Chapter XIII

Re-Engineering and Automation of Business Processes: Criteria for Selecting Supporting Tools

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ABSTRACT

Re-engineering of business processes and their automation is an activity very common in most organizations in order to keep or create a competitive business advantage in the changing business environment. Business Process Modeling Tools (BPMTs) and Workflow Management Systems (WFMSs) are the most popular tools used for business process transformation and automation of the redesigned business processes within and outside organization's boundaries. This chapter describes a set of criteria for selecting appropriate BPMTs and WFMSs among the diversity of the tools offered in the market in order to assist the interested manager or business process engineer to more successfully manage the business process transformation. While establishing the proposed criteria, we considered currently available technology and standards for visual enterprise support and inter-organizational business process modeling and automation.

INTRODUCTION

An important aspect for every business, in order to be competitive, is the re-engineering of its business processes (see the two seminal papers by Hammer, 1990, and Davenport & Short, 1990, for an introduction to business process re-engineering) and their automation. Many enterprises have already started re-engineering efforts in order to keep or create a competitive advantage in a changing business environment, to address the rapid growth of the Internet market, to cross the chasm between organizational structures and e-commerce, and so on.

For a successful business transformation, new frameworks are needed for understanding the emerging organizational structures supporting new services (see for example the framework proposed by Schlueter & Shaw, 19970, as well as appropriate tools to support the whole business process lifecycle, i.e., every step and activity from capturing, modeling and simulating existing, redesigned or new business processes to their automation. Currently available commercial Business Process Modeling Tools (BPMTs) aim at supporting the first steps of the business process life cycle, i.e., the modeling and evaluation of business processes for improvement and re-engineering purposes (Enix, 1997).

The later steps of business process life cycle, i.e., implementation and automation, can be supported by a number of available technologies and tools like commercial groupware tools, Workflow Management Systems (WFMSs) or commercial transaction processing systems, depending on the type of process and on the degree to which a process depends on humans or software for performing and coordinating activities. Among these tools, the most popular for business process automation and implementation are the WFMSs. (See Georgakopoulos et al., 1995, for an overview on WFMSs and Dogac et al., 1998, for a collection of papers on a number of interesting issues related to WFMSs and interoperability.)

The rapid growth of the Internet and the provision of e-business services to increase sales and productivity introduced the need to model inter-organizational processes and consequently the support of inter-organizational workflows (i.e., the ability to model and automate processes that span several organizations). When dealing with inter-organizational processes, model interoperability becomes more of an issue. Relevant international standard organizations, such as the Workflow Management Coalition Group (WfMC, 2002), are currently dealing with the provision of protocols enabling the interaction and data exchange based on widely acceptable standards as the Extensible Markup Language — XML (WfMC, 2001). Thus, BPMTs and WFMSs should efficiently address interoperability issues to deal with inter-organizational processes.

A number of evaluation reports of existing BPMTs and WFMSs are being produced and updated regularly mainly by consulting companies such as SODAN, OVUM, Datapro, etc. These reports lean more towards the evaluation of specific products than the provision of a comprehensive framework for evaluation. This chapter aims at filling this gap by presenting a set of criteria to be taken into account by the person embarking on a search for suitable BPMTs/WFMSs and highlighting additional features they should support to conform with e-business requirements. Although the simultaneous attainment of all requirements is — and is likely to remain — moot, their awareness is likely to inform advantageously their prospective users, while being of use to developers/researchers, too.

The following sections provide a definition of business process, business process and workflow models, BPMTs and WFMSs, and subsequently discuss some classes of selection criteria.

BUSINESS PROCESS MODELS, WORKFLOW MODELS AND SUPPORTING TOOLS

A business process is a set of *activities* that are executed in order to achieve a business objective; this objective is usually to offer the right product or service to a customer with a high degree of performance measured against cost, longevity, service and quality (Jacobson et al., 1995). For a complete description of a business process, aside from the information describing constituent business process activities, we need information related to *resources* assigned to activities, i.e., objects necessary for the execution of activities, like actors, documents, data and so on; *control* of a business process which describes 'when' and 'which' activity will be executed; the *flow* of data in the process; and the *organizational structure* which consists of organizational units, people, roles, competence and so on. Consequently, business process modeling approaches should enable the modeling of all these types of information while at the same time providing facilities for tracing, simulating and graphically animating the constructed business process models.

