A Technology Adaptation Model for Business Process Automation

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Abstract

A number of new technologies aimed at automating office work has been developed over the last 20 years with seemingly little impact on overall office productivity. We propose a conceptual model for technology adaptation for business process automation that stresses both technology-organization fit and technology-process fit. The goal of our study is to develop a systematic approach that addresses the needs for the organization to be adaptive and for work to be flexible. The technology adaptation model we develop is useful for technology providers in the workflow management area and for business managers who wish to take advantage of the new work-related technologies.

1. Introduction

Industry and academia have embraced a range of new ideas about organizational structure [Galbraith95] and have turned to business process reengineering as a way of bringing about rapid improvements in the efficiency, responsiveness and flexibility of organizations [Hammer&Champy93]. These two sets of ideas, the one concerning the need for flatter organizational structures and devolution of decision making authority, and the other concentrating on business processes, are strongly related. Business process reengineering (BPR) involves fundamental changes in the way business activities are organized and executed and is one of the key enablers of the process-oriented view of organizations.

According to Earl [Earl94], information technology enables business process reengineering through its ability to automate, communicate and informate. A broad range of technologies have been developed to support work activities. The application of these technologies to support business processes has been called business process automation (BPA) [Andresen95]. We define BPA as the automation of process coordination tasks that were previously performed by humans. This includes activities such as filing and retrieval, physical reproduction and distribution of documents, making and answering telephone calls, manual faxing, monitoring and controlling work, and making routine decisions. Thus, BPA is concerned primarily with the automation and communication aspects in Earl's scheme.

Information technologies that support BPA include groupware, e-mail, imaging systems, document management systems (DMS), data warehousing, on-line analytic processing (OLAP), computer telephony integration (CTI), and workflow management systems (WFMS). Related research sub-fields include business process reengineering, computer systems for cooperative work (CSCW), workflow automation, information retrieval, active databases, data mining, decision support systems and organizational learning. All of these technologies and related research areas are devoted to improving and automating the work, and thinking, that is performed within and between business enterprises. While each technology and research substream provides a useful viewpoint, there is a need for integration of the technologies at the technical level and for a better conceptual understanding of how the different perspectives provided by the research subfields can be integrated.

A *second need* is to understand how these technologies can be applied to business. Unless care is taken, attempts to automate business processes may have unintended consequences for the organization and may run into obstacles in gaining user acceptance. There is a potential clash between the mechanistic aspects of BPA technologies and the more organic and human aspects of organizations. In particular, it is important to understand how BPA impacts the emerging need for organizations to be adaptable and flexible and to encourage decentralized, innovative thinking when that is called for. This is the central issue of this paper. We propose a framework for considering the broad range of issues that must be addressed in attempting to automate business processes in ways that maintain flexibility and adaptivity and foster rather than inhibit freedom of thought and individual inventiveness.

It has been found that almost any use of technology in organizations is highly idiosynchratic. Patterns of use and conceptions of the technology emerge through

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interaction with the human participants in ways that are quite indeterminant [Orlikowski&Robey91]. Patterns of use of e-mail and groupware systems have been studied fairly extensively (for example, [Sproull&Kiesler91, Orlikowski92].) Because of their relative newness, relatively few empirical studies have been carried-out in the area of work flow systems. Since WFMS provide less freedom for users, and offer more opportunities for management control, their introduction might be more difficult than that of other groupware.

According to the Workflow Management Coalition, an international organization of workflow system vendors, users and analysts, a WFMS is "a system that completely defines, manages and executes workflow processes through the execution of software whose order of execution is driven by a computer representation of the workflow process logic" [WfMC96]. For our purposes, a "work flow system" is an organizational system consisting of humans and computer hardware and software that executes one or more business processes.

The remainder of the paper is organized as follows. In the next section, we describe a technology adaptation framework for business process automation. In section 3, we examine general organizational and work-related needs and identify requirements for adaptability, work flexibility, control, organizational structure and worker empowerment. In section 4, we develop a classification of different process types and a number of design variables that should be considered when implementing BPA. In section 5, we conclude with a summary and further suggestions for research.

