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A MODEL FOR THE NEXT-GENERATION OF BUSINESS AUTOMATION ENVIRONMENTS

By

MICHAEL RANNEY

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The members of the Committee approve the thesis of Michael Ranney defended on Friday, October the 13th.

Theodore P. Baker
Professor Directing Thesis

Daniel G. Schwartz
Committee Member

Ladislav J. Kohout
Committee Member

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ABSTRACT

The new millennium brings forth an increased awareness of the abilities that Information Technology (IT) brings to the business setting: IT is now seen as a means for change, and not simply as a means for automating administrative tasks. This awareness has inspired a more structured way of thinking about systems development, which in turn establishes a new branch in the Software industry that of developing Business Process and Workflow Management related tools. An increasingly large number of products are currently on the market. This presents the interested manager or IT professional with the problem of choosing between different competing and largely incompatible products, a choice whose importance and long-lasting effects cannot be underestimated.

In response to this we have developed a model of requirements for Business Process and Workflow analysis, design and implementation tools. The model builds on a taxonomy of such tools, whereby three distinct categories are established. In each category, requirements and detailed concern pertaining to each one of them are identified, thus promoting comprehensiveness and modularity.

The nature of the concerns aims at a broad audience of academics, professionals and researchers interested in contributing to the next generation of business automation environments.

CHAPTER 1

INTRODUCTION

During the last decade, the need to keep or create a competitive advantage in a changing business environment gave birth to a more structured way of thinking in enterprises. This culminated with such management ideas as Business Process Reengineering (BPR), inaugurated by the two seminal papers by Haninier (1990) and Davenport & Short (1990). Subsequently, the ideas contained therein were developed in Davenport (1993), Haninier & Chanipy, (1993) – but see also the review in Davenport (1993), Haninier & Stanton (1995). Other researchers followed with a number of books, see for example: Johansson *et al*, (1993), Carr & Johansson, (1995), Jacobson *et al*, (1995). An accumulation of research papers has been published. A useful survey of the field up to 1994 can be found in Barothy *et al*., (1995). The objective of BPR is to transform the information technology (IT) infrastructure that supports company operational activities, in an effort to improve the business setting. BPR met with extraordinary success in the United States in the first years of the last decade, whereupon it was transplanted to Europe. Now, after the tide has waned, more sober evaluations can be made, and fruitful conclusions can be drawn (for example, see Davenport & Stoddard, 1994).

First, it became apparent that BPR, along with downsizing, restructuring, etc., was as much a child of the times as other, previous management trends like Total Quality Management, Just In Time management, and so forth: specifically, BPR was a response to a recess in the global business-economic world. It was an apt tool for rendering or keeping an enterprise efficient and competent in a harsh environment; it seems now, though, that other means should be sought for increased competence in a period of growth.

Second, the focus on Business Processes (BPs) proved to be in tune with other general concerns in the area of business automation and the role of IT as an innovative productivity enabler. After remarks that IT failed to show the gains expected from it, researchers in the field recognized that IT could be used for more than providing personal assistance in the form of desktop PCs. Specifically, the role of IT for facilitating communication and information exchange was appreciated; IT became a tool for assisting and conducting group tasks and processes. This establishes a new branch in the Software industry – a branch of BP and Workflow Modeling and Management related tools. For an introduction to workflow, see White & Fischer, 1994; Georgakopoulos *et al*., (1995). Also, details about available tools can be found in the commercial press (see Thé, 1995). Finally, an introductory survey of technology enablers for BPR can be found in Currid (1994).

