of the problems described below conflicted with the expectations described above.

3.1 Conflict with Established Tools and Procedures

Workflow applications coordinate the activities of many people and potentially span many organizations. This requires, of course, that everyone involved adopt the workflow management system as the means to accomplish this process. Some organizations may, however, already have tools and detailed procedures for performing their portion of the application process. Consider, for example, an organization that performs a service for many programs. Service organizations establish standardized procedures intended to provide a certain level of service at the lowest possible cost. Including such a service organization in a program process is difficult, because it requires that the organization use a different process for one program than for all other programs.

Program management suggested that we develop an application to coordinate all the steps involved in providing information access to employees of the program's partners. In this process, documents about an employee are sent to a coordinator who arranges an identification badge, a series of computing accounts, and possibly a desk and telephone if the employee will be onsite. Of course there are many dependencies between these requests, such that the request for one type of account must wait until other accounts have been granted.

This application appeared to be a natural choice for workflow management because it involves many people in different organizations, is repeated many times, and must follow a consistent verifiable process to ensure the protection of the information accessed via these accounts. We discovered, however, that the coordinator interacted with a collection of organizations that served the entire enterprise, and each organization had its own tools and procedures. Some required a request prepared using a word processor and transmitted via email, others required completion of a web-based form, and one required a faxed form with signatures. These documents and forms were an essential part of their procedures and audit trails. Furthermore, these organizations used varied means to communicate the outcome of the request back to the coordinator. But if these organizations did not adopt the workflow management system, we would be left with a workflow involving only one person, the coordinator. Such an application could have been built, of course, by developing code that would enable the workflow management system to initiate each of these processes and interpret the results, but the benefits would not merit the cost. A workflow management system should not be expected to perform all the functions of a human coordinator.

3.2 New Processes Are Flawed

Each application was developed in close collaboration with the experts who defined and documented the processes that it supported. We consistently found, however, that the documented process and their explanations of the process were incomplete and inaccurate. When the people who performed the process saw demonstrations of an application, they asked questions about how it would address a variety of circumstances that had not been considered and required exceptions to the process.

There are two parts to this problem. First, people seem to believe that they can design a flawless business process. Experienced developers know that new systems of any kind rarely work as expected.

The second and related part of this problem is that people were not able to describe their work procedures accurately. This is a well known phenomenon. Suchman [9] asked members of an accounts payable organization to describe their processes, and she received a text-book explanation. When she observed their work, however, no single instance of their work followed the processes they had described. She distinguished between their plan (their documented process) and their procedures situated in the context of a particular process instance [10]. People engage in considerable problem solving to ensure that the work complies with the expected results of the overall plan, but they accommodate the circumstances that are unique to each work instance.

Note that this phenomenon may partially explain the first part of this problem. People are not aware of the deficiencies in a new process because it is used as nothing more than a plan. They find ways to achieve the results of the plan, and only insist on changing it when the discrepancies are large. It also explains why domain experts do not consider all possible outcomes of each process step, but only the primary or most likely outcomes.

Early in his career Hiroshi Ishii [6] developed a workflow modeling and automation technology for office work and encountered this same problem. He successfully built a technology capable of managing the flow of work, but found that people did not consistently perform their work in accordance with the process they had described. He was sufficiently discouraged by this experience to abandon this line of research.

Because of this problem, the user community would not adopt the first version of any of our applications. In one case they required

revisions to the application before even trying to use it, and the second version was deployed to only a subset of the intended user community. At least two iterations were generally required to achieve a usable application.

3.3 Key Roles Excluded

The principle of user centered system design requires engaging an application's users during its design. Workflow management applications are intended to coordinate contributions from people who perform different roles and often work in different organizations. People in distant organizations (for example, in other companies) may not be available for consultation about an application during its development. Even people who are near at hand may not be consulted because their role appears peripheral or too simple to merit discussion.