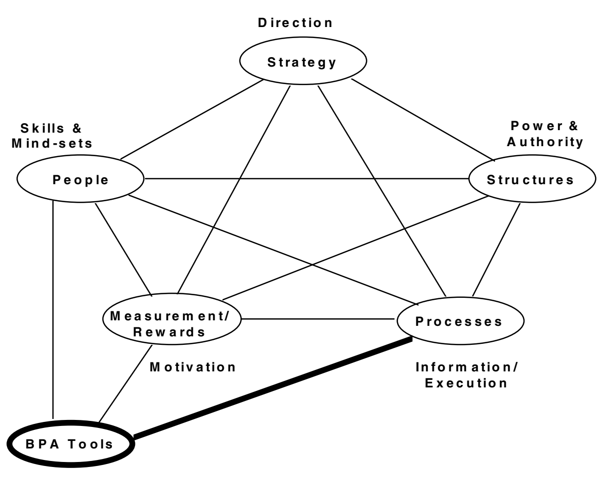

Figure 1. Organizational Context for BPA Implementation

2. A Business Process Adaptation Model

BPA Technologies support business processes in the context of the total organization, its strategies, its people, its organizational structure, and its measurement and rewards system. All of these elements need to be jointly designed to ensure the achievement of strategic goals, efficient execution of work, desired behavior of employees and the development of a corporate culture and set of norms that will ensure continued adaptation, innovation and success. These relationships are shown in Figure 1 which adds a "BPA Tools" element to the "STAR" organizational design framework of [Galbraith95]. Note that the relationship between BPA technologies and the organization is not only derived from their role in supporting business processes. BPA technologies are used directly by people in the execution of their work and facilitate the monitoring and measurement of performance thereby enabling reward systems that would not be feasible in a paper-based control system. Although BPA technology does affect the strategy and structure, we do not ddress these two relationships in this paper due to space limitation.

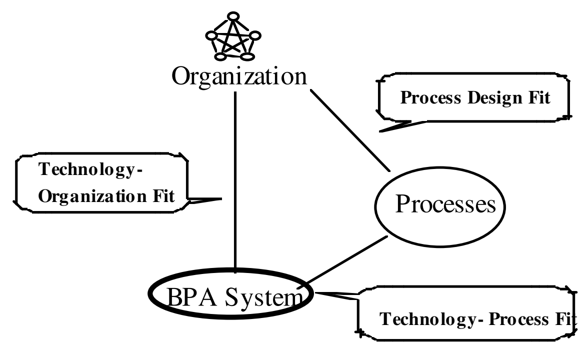

Figure 2. The Triangular Model for BPA Technology Adaptation

In this paper, we consider the problem of fit between BPA technologies and general organizational and specific process needs. We attempt to characterize these requirements in terms of a number of design variables. Figure 2 illustrates the triangular relationship between the BPA system, the organization, and the processes. While the BPA system materializes the BPA technology, the organization is the way people are organized, and the processes refer to the flow of work and information. According to this model, successful implementation of BPA technologies requires the following:

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- Process Design Fit: The business process itself must be appropriately designed.
- Technology-Organization Fit: A good fit of the BPA technologies to the nature of work and to long-term organizational needs.
- Technology-Process Fit: The chosen BPA technologies must be tailored to the needs of the specific process in which they are embedded.

The use of "adaptation" rather than "fit" in the title for the model emphasizes: (1) the need to adapt whatever BPA technologies are chosen to the nature of the organization and the needs of the particular process, and (2) that the process whereby these technologies are introduced into the organization can take place over a considerable period of time and can be a major determinant of success or failure.

Process Design Fit: To develop a successful implementation of a workflow automation process we will usually need to undertake a reengineering project involving design and implementation steps such as those depicted in Figure 3.