A business process *model* is a process abstraction that depends on the intended use of the model. In the rest of the chapter, when a process model is intended for business process analysis, improvement and re-engineering, it will be called *business process model*. When such a model is intended for business process implementation and automation, it will be called *workflow model*.

In other words, a business process model can be seen at two levels: at the re-engineering level and at the automation (implementation) level. Thus, the model produced at the re-engineering level is later transformed to another model at the automation level in order to be used by application development programs or to be directly executed in an existing working environment. Each model captures level-specific information; however, there is some core business process information, like activities, resources, control information, flow of data and organizational structure, which has to be modeled at both modeling levels. Information — like execution time and cost of each activity, activity waiting time, cost of people, laws governing the organization, etc. — is information captured in the model at the re-engineering level. Information — like information technology required, details about the working environment and any other information necessary for the implementation of the business process — is captured in the workflow model at the automation level (see Figure 1). More about business process modeling may be found in Tsalgatidou and Junginger (1995).

Popular tools supporting the modeling, re-engineering and automation of a business process are *Business Process Modeling Tools (BPMTs)* and *Workflow Management Systems (WFMSs)*. More specifically:

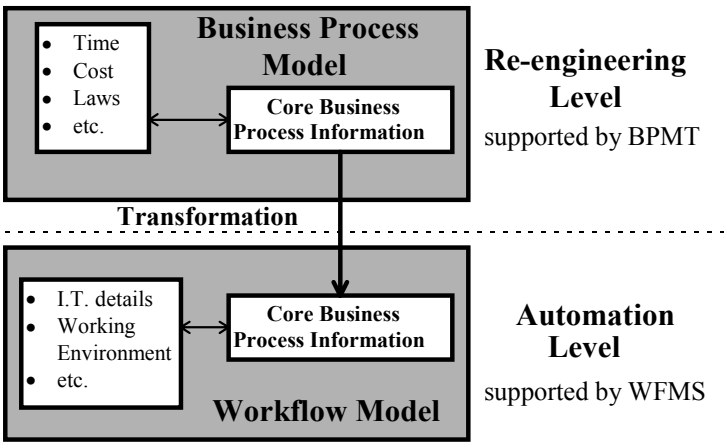
- *BPMTs* aim at the development of business process models for management, documentation or re-engineering purposes. They focus on capturing and modeling details that are essential for business process analysis and simulation, like for

example time, cost, resources, etc., the results of which can then be used for business process re-engineering and subsequent automation. Examples of BPMTs are the ARIS Toolset (IDS-Scheer, 2002), the Workflow-BPR (Holosofx, 2002), the Workflow Analyzer (Metasoftware, 2002), the Process Wise (ICL & Fujitsu, 2002) or even UML (Jacobson, 2001), to name a few.

- *WFMSs* aim at the development and subsequent automation of workflow models and thus, they differ in the level of detail in which their scope is located and their focus of attention: while BPMTs focus on higher-level chunks of business operations and their re-engineering, WFMSs aim mainly at transferring the process models (usually developed previously by BPMTs) in real-world settings. In order to accomplish that, they may interoperate with databases, LANs, document handling and imaging systems, legacy applications, etc. Examples of WFMSs are the FlowMark (IBM, 1999), Visual Workflow (FileNet, 2002), InConcert (InConcert, 1999), etc.

Therefore, it seems that an organization, in order to successfully support the whole business process life cycle (from modeling of a process to its automation) and efficiently cooperate with other organizations, needs to use appropriate BPMT and WFMS tools. A very important issue that arises here is the integration between BPMTs and WFMSs so that business process models developed by a BPMT can be then transformed in workflow models and utilized by a WFMS. We call this issue vertical interoperability, which is one of the main criteria for selecting appropriate tools. This, along with other criteria — which are based on the above intended functionality of BPMTs and WFMSs, and can assist in the selection of appropriate commercial tools — are presented in the following section. Especially when dealing with modeling and technical and process automation aspects, interoperability is considered as the key issue to enable inter-organizational processes. The conformance to standards, as those proposed by WfMC, facilitate such characteristics.

