Selection Criteria for Tools Supporting Business Process Transformation for Electronic Commerce

Aphrodite Tsalgatidou
University of Athens, Dept. of Informatics
Panepistimiopolis, TYPA Buildings,
Athens 157 71, Greece,
E-mail: afrodite@di.uoa.gr

Abstract: E-commerce concerns the digitization of markets and the emergence of a new industry to sustain these electronic markets. Being a paradigm that emerges across disciplines, e-commerce will affect most aspects of not only traditional commerce but every day life as well. Many organisations have already embarked upon reengineering efforts in order to keep or create a competitive business advantage in a changing business environment. Business Process Modeling Tools (BMPTs) and Workflow Management Systems (WFMSs), are the most popular tools used for business process transformation and automation of the redesigned business processes. This paper describes a set of criteria for selecting appropriate BPMT and WFMS 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.

Keywords: E-commerce, Virtual Enterprise, Tool Requirements, Business Process Re-engineering, Business Process Analysis and Design, Workflow Analysis and Design, Workflow Management.

1. Introduction

Electronic commerce (e-commerce) is the ability to conduct business via electronic networks such as internet and the world wide web. Although e-commerce is based on the principles of Electronic Data Interchange (EDI), it goes far beyond EDI in that it aims at supporting the complete external business processes, including: establishment of initial contact (e.g. between a potential customer and a potential supplier), exchange of information, pre- and post-sales support (distributing information on available products and services, technical guidance on product use etc.), sales, electronic payment, distribution, and so on.

E-commerce promises to alter dramatically the way business is performed. Business processes supported by e-commerce can span organisations' boundaries with each organisation enacting its own parts of those shared processes. A novel example occurs with the 'virtual enterprise' which is primarily an interoperable network of existing enterprises addressing a particular market opportunity, with each participating company contributing its own core competence. Advances in communications and information technology represent enabling factors for virtual enterprises. However, there are still issues to be resolved especially in the development of supporting platforms, reference architectures, information exchange standards, interoperability and integration issues, coordination of transactions, and so on (see the work in [CA 97] for an interesting discussion on the main requirements of a virtual enterprise supporting platform).

Moreover, an important aspect for every business in order to be successfully involved in the e-commerce arena, is the reengineering of its business processes (see the two seminal papers by [Ha 90] and [DS 90] for an introduction to business process reengineering). Many enterprises have already started reengineering efforts in order to

keep or create a competitive advantage in a changing business environment, to address the rapid growth of the internet market and to cross the chasm between organizational structures and e-commerce.

For a successful business transformation, new frameworks are needed for understanding the emerging organizational structures supporting e-commerce services (see for example the framework proposed in [SS 97]) as well as appropriate tools to support the whole business process life-cycle, 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 lifecycle, i.e. the modeling and evaluation of business processes for improvement and reengineering purposes [En 98]. 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 (WFMS) or commercial transaction processing systems, depending on the type of the 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 WMFS. See [GH+ 95] for an overview on WFMS and [DK+ 98] for a collection of papers on a number of interesting issues related to WFMS and interoperability.

A number of evaluation reports of existing BPMT and WFMS are being produced and updated regularly mainly by consulting companies, like for example, SODAN, OVUM, Datapro, etc. These reports lean more towards the evaluation of specific products, than the provision of a comprehensive framework for evaluation. This paper 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 BPMT - WFMS. 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 section provides a definition of business process, business process and workflow models, BPMT and WFMS and subsequently defines some classes of selection criteria for the discussion which follows in section 3. Finally, section 4 draws some conclusions.

2. Business Process & Workflow Models and Tools: some definitions

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 [JEJ 95]. For a complete description of a business process, aside 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 paper, when a process model is intended for business process analysis, improvement and reengineering, 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*.

The main phases of business process lifecycle are: modeling, analysis and redesign of business processes, modeling, analysis and design of workflows and their automation (see figure 1). These phases are mainly supported by two kinds of tools: *Business Process Modeling Tools (BPMTs)* and *Workflow Management Systems (WFMSs):*

- *BPMTs* aim at the development of business process models for management, documentation or reengineering purposes. Thus, 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 reengineering and subsequent automation (examples of BPMT are the ARIS Toolset [Id 97], the Workflow-BPR [Ho 97] the Workflow Analyzer [Me 97] or the Process Wise [IF 97] to name a few).
- *WFMS* aim at the development and subsequent automation of workflow models and thus, they differ in the level of detail their scope is located and their focus of attention: whilst BPMTs focus on higher-level chunks of business operations and their reengineering, the WFMS aim mainly at transferring the process models (usually developed previously by BMPTs) 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 WFMS are the FlowMark [Ib 97], Visual Workflow [Fi 97], InConcert [In 97] etc.)