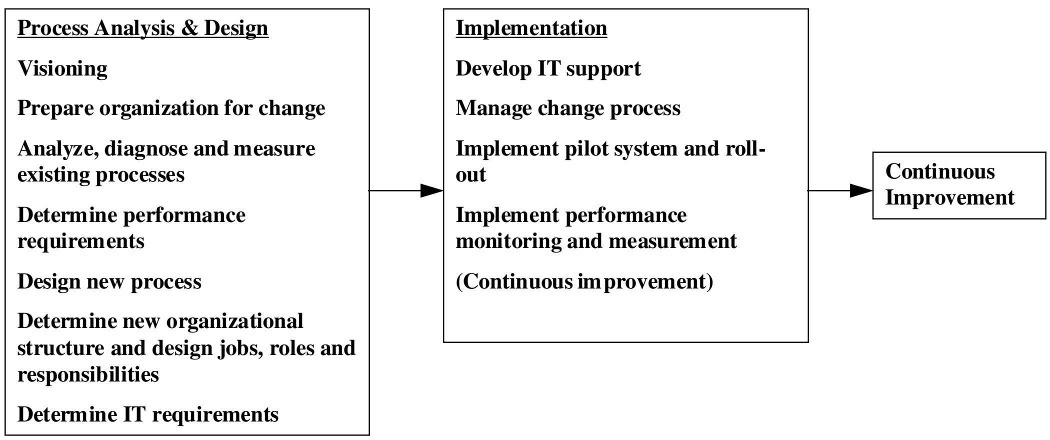

Figure 3. Process Design and Implementation Steps

Note that the determination of IT requirements is the culmination of a number of steps involving the determination of organizational requirements and a subsequent partial redesign of the organization itself. The importance of the steps entitled "preparing the organization for change" and "managing the change process" should also be stressed. Change management turned out to be the single most important implementation problem in a survey of 105 firms who had engaged in reengineering projects [Groveretal95].

In the remainder of this paper, we concentrate on the needs for Technology-Organization (T-O) fit and Technology-Process (T-P) fit. Methods for reengineering business processes to fit organizational strategies are outside the scope of this paper. However, we develop a classification of the various types of business processes that could be the products of this design process.

Technology-Organization Fit: The T-O dimension emphasizes two conceptually different issues that we feel have been neglected in the application of workflow technologies in practice. The first set of issues arise from the need for these systems to fit the requirements of work and to support the need for more adaptable, flexible organizational designs. We call this set of issues "organic" in contrast to the purely "mechanistic" approaches that have characterized most workflow system design to date. We believe that mechanistic approaches are needlessly limiting and can lead to implementation failures. The second set of issues concerns the need for BPA technologies to be adopted across the total organization. While the current state of the art probably means that different WFMS will be used for isolated processes, the end result of this could be costly in the same way that non-integrated business data processing systems were limiting and costly in the early days of MIS.

Technology-Process Fit: The T-P dimension focuses on the automation requirements for a specific business process. Each process will have its own specific requirements from both the "organic" and "mechanistic" points-of-view. Once these requirements have been determined an appropriate specification of the work flow system that supports the process can be determined.

Although our research is at a preliminary stage, the identification and classification of workflow system

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requirements on both the T-O and T-P dimensions should have the following benefits:

1. Provide information for software designers and developers.
2. Improve management understanding of BPA technologies.
3. Provide the basis for more systematic selection and evaluation of BPA hardware and software.
4. Reduce the risks involved in implementing BPA technologies.

In the next two sections, we examine the implications of the T-O and T-P viewpoints for workflow system requirements.

3. Technology-Organization Fit: The Clash between Automation and Organizational Needs

Progress in the development of information technologies makes business process automation an attractive means for increasing organizational efficiency and reducing costs. On the other hand, there is a danger that process automation may institutionalize the "wrong" processes and make the business harder to reengineer in the future. An example of the tendency of automated systems to constrain process innovation is discussed in [Wastelletal94]. The bill production process at a telecommunication services company was well understood and highly automated. However, the handling of exceptional cases, was manual and management wanted to customize the process to individual customer preferences. The design of the data processing system, its rigidity and the difficulties involved in changing it were seen as a major impediment to process improvement. As is the case in most organizations, centralized data processing had achieved huge gains in transaction processing efficiency but had, because of technological limitations and a focus on the main goals of the system at the time of its conception, neglected many secondary information flows and possibilities for variations in the system to fulfill future customer requirements. Mainframe systems have enabled tremendous process improvements (in terms of throughput efficiency and average cycle time reductions). However, the competitive situation today, demands more flexible solutions and more attention to customer service. Considerations of second-order importance at the dawn of the information age are now major issues in an era of increased complexity, speed and competitiveness. Thus, the first issue that must be considered when applying work flow technologies is their impact on organizational adaptability.

A second issue concerns the fundamental assumptions that are made about the nature of work. WFMS research and development efforts have, necessarily, adopted a rather explicit and mechanistic view of work in which there are defined set of tasks to be executed by human and software agents and a predetermined partial ordering over the sequence in which these tasks must be executed [Bussler&Jablonski94]. On the other hand, studies of actual work processes in organizations indicate that work is much more complex and involves the evolution of "work practices" by managers and workers that are continuously adapted and that employ a rich pattern of human communication and sense-making activities. These work practices enable work to be done despite frequent unforeseen exigencies [Suchman83]. These two views of work are summarized in Table 1 which combines two tables from Sachs [Sachs95] and adds several additional issues that we feel are relevant to BPA.