Figure 1. Business Process Modeling for Re-Engineering and Automation Purposes



CRITERIA FOR SELECTING BPMTS AND WFMSS

The criteria are classified into the following categories: *user interface, modeling, analysis and validation, technical and process automation aspects*. They are presented as follows: in each category, the requirements concerning both categories of tools are presented first; these are then followed by a description of requirements specific for BPMT or WFMS, if any. The first three sets of criteria concern both categories of tools and mainly BPMTs, while the automation aspects mainly concern WFMSs.

User Interface Aspects

Requirements on user interface aspects can be classified into two categories: user interface requirements related to users and user interface requirements related to machines.

User Interface Requirements Related to Users

These concern mainly the provision of a highly interactive and graphical user interface (GUI), which, in the current state of the art, is more or less a truism. However, the provision of a GUI does not imply that all aspects of the process analysis and design can be carried out graphically. It is usually the case that a broad solution can be graphically designed, while the details must be filled in using some kind of high-level programming language script. Therefore, an additional requirement for *entire GUI definition* is set here. Support for efficient *GUI navigation* in the process models produced is also required. This support must be in accordance with the conceptual modeling mechanisms provided by the tool. *End user customization* facilities should also be provided.

Machine-Related User Interface Requirements

Portability and *adaptability* of the user interfaces are key issues here. Given the fact that the hardware infrastructure of business environments consists of diverse hardware architectures and operating systems, and that a large number of employees is likely to access business computing resources from different access points, e.g., desktop PCs, portable PCs, etc., the user interface should be portable across these diverse access points. This should affect neither the functionality of the interface itself nor its user friendliness. Portable languages such as Sun's Java Programming Language combined with CGI techniques enable the fulfillment of this criterion. Furthermore, given the ongoing increase of interest for intranet-related technologies, it is highly unlikely that BPMTs and WFMSs will escape the need to adapt to business intranets. As intranets promote the interoperability of diverse software platforms and since an increasing number of intranet applications provide a Web accessible gateway, it is a natural consequence that the user interface of the tools this chapter is dealing with should be adaptable to the changing intranet environment. The possibility of dynamically downloading user interfaces from central interface repositories should not be excluded as an option.

Modeling Aspects

Modeling Philosophy

The modeling philosophy employed by a tool is often advertised as the major feature of a BPMT. Actually, the model provided is the single most important founding principle of a BPMT since all analysis and subsequent benefits provided by a tool are based on the model expressiveness and its properties. For example, if a process is not accurately modeled in a BPMT, no analysis facilities can serve any useful purpose. Additionally, a BPMT without sufficient modeling depth can be counter-productive, since conclusions will be reached based on incomplete or inaccurate information. The Conversation for Action Model (Winograd & Flores, 1987) used in the Action Workflow (Medina-Mora et al., 1992), Petri Nets (Tsalgatidou et al., 1996) or some form of data flow diagrams (Jacobson, 2001; DeMarco, 1979) enriched with control information, are popular approaches. Assuming that BPMTs are used to model business processes, and that BPMTs and WFMSs interoperate, the role of a WFMS in workflow modeling is limited, since either the entire workflow model or a significant part of it is usually performed at the BMPT. In order to effectively automate a business process, the model adopted must facilitate its accurate and complete description. Thus, it is important to support a concise method for process modeling within the BPMT and WFMS environment. If similar models are not supported, a systematic transformation algorithm to depicted business process modeling entities within the WFMS is needed (Nikolaidou, 1999). Related interoperability issues are discussed in a following paragraph.

Conceptual Modeling Mechanisms

Business process and workflow modeling results in the construction of conceptual models of a given part of reality. Hence, requirements on conceptual modeling tools apply to BPMTs and WFMSs as well, the most prevalent being: abstraction mechanisms (classification, aggregation, generalization/specialization) and structuring mechanisms (for example, a model may be structured in terms of the processes investigated, the stakeholders involved, etc.). In many cases, workflow implementation is performed without studying the involved business processes, resulting in poor performance. This is due to the inefficient modeling constructs provided by WFMSs compared to BPMTs. The ability to integrate aggregated models and the provision of different abstraction levels for process description are essential features for inter-organization process support.