We believe that although BPR has been reduced to its proper proportions, this spin-off effect in business automation is here to stay and is likely to even increase in importance. Recent interest in company-wide and more local-area networks shows that IT as a communication enabler will be the locus of related research in the years to come. Major software companies, along with newly formed, yet competent, small and middle sized ones, have followed the lead and a large range of products is now being offered

This presents the interested manager or IT professional with a puzzling problem, that of choosing between different competing and largely incompatible products. The cost for fully-fledged BP or Workflow Management tools is a serious investment choice. Moreover, the introduction of such tools in an enterprise business setting can introduce a significant training investment, alter the established way of working and everyday routines, and even transform large parts of the company structure. The difference between a successful and an unsuccessful choice may mean more than an unproductive investment.

In response to this, several companies were quick to start producing evaluation reports of existing BP and Workflow Modeling and Management tools. Regularly updated and in electronic form, these often represent an indispensable tool for the prospective purchaser (such reports are offered by a number of consulting companies, for example, SODAN, OVUM, Datapro, etc.). However, they are the result of proprietary research and cannot be brought to open discussion. Moreover, they lean more towards the evaluation of specific products than to the provision of a comprehensive model for evaluation.

Our work aims at responding to the latter shortcoming. Taking from our own experience with the field, and our own encounters with many of the tools offered in the market, we developed a model of categorized requirements with detailed considerations to be taken into account by the person embarking on a search for a suitable BP and Workflow Modeling or Management tool. We did not intend to come up with an infallible market guide. Rather, we intended for a set of requirements to be fulfilled by any BP or Workflow Modeling or Management tool striving for completeness. Whether the attainment of all the requirements set forth is possible remains moot. However, awareness of these requirements is extremely valuable to prospective users, developers and researchers. This type of treatment is typical with emerging technologies such as Operating Systems, Database Management Systems, and Compilers.

We present a taxonomy of BP modeling and Workflow Management tools in Chapter 2. This will be the basis for developing the model and criteria for consideration, to be laid down in Chapter 3 through Chapter 6. We give an example of our model's use in Chapter 7 Finally; conclusions are drawn in Chapter 8.

CHAPTER 2

A TAXONOMY OF BP MODELING AND WORKFLOW MANAGEMENT TOOLS

From the outset of the present research it became apparent that BP and Workflow related tools are grouped into three categories according to their focus and scope:

- Business Process Analysis and Design
- Workflow Analysis and Design
- Workflow Implementation

How these business automation tools relate to models and the Business Setting is diagramed in Figure 1. The rectangular nodes represent the distinct tool categories and the arrowed lines represent the relationships the tools have with the Business Setting and relevant models.