A change management application we developed had essentially two roles, coordinators and data managers. A coordinator proposed a change and then requested assessments of this proposal from other coordinators and from data managers. The coordinators were the experts who documented this process and worked with us to define all the details of the workflow application. The data managers' task in the workflow was quite simple; they simply had to record their assessment. We discovered, however, that the data managers had requirements that were not known by the coordinators and not addressed. A data manager asked to provide an assessment may not have all the information required and may need to ask other data managers for assistance. Before introduction of workflow management, they simply emailed the change proposal to the other data managers asking for their assistance. They could not, however, email the contents of the workflow application, and it did not provide any method for requesting this assistance. Early engagement with data managers could have avoided this problem.

3.4 Process Owners Lack Global Scope

Software development projects are generally sponsored and managed by an organization to improve the processes and services of that organization. A workflow application, however, will generally be most effective if its users span organizations. Ideally, the development team should work with representatives and users from all the organizations that will participate in the process and ensure that the application facilitates all their work. As Grudin [4] observed, the developers of a collaborative application should ensure that the people who do the work also get the benefit. But the organization that owns the process may not want to invest in development activity that benefits another organization.

We began development of an application to manage the approval process for software delivered to partners. The group responsible for information protection was an important participant in that process, and they wanted the workflow to route the approval request to an analyst and then the group's manager who would provide a digital approval signature. The manager responsible for the overall approval process insisted that the workflow must not include the analyst but only the manager. The development manager's view was that his application should not support the internal process of this other group. They should build their own workflow application if they wanted to route the approval internally. We developed a prototype of this workflow application, but the process was too contentious to proceed beyond that phase.

3.5 Increased Process Rigidity, Not Flexibility

As noted in section 2, the program expected that workflow applications would be developed and revised quickly and inexpensively. Indeed, a separate and editable workflow process model enables much greater process flexibility than a database application in which the process is embedded in triggers. But a workflow application is much more than a simple description of the process flow. Developing a workflow application requires modeling the data that will be managed in the workflow, defining the process rules, and developing the user interface required to view and edit the process related data. It requires the same software development rigor as any other application development. In contrast, a process facilitated by a human coordinator using email and office documents can be changed by simply updating the process documentation and informing everyone about the revisions.

The completed workflow applications were inherently less flexible than the human-powered systems they replaced. The administrator who supported all the workflow applications frequently was asked to restart a process instance that had successfully finished because someone forgot to include information or because another task had arisen that should have been performed in that context. The policy for every application was that the application data were not revisable after the process finished because that would be a revision of history, but human process coordinators readily accommodated these exceptions.

Recognizing the importance of flexibility, we designed the applications to provide the coordinators with options at every possible opportunity. For example, in a change management application the coordinators identified the team of people who would assess the impact of a proposed change. Although there was a deadline for submitting an impact assessment, the coordinator could decide to stop waiting at any time and proceed without assessments. The coordinator could also request additional assessments if those received were insufficient. None of these options were documented in their business process or in the first version of the application, but they were added as coordinators discovered how their procedures differed from their process [10].

3.6 Tracking System Mindset

Human coordinators created systems to track the progress of each process instance, and the workflow applications were intended to replace and consolidate these tracking systems. For example, eight different teams all performed the same change management function, and the coordinators on each team maintained spreadsheets showing the current status of each change. Consolidating these spreadsheets into a unified report for management was challenging.

We found that their experience with tracking systems influenced expectations of a workflow application. Everyone involved in a process was accustomed to sending status information about their tasks to a coordinator who updated the spreadsheet or database. Of course, there was no need to send a message about a status change for workflow managed processes because the application automatically registered when tasks were completed.

This automation also implied that rolling a process back to an earlier status was difficult. Suppose a change was approved but a manager decided to reconsider it because of new information. A

human coordinator could easily modify the tracking database to show the changed status, but rolling back steps in a workflow management system is an ongoing research challenge.