Flexible and Explicit Time Modeling

Despite long and intense efforts, time has proved especially difficult to be effectively modeled; the repeated attempts of the database community bear witness to this. BPMTs and WFMSs could not be exceptions; thus, a fitting representation of time, along with constraints, precedences and antecedences is invariably needed in business process and workflow modeling.

Model Annotations

No modeling formalism can capture all relevant details and pertinent facts. Process models often need to be annotated with extra-model information such as designer comments and rationale, analysis and validation statements, etc.

Organizational Structure Modeling

The modeling of human resources in a business process as simple agents may not be enough for conveying all relevant information. A more rigorous modeling of the organizational structure is in need, encompassing entities such as departments, actors, roles and so forth. The resulting organization models must be suitable for integration with the process models per se, so that actor participation in specific activities, actor permissions on specific resources, along with more general security specifications, could be specified accordingly. Object-based representation is usually adopted by existing BPMTs and WFMSs, enabling abstract representation of entities and the formation of hierarchies. Besides the ability to accurately represent the organizational structure, the interaction with external tools where relevant information is kept is considered as an additional feature. The conformance with existing (i.e., UML) or emerging standards (i.e., WfMC Entity Representation Model) contributes to this direction.

Resource Modeling

Resources can be modeled simply as input and/or outputs of process steps. A more economic and comprehensive approach is to create a model of the resources in use, for example creating a document type ontology, placing documents in a hierarchy, etc. Resource modeling should acquire the same features as organizational structure modeling.

Representation of Control, Data and Materials

Representation of data flow as well as materials and control flow among process steps is essential. The conformance with existing or emerging standards enables the interaction between different process models which is essential for inter-organizational process support.

Flow Type

Most existing BPMTs and WFMSs are built around a well-structured process paradigm (sequential or if-the-else-based flow), that is, process steps are modeled as following each other in a well-ordered succession. This usually fails to capture the dynamics of a real business environment. Although no final propositions have been made, some rule-based formalisms (rule-based flow) do offer a plausible alternative.

Analysis and Validation

- *Business process and workflow models should be formal, or amenable to formal analysis, for static analysis and validation*. Static analysis and validation of a model refer to the study of the derived models using specific algorithms and analysis approaches (not simulation). Such analysis and validation should be able to derive results on process metrics, identification of constraints and resource cost evaluation, among others. This entails some kind of mathematical formalism along which the relevant models are structured. Absence of such a foundation does not render static analysis and validation infeasible; they are, however, more difficult to use and more dependent on ad hoc approaches. Analytical tools used by BPMTs

usually include: case analysis, weighted average analysis, critical path analysis, throughput analysis, resource utilization, value chain analysis and activity-based costing.

- *Executable business process and workflow models for dynamic analysis and validation*. Dynamic validation refers to the study of the derived models by way of their dynamic behavior. Simulation of the model specification is the main approach used for dynamic validation. By varying rates of input, a BPMT can simulate activities and assess performance issues, such as bottlenecks in a process. Procedures can then be developed based on these simulations to successfully plan for and manage uncontrollable variations of input. What-if analysis and if-what analysis of changes in business process and workflow models should also be provided. Most WFMSs provide workflow process animation tools but depend on external BPMTs for simulation and analysis. Therefore, the sophistication of analysis and simulation provided by BPMTs, as well as the degree of integration and interoperability between BPMTs and WFMSs, have a direct impact on the ability to validate and evaluate workflow process models.

Technical Aspects

Vertical Interoperability

As discussed in the second section, one of the major objectives of BPMTs, apart from assisting the re-engineering process, is to provide for implementation and automation of business processes through integration with WFMSs. For example, consider a situation where the business process model used by a BPMT is different than the workflow process model utilized by a WFMS. In such a case, their integration involves filtering business process model objects, validating the resulting workflow process model and placing it in the representation used by the WFMS engine. Therefore, BPMTs must export and possibly translate their process definitions to WFMSs or share process models and definitions with WFMSs. More detailed discussion on this may be found in Georgakopoulos and Tsalgatidou (1998).