Organizational/Explicit	Activity-based/Implicit
Position in hierarchy	Informal politics and network of contacts
Definable roles	Competencies and mutually agreed responsibilities
Tasks	Know-how
Procedures and techniques	Conceptual understanding
Work flow (partial ordering of activities)	Work practices
Explicit methods and procedures	Rules of thumb, judgment
Electronic documents and messages	Human communication & exchange of experiences
Teams	Communities
Training	Learning

Table 1. Explicit and Implicit Views of Work

For convenience, we label these two views "mechanistic" and "organic", respectively. Along with [Sachs95], we argue that both views are essential for successful workflow automation. Given the current state of computer science, it is necessary to design work flow management systems according to the mechanistic view. However, to the extent possible, WFMS must

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accommodate and support the more organic requirements of actual work practice. We call this the requirement for “flexibility” meaning that the WFMS should not unduly restrict users and inhibit the use of common sense and native intelligence that is emphasized by the organic view of work. As an example, [Sachs95] describes the implementation of the Trouble Ticketing System (TTS) at AT&T. TTS was a large database that also functioned as a scheduling, work routing and record keeping system. Under TTS, workers communicated through the system rather than with each other. “While TTS was designed to make job performance more effective, it had the opposite effect: discouraging the training of new hands, breaking up the community of practice by eliminating trouble-shooting conversations, and extending the amount of time spent on a job by segmenting coherent troubleshooting efforts into unconnected, ticket-based tasks”, [Sachs95]. One of the responses of the workers in this case, as in most work situations, was to devise a number of “work-arounds” - ways to get the work done by ignoring or subverting the formal requirements of the system. Work flow systems can never be perfect in practice. A flexible WFMS and workflow design would recognize the inevitability of work-arounds and would, in fact, explicitly encourage them by providing support for user initiatives when exceptions occur. More fundamentally, a flexible WFMS in this case could encourage human conversation by providing easy telephone connections between team members.

Another aspect of work is the interplay between the organizational need for control information and the motivation of employees. BPA technologies provide opportunities for detailed monitoring of performance. However, the desirability for such control, and the type of control that should be used (market-based, bureaucratic or clan-based, [Ouchi79]) varies with the situation. In particular, there is always the choice between measuring performance on the basis of task outcomes or employee conformance to prescribed patterns of behavior. As horizontal processes and team-based organizations become more important, there is also a need to collect and measure data at the level of teams rather than individuals. A final dimension of control that is important is the need for high security, integrity and audibility in financial and other processes which might be subject to abuse if not carefully protected.

A third issue concerning workflow systems, involves their compatibility with the objectives and structure of the organization itself. We adopt a simplified view of organizational structure which, nevertheless, is sufficient to determine some of the major requirements for an effective WFMS. By their very nature, WFMS tend to introduce formality and structure into organizations. However, this may not always be desirable. According to the landmark study by Burns and Stalker [Burns&Stalker 61], when the external environment is stable, firms tend to adopt a “mechanistic“ form of internal organization characterized by rules and procedures and a clear hierarchical structure. Internal processes are formalized and centralized with most decisions made at the top. On the other hand, in rapidly changing environments, the internal organization tends to be “organic“ with much looser controls, less attention to rules and regulations and a less pronounced hierarchical structure. The mechanistic versus organic dimension can be characterized in terms of the degree of centralization and formalization exhibited by the firm. Centralization is concerned with the delegation of decision authority throughout the organization and the extent of participation by managers in decision making [Aiken&Hage68]. Formalization is the degree to which rules define roles, authority relations, communications, norms and sanctions and procedures [Halletal67]. Several studies have shown that firms that are more decentralized and less formalized are likely to adapt innovations more rapidly than those that are more structured. For example, an empirical study confirming these findings in the area of adoption of market research results was conducted by Deshpande [Deshpande82].

A brief glance at the characterization of formalization given above is sufficient to raise concerns about the efficacy of workflow management systems in situations where innovation, flexibility and managerial intuition and knowledge must be brought to bear on the work situation. All WFMS codify jobs and organizational rules and describe tasks in great specificity. They also tend to enforce the routing of tasks between individuals thereby restricting the free flow of information and flexible collaborative endeavors that are desirable in the newer, more organic forms of organization.