As noted earlier, the tracking systems were the primary source of data for management's review of application performance. We were surprised to discover that an organization with a workflow managed process continued to use spreadsheets to track status and was developing a database application to consolidate all the data in these spreadsheets. As we probed deeper into other applications, we found that this approach was not unique. One workflow application was cancelled in favor of similar functionality provided by a database tracking application. In another case, an organization requested regular dumps from the workflow system into spreadsheets. The data they were tracking was all in the workflow management system, but they were not taking advantage of it. The benefits of a workflow management system will certainly not be realized if the process participants maintain a separate tracking system. They will be duplicating their work.

3.7 Shift in Locus of Control

Ideally, a workflow management system could replace human coordinators, although with reduced functionality as we have seen. In many applications the workflow system could reduce the workload of human coordinators, allowing fewer people to coordinate many more process instances. Organizations that provide a coordination service could see their role diminished if a workflow management system was able to perform their functions. These organizations owned the processes we automated and were the primary customer for the technology. We observed that they designed process tasks in a way that retained much of their central role and responsibility, relying minimally on the capabilities of the workflow management system.

Note that a reduction in their control and involvement would also shift control and involvement to people in other roles. Just as people type their own letters today instead of having a secretary do it for them, participants in these processes would enter their own data instead of sending it to a coordinator for entry.

3.8 Minimal Impact on Process Flow Time

Some program managers expected that workflow management applications would reduce the time to complete automated processes, but the impact on process flow time was small. Indeed, there are published cases of workflow management systems increasing flow time. A workflow management system that tracked the jobs flowing through a printing shop increased the time required to process these jobs [1]. The system made entering information about activities a time-consuming task that took the print staff away from their printing work. After the system was implemented, the print shop was only able to achieve their earlier productivity when the computers were down. Nonetheless, the system was viewed as a success by management, which valued the process visibility and tracking that it provided more than process speed.

The applications that we implemented did not take our knowledge workers away from their tasks. Instead, the applications provided them with essential information about work to be done, information that they would have received in email attachments otherwise. Our workflow management applications did not reduce flow time because most of the time was spent performing the tasks, not delivering the message that a task should be performed. People performed the tasks; the workflow management applications just delivered the message and recorded the results.

4. Conclusion

This aerospace program asked us to help implement workflow managed applications because of management's expectations that these applications would efficiently and flexibly coordinate processes both within and between companies. Management expected workflow management to ensure that the documented processes were followed consistently while providing weekly metrics and an audit trail for each process instance. They expected the applications to replace or augment human coordinators, enabling a huge increase in work volume without a corresponding increase in coordinators. They expected the cost of developing and maintaining workflow managed applications to be low because of the integrated tools for graphical process modeling and editing.

Management's expectations were only partially met. The applications ensured that processes were followed consistently, but application development often required changes to the processes and identified gaps and inconsistencies. The applications recorded the data required for metrics and audits, but they were not used for this purpose. The users preferred to maintain and use tracking data that mirrored the contents of the workflow application.

The workflow applications did successfully reduce the workload of human coordinators. We can think of the workflow management application as the coordinator's assistant, performing the routine coordination tasks and enabling the human coordinator to handle all the exceptional conditions that arise. There were about a dozen coordinators participating in one of our applications, and their manager said that he would have needed to hire five more if the application had not been available. It allowed each coordinator to handle more process instances, and this proved to be its primary benefit.

Management was disappointed by the cost and time required to develop and maintain workflow managed applications. This can be attributed, in part, to the program's standard software development process. Many applications were developed for this program and any changes to any application were required to follow a standard schedule of testing and block point release. We were unable to make and release simple revisions to a workflow process outside this schedule.

The users of our applications also had expectations. The expert users expected to be able to maintain the workflow processes themselves, but they soon discovered that it was not a job for amateurs. Furthermore, the requirement to release any workflow revisions within the program's block point schedule eroded any interest among these users in learning to do it. Users also expected the applications to be easy to learn and use and to nag them. These expectations were generally fulfilled, except when they wanted to do something exceptional, such as undoing a series of tasks that had already been done.