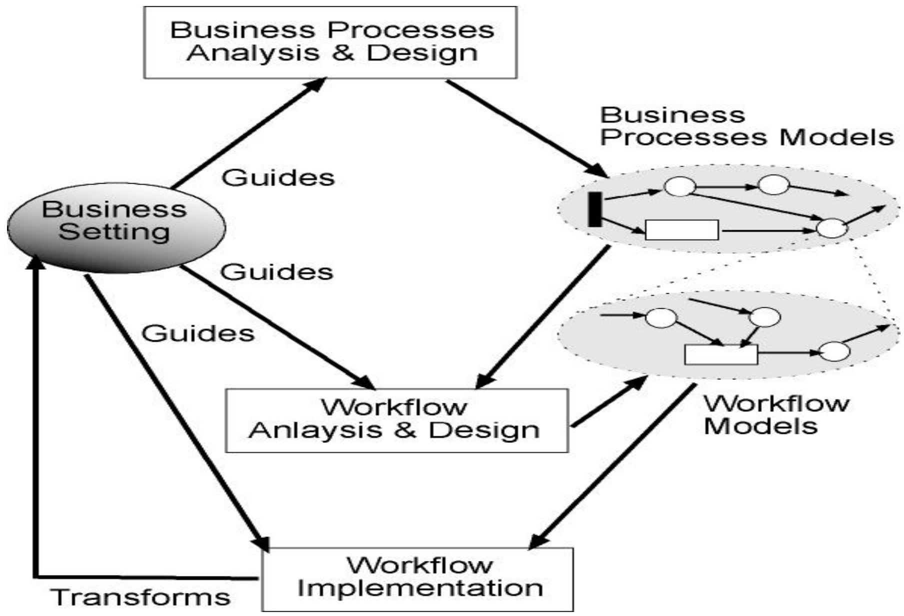


Figure 1: Business Automation Tools

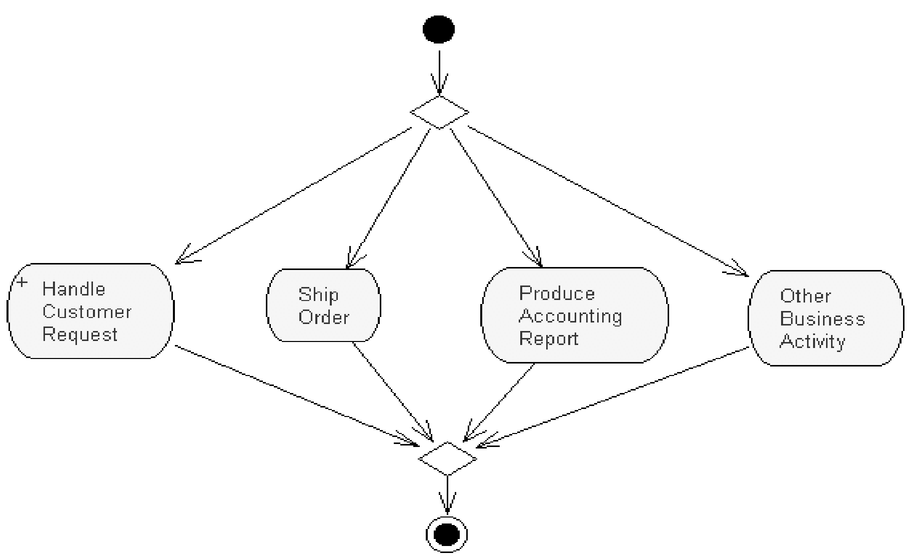
Tools supporting the Analysis and Design of BPs focus on analyzing and designing entire Business Processes Models. They support, therefore, working on a high-level of abstraction, where whole BPs are taken into consideration. These Business Processes Models are then decomposed and detailed by a series of workflows.

Tools supporting the Analysis and Design of Workflows focus on the analysis and design of workflow models. Although quite similar in their functionality to the BP Analysis and Design tools, they differ in the level of detail they address. That is, the Business Process Analysis and Design tools work on higher-level chunks of business operations. The Workflow Analysis and Design tools take as input the components of a Business Processes Model and produce decomposition into Workflow Models.

Tools supporting Workflow Implementation form the backbone of the new Information System to be installed in the business under consideration. Taking as input a Workflow Model(s) created by the Workflow Analysis and Design tools, they implement and support the new way of working. Such tools usually comprise databases, LANs, document handling systems, and imaging systems, that duly and faithfully realizing the Workflow Models previously developed by the Business Setting with the modeling tools.