A further potential clash between management requirements and current WFMS capabilities occurs in the area of worker empowerment. As advocated by proponents of lean manufacturing [Womacketal90], total quality management [Pike&Barnes94] and BPR [Hammer&Champy93] work empowerment extends beyond simply locating decision making at the level where work is performed. It includes decision making about the design and control of work processes themselves. Under a WFMS, scheduling and work allocation decisions will usually be made by the

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computer system rather than by individual workers. It may be hard, if not impossible, to allow the workers themselves to control the flow and allocation of work tasks and to design their own work processes.

In the above, we have described several examples of a clash between rigid systems and effective organizational processes. We also observe that unstructured, organic organizational forms are more effective in unstructured situations where knowledge, experience, human collaboration and learning are important. A WFMS should be able to support a formal mechanistic organizational structure in routinizable situations and an organic organizational form with a high degree of worker empowerment in highly unstructured and uncertain situations. Table 2 summarizes our discussion in this section.

Organizational Issue/Requirement	Workflow System Design Requirement
Frequent changes in organizational needs, structure and processes	Adaptability: It should be easy and cheap to adapt the workflow system as required.
The dual mechanistic/organic nature of work	Work Flexibility: Flexible user environment with strong communication capabilities, flexible routing schemes. Control: A flexible range of performance measurement schemes ranging from none at all to detailed individual or team performance monitoring.
Organizational structure (mechanistic or organic)	Structure: Capable of representing organizational structure and locating decisions anywhere in that structure. Empowerment: The ability of workers to make independent decisions and to exercise design control over the work process.

Table 2. Organizational Design Variables

For future reference, we refer to the design variables on the right-side of Table 2 as the "AWCSE" variables. The more adaptable the software, the better. The need for the other capabilities (work flexibility, control systems, structure and empowerment) varies with the work situation as discussed below.

We also argue that proper attention to the adaptability, flexibility and organizational fit issues raised above is a necessary condition for successful WFMS implementation. Many other complex issues involved in a successful WFMS implementation such as improving user acceptance, preparing the organization for change, training, and developing a culture in which the WFMS is accepted, are outside the scope of this paper.

4. Technology-Process Fit: Characterizing Processes and their Support Needs

In this section, we attempt to characterize business processes on a number of different dimensions.

4.1 AWCSE Requirements of Different Types of Process

To this point, we have discussed issues of adaptability, work flexibility, control, structure and empowerment at the level of the enterprise. However, different business processes both within and between organizations, will have different requirements along these dimensions.

To illustrate, we define six classes of business process[1]:

- Accounting Processes: support processes with a major financial component such as purchasing and accounting.
- Core processes: value-adding processes that directly satisfy customer needs such as order entry, logistics, claims processing, engineering design and so on.
- Administrative processes: support processes such as time keeping, library services, mailroom and applications for vacation leave.
- Management processes: processes that support the management planning and control function - planning, budgeting and performance reporting.
- Knowledge Intensive Processes: processes that gather and process strategic information or special knowledge that represents the core competence of the firm. Examples are processes that support R&D, market research, and help develop human capital and organizational learning.

[1] Many other classifications of business processes have been proposed, e.g., [Davenport93].

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- Ad Hoc Processes: processes that satisfy unique, transient needs. Examples are processes to support special staff meetings, small projects, market promotions, conferences and so on.

Note that the first two process types have been automated for many years. The role of WFMS here is to replace paper-based processing, to link support personnel, customers and suppliers more closely and to handle exceptions. Administrative processes have, in the main, been neglected by traditional MIS and represent a fruitful area ("easy pickings") for cost-cutting BPR applications. Support for management processes has included mainline MIS systems, separate Executive Support Systems (with links to MIS) and OLAP (on-line analytical processing). A new role for WFMS here is primarily document based - supplying executives with correspondence and multimedia documents and enabling communication capabilities such as broadcasts to employees and direct communications with associates and business partners around the world. Knowledge intensive processes have been supported in the past by isolated DSS models and expert systems (for example some accounting firms have embodied their professional knowledge in expert systems for tax assessment). Opportunities for the use of WFMS in this area, include document management and integrated access to data warehouses and organizational learning applications [Stein&Zwass95]. Finally, ad hoc processes are usually executed intuitively using the learned habits of the responsible groups, supported by mutually agreed agendas and e-mail.