We encountered some unexpected perils when implementing workflow managed applications. First, many processes involve other organizations that have their own tools, processes, and requirements. A workflow application will fail if it requires their participation but does not integrate with their infrastructure. A

related peril occurred when the sponsor of one of our workflow managed applications insisted that the application should simply send the task to the manager of another organization and provide no support for that manager's internal processes. Organizational cooperation and both process and tool integration are essential, and these conditions are not easily met.

Although this program's processes were thoroughly documented, workflow development soon revealed that the documentation was both incomplete and inaccurate. Despite working very closely with the user community, including reviews of designs and prototypes, the first production version was never accepted by end users. We worked most closely with the human coordinators whose organization owned the application, and they often prevented engagement with other users. Excluding these other roles was costly; their work often required engaging other people who did not have access to the system and its data. From the coordinators' perspective, the work is to keep track of all the tasks, and the workflow system does that, but it also controlled who could see the data, excluding some key participants. This emphasis on tracking is the likely reason why these applications had little impact on process flow time. The applications eliminated the problem of a task languishing in a coordinator's inbox, but the substantive time-consuming work was done by others.

Everyone understands that processes change and application software must be revised, and the graphical editor of a workflow management system encourages the belief that these changes will be quick and easy. Instead, instantiation of processes in software creates process rigidity. Revising any detail of the process required reviews, approvals, and a lengthy block point cycle. The human coordinators could make these changes flexibly and easily when they managed the process. Furthermore, the workflow managed application requires that all the other participants in the process perform more of the work and rely less on the coordinators.

5. Acknowledgements

The authors would like to acknowledge all the participants in the development teams that informed this research, but because of confidentially requirements we are unable to name any of them.

6. REFERENCES

[1] Bowers, J., G. Button and Sharrock, W. 1995. Workflow from Within and Without: Technology and Cooperative Work on the Print Industry Shopfloor. In H. Marmolin, Y. Sunblad, and K. Schmidt (Eds.), *Proceedings of European Conference on Computer-Supported Cooperative Work,* (Stockholm, Sweden, September 10-14, 1995).Kluwer, Dordrecht, Netherlands, 51-66.

[2] Carlsen, S., Krogstie, J., Solvberg, A., and Lindland, O.V. 1997. Evaluating flexible workflow systems, In *Proceedings of the Thirtieth Annual Hawaii International Conference on System Sciences (HICSS'97)*.

[3] Grinter, R. 2000. Workflow systems: occasions for success and failure. *Computer Supported Cooperative Work*, 9, 189-214.

[4] Grudin, J. 1995. Groupware and social dynamics: eight challenges for developers. *Communications of the ACM, 37,* 1, 1994, 92-105. Republished in R. M. Baecker, J. Grudin, W. A. S. Buxton, and S. Greenberg, (Eds.), *Readings in human-computer interaction: Toward the year 2000.* Morgan Kaufmann, 1995.

[5] Guess, V.C. 2002. *CMII for Business Process Infrastructure.* Holly.

[6] Ishii, H. and Ohkubo, M. 1990. Message-driven groupware design based on an office procedure model, OM-1. *Journal of Information Processing,* 14, 184-191.

[7] Kingsbury, N. 1997. Workflow in insurance. In P. Lawrence (Ed.), *Workflow handbook 1997,* Wiley.

[8] Orlikowski, W.J. 1992. The duality of technology: rethinking the concept of technology in organizations, *Organization Science*, 3, 3, 398-427.

[9] Suchman, L. 1983. Office procedures as practical action: Models of work and system design. *ACM Trans. Office Information Systems,* 1, 320-328.

[10] Suchman, L. 1987. *Plans and situated actions: the problem of human-machine communication*. Cambridge University Press, Cambridge, UK.

[11] Zuboff, S. 1988. *In the age of smart machines: the future of work and power.* Basic Books, NY.