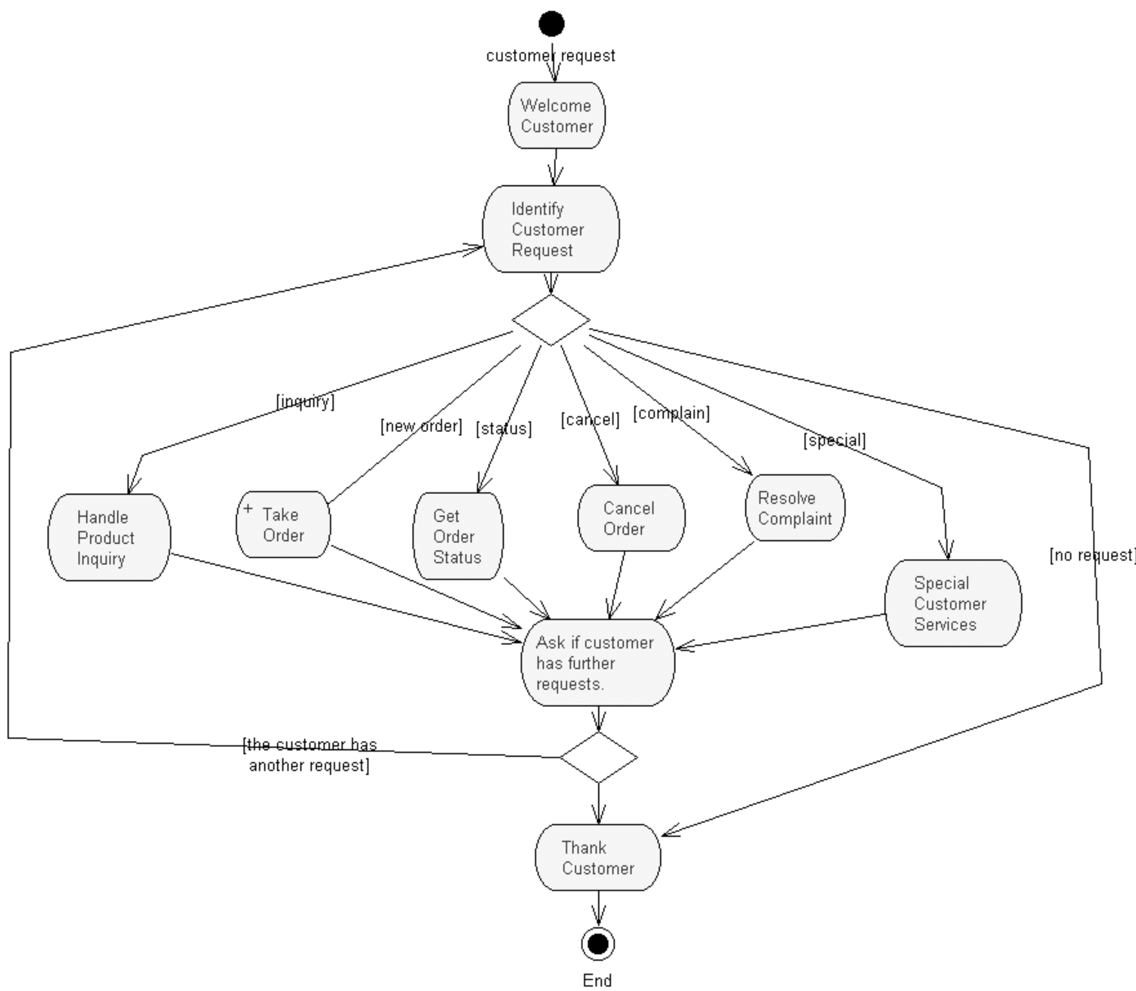
Reflecting this categorization, industry tool developers usually offer product families—that is, suites encompassing a series of tools able to cooperate unobtrusively and seamlessly, one tool providing the input for the next, thus providing solutions for the whole BPR process. To demonstrate the levels of abstraction the following text includes four graphics rendered from the Runners Inc. business model included with the demonstration version of Ensemble's Stream® -- a suite of BPR tools.

The following graphic rendered from Ensemble's Stream® is an example of the types of