Horizontal Interoperability

At the business process modeling level, this refers to the ability of the product to handle models created by other BPMTs. At the workflow level, this refers to the interoperability between various WFMSs, and between WFMSs and various heterogeneous systems participating in the workflow process. Connectivity to database systems used in the organization as well as to mainframes is also required here. Furthermore, interoperability at the workflow level requires additional technology and standards that exploit and extend current industry solutions for interoperability, such as those developed by the Object Management Group (OMG, 2002b), the World Wide Web Consortium and the Workflow Management Coalition Group (WfMC, 2002). Although there are emerging standards for WFMS interoperability and data exchange, one should note the lack of similar efforts for BPMTs. This is due to the different models used to represent different aspects of the same process, while studying it. Workflow interoperability is essential to build and support the cooperation of processes belonging in different organizations and the data exchange between them. BPMT interoperability, although a useful feature, does not directly affect inter-organization workflow support.

Object-Oriented Toolset

The usefulness of object orientation in process modeling rests in its potential for developing intuitive and economical conceptual models of the real world. An object-oriented toolset should provide the ability to model processes, resources and organization structure in an object-oriented framework, thus reducing redundancy and enhancing re-use of model components. The object-oriented paradigm is also adopted by existing and emerging standards for process and data representation, e.g., XML.

Process Models Repository

All business process modeling tools offer some kind of repository for storing and retrieving the constructed models. The functionality offered by such repositories may vary considerably, ranging from simple storage schemes to full database management systems. In the case of an object-oriented toolset, an underlying object-oriented database can improve the tool's capabilities and consolidate smoothly conceptual models and physical storage. Actually, the repository is a critical component in such systems and often distinguishes between a system that can be used in business production and one that simply cannot. Important issues here are concurrency control, recovery and advanced transactions. Therefore, it seems that there must be a database management system as part of the WFMS, even if this increases the cost of the system.

Integration with Other Tools

Communication software (like, for example, mail systems) becomes an indispensable component of corporate-wide networking. Smooth integration between workflow and communication tools should therefore be demanded. This has actually been followed in cases where companies sell workflow products to be embedded in a larger communication system, thus viewing flow of work as a special kind of communication-coordination among agents. Interoperability with other similar product families (e.g., document management systems, text retrieval or imaging systems, editing tools, fax, or payment packages if we are talking about electronic commerce applications, etc.) is required, too.

API Support

Although graphical specifications of workflow are user friendly and usually effective, the need for fine tuning or a more detailed specification than the one carried out graphically frequently arises. APIs can also be used to introduce specialized user interfaces or tools to meet specific application requirements. Furthermore, APIs can promote integration of favorable functionally equivalent components. For example, if the WFMS cooperates with a word processor, this should not be necessarily provided as part of the WFMS, but instead provide APIs for integrating the word processor the customer prefers. Workflow vendors provide APIs to accommodate such needs. Such APIs can be judged in terms of comprehensiveness, ease of use, libraries provided, etc.

Concurrency Control, Recovery and Advanced Transactions

WFMSs should support concurrency control and recovery. These are well-understood issues in database and transaction processing products, but current approaches followed by WFMSs (e.g., check-in/check-out, pass-by-reference/pass-by-value, etc.)

are primitive when compared to the concurrency support provided by database management systems.

Robustness and Availability

Continuous availability of WFMSs is crucial especially for critical systems. WFMSs should be resilient to failures and provide mechanisms for backup and efficient recovery. According to Alonso et al. (1997), the lack of robustness and the very limited availability constitute one of the major limitations of existing WFMSs, which lack the redundancy and flexibility necessary to replace failed components without having to interrupt the function of the system. Therefore, special attention should be paid on this aspect when selecting a WFMS.

High-Volume Processing, Performance and Scalability

High-volume processing is a key requirement for WFMSs. Many business processes require handling of a large number of workflow instances. Performance of a WFMS should be independent of the workload in the sense that many workflow instances could be created and processed when needed, without penalties to system performance. The use of more powerful computers may not necessarily yield corresponding improvements in WFMS throughput. Therefore, scalability of the workflow engine (server) and work list handler to deal with load balancing is an important requirement.

General Requirements

Both BPMTs and WFMSs share some requirements in common with most industrial-strength software products, such as availability in specific platforms usually encountered in business environments. UNIX, Windows NT, OS/2 and AIX are among the most popular server platforms, while Windows95 is the platform usually encountered by clients. Compliance to industry standards (e.g., CORBA (OMG, 2002b)), version update and customer support, ready case studies and product maturity is also required.