Process Type	Adaptability	Worker Flexibility	Formal Structure	Control	Empower-ment
Accounting	Low	Low	High	High	Low
Core	Depends	Depends	Medium	High	Depends
Administrative	Medium	Medium	High	Medium	Medium
Management	Medium	Medium	Medium	Medium	High
Knowledge intensive	Medium	Medium	Low	Low	High
Ad hoc	High	High	Low	Low	High

Table 3. Characterization of Business Process with AWSCE Design Variables

Table 3 shows possible requirements of each process type in terms of the AWCSE requirements developed in the previous section.

The AWCSE design variables should be evaluated carefully whenever a workflow system is designed. The values in the body of the table are meant to be suggestive only. We have used "depends" to characterize the requirements of core processes to emphasize the point. If the organization is in a highly stable, mature industry, traditional hierarchical methods for management and control may be perfectly adequate and the requirements for adaptability, flexibility and empowerment might not be very high [Galbraith95]. We believe that adaptability and flexibility are always desirable system attributes. Control may or may not be desirable. For example, in decision support situations, monitoring of the decision process could seriously inhibit the decision makers. Similarly, empowerment may or may not be a desirable design goal depending on the situation. For example, in an (administrative) workflow application for a mail-room one would probably concentrate on the throughput and control dimensions and leave very little freedom for the exercise of individual initiative.

4.2 Mechanistic Design Variables

In addition to the work/organizational requirements analysis described above, business processes can be characterized on a number of other dimensions that have important implications for their design. In particular, we identify five important dimensions: topological complexity, dynamic complexity, external connections/media, variability and throughput.

Topological Complexity

Topological complexity measures the shape, size and density of interconnections in the workflow system. High values for the following variables can be expected to increase the complexity of the workflow system making it harder to design, support and modify.

- Number of Agents: The number of agents involved in a workflow process is an indication of process complexity.

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- Number of Roles: The same number of agents may result in different complexities due to different number of agent types, i.e., roles.
- Organization of Agents: For example, complexity will increase if a relatively large number of formal organizational roles are needed for the purposes of approval, consultation, inspection, and so on.
- Number of Steps in the Workflow Process: The length of a workflow process in terms of the average and maximum number of sequential steps that need to be executed to process a given job or case.

Dynamic Complexity of Workflow Processes

The following temporal dimensions also have important implications for the design of the workflow process and the choice of supporting technologies.

- Interactions between Agents: Different cultures in similar organizations may result in different ways and frequencies that agents interact with each other during the workflow process.
- Variability of Agent Composition: Some workflow may be ad hoc because its agent composition may change from time to time.
- Number of Exceptional Cases**:** The ability to handle entirely unanticipated events is a human quality which the workflow system should recognize and support.
- Duration of the Workflow Cycle: Some workflow processes may be completed in a matter of minutes while others may take days or months to complete.
- Repetitiveness of the Workflow Process: Many workflow processes only occur continuously, others only once in a while. An example of the latter is a Christmas charity organization that organizes volunteers to do some charity work once a year.

High values for the number of interactions, agent variability, exceptions and length of the work flow cycle are likely to imply higher procedural complexity.

External Connections/Media

The nature of the connections to external systems/organizations and the number and types of the different media obviously has a strong influence on the type of WFMS that will be required and the design of the underlying workflow system. The reference model developed by the Workflow Management Coalition [WfMC96] specifies five interfaces from the central "Workflow Enactment Engine" to: Process Definition Tools, Administration and Monitoring Tools, Other Workflow Engines, Applications invoked by Workflow Clients and Applications invoked directly by the WFMS. For our purposes, the last three interfaces best reflect external connection requirements. Of particular relevance will be required connections to imaging systems, telephone call centers, mainframe systems, remote sites, the internet or intranet, and possible EDI applications. With regard to media, application requirements range from primarily text, to image, compound and multimedia documents, and possibly to voice and even video services.

Process Variability

Business processes can change either dramatically or incrementally over time. Understanding the sources and natures of process changes is important to make workflow system more adaptive to changes.