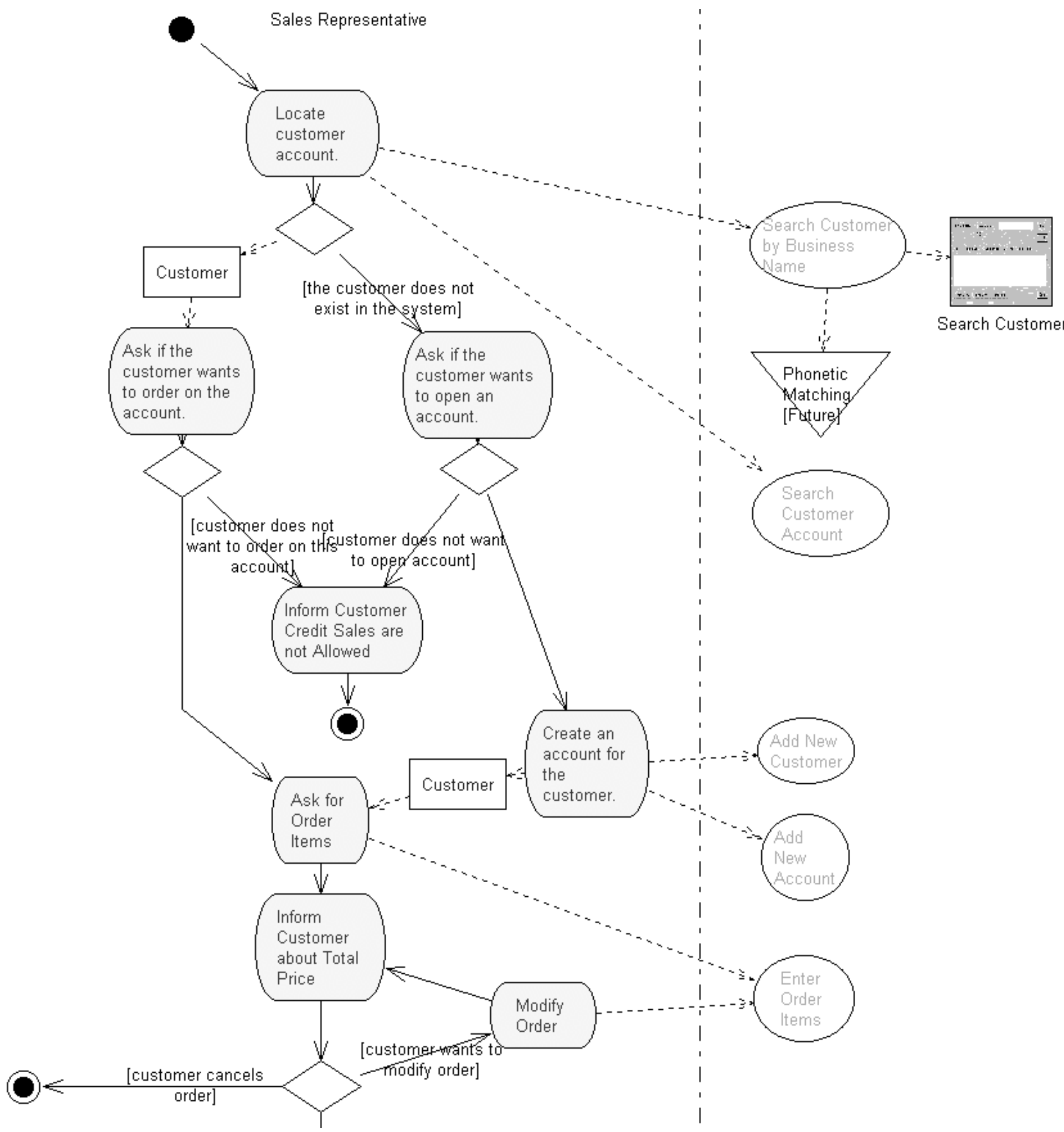


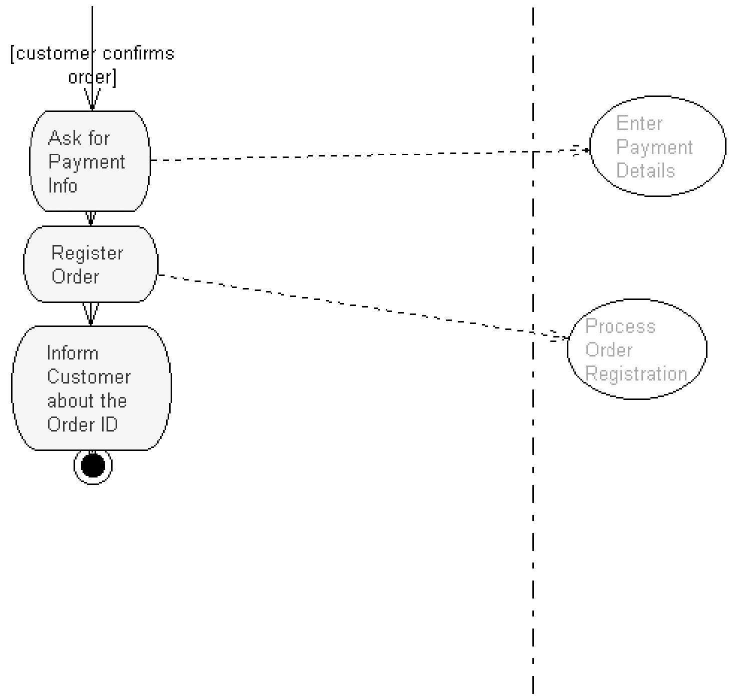
objects and level of detail that might be seen in a Business Processes Model. The labeled nodes represent BPs.

The following graphic rendered from Ensemble's Stream® is an example of how the Handle Customer Request, BP might be decomposed into a Workflow.