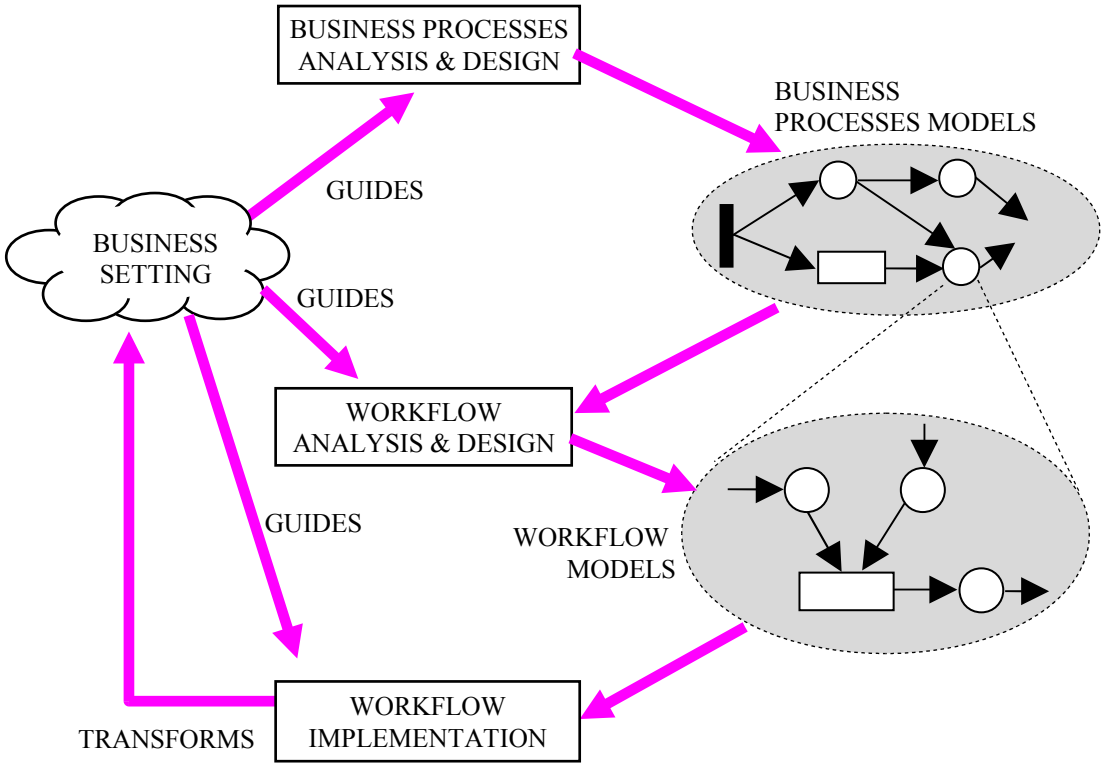

Figure 1: Business Process Lifecycle

Based on the above intended functionality of BPMT and WFMS, criteria for selecting commercial tools which support the business transformation and the business process life cycle, can be classified into the following categories: *user interface, modeling, analysis*

and validation, technical and process automation aspects. In what follows, the criteria along each of these categories will be examined in turn.

3. Criteria for Selection of BPMT and WFMS

The criteria are presented as follows: in each category, the requirements concerning both categories of tools are presented followed by a description of requirements specific, if any, for each category of tools. The first three sets of criteria concern both categories of tools and mainly BPMTs while the automation aspects mainly concern WFMS.

3.1. 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.

3.1.1. User Interface Requirements related to users

- *Provision of a highly interactive and preferably graphical user interface (GUI)*. In the current state of the art in software development this is more or less a truism. All BPMT and WFMS are GUI operated; two aspects of particular importance in graphical modeling tools are:
    - *Entire GUI definition*. 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 scripts.
    - *GUI process navigation*. Process models are prone to increasing to unmanageable sizes, difficult to be comprehended and handled on screen. Support for efficient navigation in the process models produced is a definite advantage. Such navigation may take the form of hypertext links among different parts of a model or among different models, zoom-in/ zoom-out facilities, fold/unfold, etc. This support must be in accordance with the conceptual modeling mechanisms provided by the tool.
- *End user customization*: The business process engineer using the tools to construct a process model and the employees enacting tasks defined by the tools must be able to customize their work procedures to their particular needs and preferences; this, however, must not compromise general design and enterprise goals.