- Organizational Redesign: Organizations may undertake major changes for many reasons such as merger and acquisition, major business reorientation, or business reengineering.
- Procedure Adjustment: Changes in the way work is done can occur when business policies are adjusted in terms of decision making rules and management procedures.
- Process Improvement and Innovation: In order to reduce production or service cycles, improve quality, and reduce costs, business process may be modified or completely redesigned with or without dramatic change in the organizational structure.
- Interorganizational Relationship Changes: Interorganizational relationships can change over time either in the form of adding new or removing old organizations, or in terms of interaction procedures.
- Unanticipated Events: A good system should be able to handle surprises without interrupting normal operations.

Throughput and Responsiveness

The requirements for high throughput and efficiency, particularly in value-added transaction-based processes, can impact the choice of WFMS. Flexible, LAN-based systems with desirable user features and a broad range of organizational capabilities as we have defined, may not scale-up for use in major production systems, requiring the organization to build their workflow system around a mainframe (an example is the Fedex

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imaging system described in [Candleretal96]. In data processing, the number of transactions to be processed per unit time is often a good measure of throughput requirements. However, the concept of a "transaction" does not fit the multi-faceted nature of work addressed by WFMS. Some possible metrics relating to throughput and responsiveness requirements are as follows:

- Cases per hour and total processing time per case: where a case is a unit of work such as a job or an extended transaction for a customer.
- Customer Response Time: average, minimum and maximum time taken to respond to a customer request.

4.3 Mechanistic Characterization of Business Processes

For ease of reference, we will refer to the design variables defined in this section as the "CEVT" variables. By way of illustration, Table 4 shows possible requirements of each of the above process types in terms of the CEVT design variables.

Process Type	Topological Complexity	Dynamic Complexity	External Media	Process Variability	System Throughput
Accounting	High	Low	Low	Low	High
Core	Depends	Medium	Depends	Depends	High
Administrative	Medium	Medium	Low	Medium	High
Management	Medium	Medium	Medium	Medium	Medium
Knowledge intensive	Low	Medium	High	High	Low
Ad hoc	Low	High	Low	High	Low

Table 4. Characterization of Business Processes with CEVT Design Variables

For example, the accounting process type is characterized by high topological complexity and low dynamic complexity as it usually involves many agents in the accounting department and is quite stable. An Accounting system is usually internally focused and requires only text and numeric data so that it has low requirements with regard to external connections and media. However, it may require high throughput capacity to handle large numbers of transactions. At the other extreme, an ad hoc process has most of its system requirements reversed in comparison to accounting processes. Core processes have variable requirements on topological complexity and process variability depending on the specific process and are therefore marked as "depends" in the table.

The design variables illustrated for hypothetical processes in Tables 3 and 4 provide some idea of the complexity of workflow systems. Further research will be needed to refine these concepts and to determine their usefulness in characterizing specific process design situations.

5. Conclusion

BPA technologies and WFMS in particular, have the potential to alter the nature of work in organizations. While they are probably evolving satisfactorily towards a rational "mechanistic" representation of work and business processes, they will also need to satisfy the more "organic" needs of work and organizations. As management changes their view of the objectives and structure of the organization, WFMS must fit seamlessly into whatever organizational philosophy is needed to further the aims of the organization.

Organic (AWCSE)	Mechanistic (CEVT)
Adaptability	Topological Complexity
Worker Flexibility	Dynamic Complexity
Control	External Media
Organization Structure	Process Variability
Empowerment	Throughput/ Responsiveness

Table 5. Workflow System Design Variables

The Triangular BPA Adaptation Model in Section 3 emphasizes the dual requirements for work and organizational fit and specific process fit. From an analysis of the need to fit organizational and work related needs, we developed a number of variables that we believe must be considered in the design of any workflow system. The AWCSE requirements, namely adaptability, work flexibility, control, structure and empowerment as defined in section 3, represent the "organic" side of organizations. With regard to the need for the WFMS to fit the needs of a specific process, we developed a number of variables in section 4, that measure the more mechanistic dimensions of business processes. These CEVT variables along with

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the AWCSE variables (see Table 5) provide a basis for a general approach to the design of work flow systems and the selection of WFMS.

We believe that the future will see variations of workflow integration methodologies and systems, each of which will focus on providing automation solutions to one or more types of business process. Work on designing WFMSs that provide more flexibility and adaptability has been attempted [Kumar&Zhao96]. Careful consideration of the implications of the design variables identified in this paper should guide this future evolution.

We are currently working toward a methodology for BPA system design and evaluation that is based on the model and design variables developed in this paper. This methodology should provide useful guidelines at both the system planning level and the system design level.

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