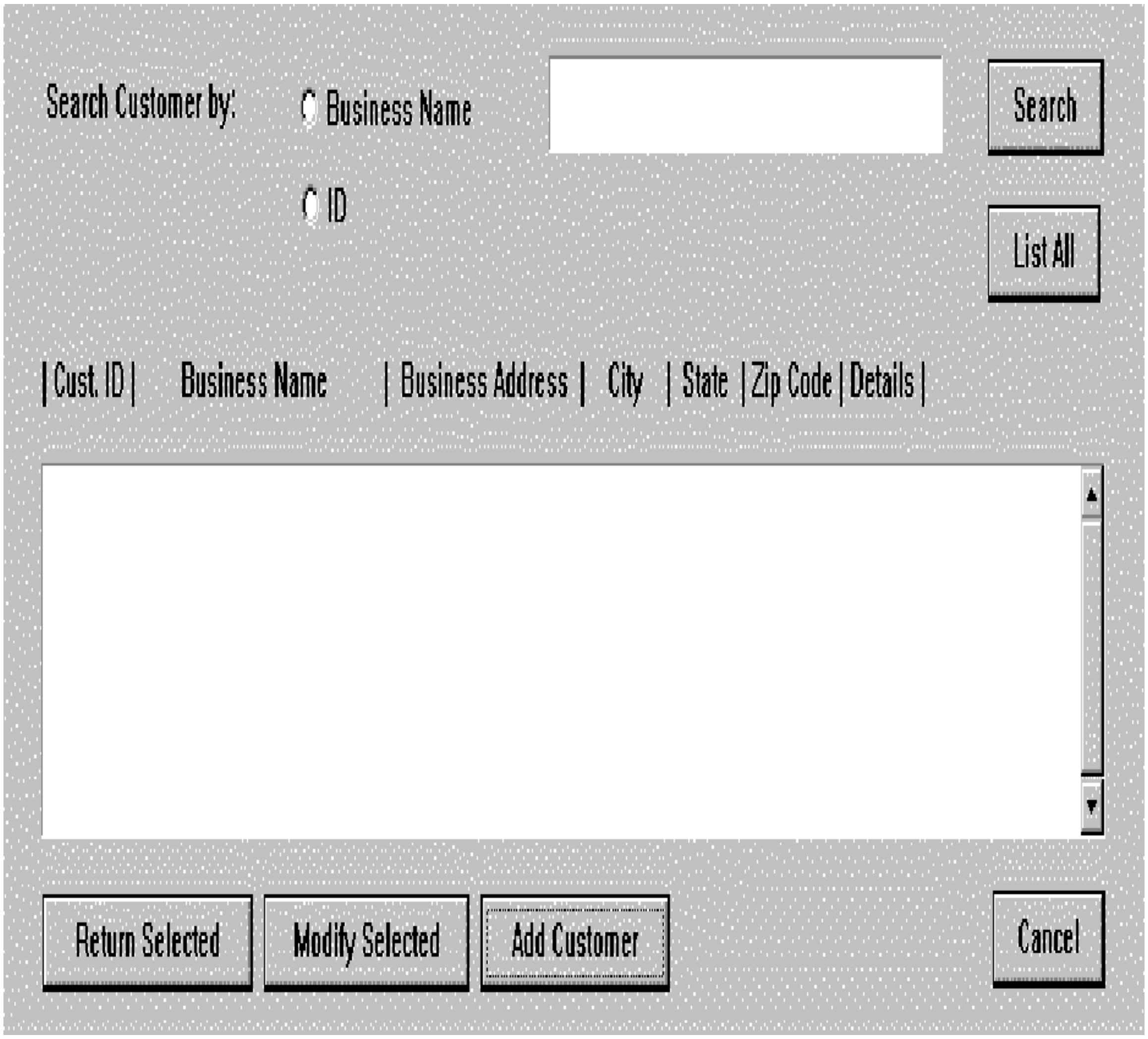


The following graphic rendered from Ensemble's Stream® demonstrates how the Take Order process represented in the previous graphic might further be decomposed into a more detailed Workflow.





The Workflow Implementation tools used to realize the Workflow Model might be a client/server application – that is, a system that manages the data on a central server and is controlled by users of library of window-based interfaces. For example the Search Customer resource in the preceding graphic might be designed using a visual programming language to present the user with an interface that might resemble something like the following graphic rendered from Ensemble's Stream®.



Following the categorization laid out in the previous paragraphs, three groups of requirements are identified; to these, an additional group of general requirements was attached containing more general miscellaneous issues factored out from the other groups and applicable to all. Specifically, the proposed model is composed along four distinct axes of evaluation:

- Tool Requirements for Analysis and Design of BPs

- Tool Requirements for Analysis and Design of Workflows
- Tool Requirements for Workflow Implementation
- General Tool Requirements

In the following chapters, the requirements along each of the above axes will be examined in turn defining a model for the next generation of business automation environments.

CHAPTER 3

TOOL REQUIREMENTS FOR BPS ANALYSIS AND DESIGN