3.1.2. Machine Related User Interface Requirements

- *Portability*

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 (supported services) nor its user friendliness. Portable languages such as

Sun's Java Programming Language combined with CGI techniques enable the fulfillment of this criterion.

- *Adaptability*

Given the ongoing increase of interest for intranet related technologies, it is highly unlikely that BPMT and WFMS will escape the need to adapt to business intranets. As intranets promote the interoperability of diverse software platforms (even those created by different software vendors) and since an increasing number of intranet applications provide a Web accessible gateway (usually via CGI components), it is a natural consequence that the user interface of the tools this paper 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.

3.2. 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 [WF 87] used in the Action Workflow [MW$^+$ 92], Petri Nets [TL$^+$ 96] or some form of data flow diagrams [De 79] enriched with control information, are popular approaches. Assuming that BPMTs are used to model business processes and that BPMT and WFMS interoperate, the role of WFMS in workflow modeling is limited, since either the entire workflow model or a significant part of it is usually performed at the BMPT.

- *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 BPMT & WFMS as well, the most prevalent of which 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.).

- *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.

- *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.

- *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.

- *Representation of control, data and materials*. Representation of data flow as well as materials and control flow among process steps is essential.

- *Flow type*. Most existing BPMT & WFMS are built around a sequential process paradigm (sequential 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 complement.

- *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. BPMT & WFMS could not be an exception; thus, a fitting representation of time, along with constraints, precedences and antecedences is invariably needed in business process and workflow modeling.

3.3. 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 BPMT 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 WFMS provide workflow process animation tools but depend on external BPMT for simulation and analysis. Therefore, the sophistication of analysis and simulation provided by BPMT as well as the degree of integration and interoperability between BPMT and WFMS have a direct impact on the ability to validate and evaluate workflow process models.

3.4. Technical Aspects

- *Vertical Interoperability.* As discussed in section 2, one of the the major objectives of BPMTs, apart from assisting the reengineering process, is to provide for implementation and automation of business processes throught integration with WFMS. Therefore, BPMTs must export and possibly translate their process definitions to WFMSs or share process models and definitions with WFMSs.

- *Horizontal Interoperability.* At the business process modeling level, this refers to the ability of the product to handle models created by other BPMT. At the workflow

level, this refers to the interoperability between various WFMSs and between WFMSs and various heterogeneous systems participating in the workflow process.

- *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.

- *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.

3.4. Process Automation Requirements

These requirements concern mainly WFMS 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' work load 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 BPMT and facilitate process evaluation and improvement.

- *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*).

- *Integration with communication 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. Also, interoperability with other similar product families, for example, document management, text retrieval, imaging, fax, etc., is usually required.

- *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. Workflow vendors provide APIs to accommodate the need. Such APIs can be judged in terms of comprehensiveness, ease of use, libraries provided, etc.

- *Concurrency control, recovery and advanced transactions.* WFMS should support concurrency control and recovery. These are well understood issues in database and transaction processing products, but current approaches followed by WFMS (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.

- *General Requirements.* Both BPMT and WFMS share some requirements in common with most industrial-strength software products, such as availability in specific platforms, compliance to industry standards (e.g. WfMC [Wf 97], CORBA [Om 97] etc.), version update and customer support, ready case studies and product maturity.

4. Conclusions

E-commerce concerns the digitization of markets and the emergence of a new industry to sustain these electronic markets. Being a paradigm that emerges across disciplines, it can be stated that e-commerce will affect most aspects of not only traditional commerce but day-to-day life as well. Apart from pure technical issues which still remain unsolved, what is necessary for e-commerce to take off is a shift in the paradigm commerce is performed and a subsequent transformation of business environment. An example of this need is the emergence of virtual enterprises and shared business processes that are jointly owned and operated by a company and its trading partners. Within a virtual enterprise, each participating company should preserve its privacy and autonomy, which, among others, means that each company should be able to reengineer and automate its business processes according not only to the needs of the virtual enterprise but also according to the particular needs of the company and its internal environment. This reengineering effort, in order to be successfully carried out, needs to be supported by appropriate frameworks and tools through out the whole business process life cycle.

This paper attempted to provide a set of criteria to help the interested engineer to select appropriate BPMT and WFMS among the diversity of tools offered by software vendors.. It has to mentioned 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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