Process Automation Requirements

These requirements concern mainly WFMSs used for the automation of business processes and are the following:

- *Work-in-Process Tracking*. All objects of a workflow must be monitored by the system so that the process status is visible to management whenever required.
- *Automatic Resource Allocation*. This refers to an intelligent balancing of work among different employees, depending on particular persons' or groups' workload and responsibilities. This may, for example, involve task monitoring and "pushing" tasks to employees, as well as identification of inactive human resources.
- *Manual Resource Allocation*. It is clear that automatic resource allocation cannot be a surrogate for human control; the complexity of an organizational setting, along with the exigencies of a competitive business environment, often require human intervention. Such intervention may take the following forms: "pull applications" (employees may choose their next piece of work from a pool of tasks) to be completed, negotiation of work among people in the organization (including the

exchange of allocated work chunks, the splitting and/or sharing of work among related agents, etc.) and assignment of specific tasks to specific employees (usually carried out by the management).

- *Security*. Permissions must be potentially granted for initiating workflow processes, viewing status reports, re-routing a document, end-user customization, etc.
- *Statistics*. Already hinted to above, comprehensive statistical measures and status reports are indispensable for giving a clear and succinct picture of workflow execution. Such statistics and execution data should be possible to be fed back to a BPMT and facilitate process evaluation and improvement. This feature is essential for business process re-engineering. Thus, graphical representation of results and statistical processing of data could be useful.
- *Information Routing*. At least two kinds of information routing can be discerned: static routing, which involves information transfer from one person to the next according to a predefined schedule (and cannot be altered at will while in operation), and dynamic routing, which attempts to bring feedback concepts and responsiveness to information flow; techniques (like rule-based routing related to specific events) may be used to describe not a mere sequential list of actions, but situations along with the system responses.
- *Parallel Processing*. A prerequisite for modern multi-user systems, parallel processing allows work to be routed to multiple queues or in-baskets for simultaneous processing by distinct agents; priority and version control is essential, as well as handling of multi-user access problems, also encountered in the database community.
- *Document Rendezvous*. The term refers to the automatic matching of new incoming documents with existing documents pertaining to them already in the workflow; the resulting set of documents is then clipped together before being routed to the next action step.
- *Setting and Handling of Deadlines*. This can refer to setting and handling deadlines for task completion (task deadline), or for the termination of a specific activity carried out by a specific employee (employee deadline).
- *Tracing and Reporting*. Generation of reports with data about the business process from different perspectives (e.g., from enterprise perspective, resource flow perspective or from an activity perspective, including scheduling and costing information) are very useful for analysis of the business process at hand and for re-engineering purposes. Such reports can also be used for business process documentation, management presentations, user training or ISO 9000 certification and should be provided by BPMTs. Furthermore, workflow monitoring facilities should be provided by WFMSs, in order to give information about workflow execution and illustrate which activities are currently active, by whom they are performed, priorities, deadlines, duration and dependencies. Such data are very useful as they can be fed back to BPMTs and facilitate process evaluation and improvement. Reporting involving OLAP (On-Line Analytical Processing) tools, in case they are integrated with the WFMS, is also critical, as it helps managers to make critical decisions based on the comprehensive facts of their business.

CONCLUSIONS

Successful business process re-engineering and automation in an organization depends on the selection of appropriate supporting software tools. This chapter attempted to give a description of the intended functionality of supporting tools and subsequently provide a set of criteria to help the interested engineer to select appropriate BPMTs and WFMSs among the diversity of tools offered by software vendors. While establishing the proposed criteria, we considered essential inter-organizational process requirements to support e-commerce. The existence of emerging standards for vertical and horizontal interoperabilities, especially for WFMSs (e.g., WfMC), should also be taken into account.

In order to achieve business process re-engineering, the processes supported by an organization should be constantly monitored. Process automation may increase productivity, if workflows are implemented as the result of business process modeling and exploration. Thus, WFMSs should be used in cooperation with BPMTs.

It should be noted that we could not have aimed, nor have achieved, a perfect or complete set of requirements. The result can be therefore judged in terms of pragmatics; that is, its utility to the users, purchasers and researchers in the area. Being the outcome of our own involvement in the field, we believe that the experience gained will be of help to others.

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