With respect to the tool requirements for BPs analysis and design, three broad areas of concern are identified: user interface issues, modeling considerations, analysis and validation issues, and technical considerations. The user interface is concerned with providing a highly interactive and preferably graphical user interface (GUI). The modeling considerations focus on the modeling philosophy, conceptual mechanisms and organizational structure. The analysis and validation issues focus on providing formal static and dynamic validation and providing what-if and if-what analysis scenarios. Finally, the technical considerations focus on the complete (both vertical and horizontal) compatibility and the implementation of an object oriented toolset and repository.

User Interface

In the current state of the art in software development most tools utilize a GUI. Two-dimensional GUI presentations dominate the industry, however recent progress in Virtual Reality development tools has given rise to a more realistic 3D GUI (see Schönhage, Ballegooij and Elliëns, 2000, for a case study). All BP modeling tools make use of the graphical user interface. Trying to avoid product-specific details, we can identify two aspects of particular importance in two-dimensional graphical BP modeling tools, i.e., GUI definition and GUI navigation.

The presence of a GUI does not imply that all aspects of BP analysis and design can be carried out graphically. It is usually the case that a broad solution can be designed encompassing a graphical representation of process steps and resources, while the details must be filled in using some type of high-level programming language.

Process models have the propensity to grow to unmanageable sizes. Complex models are difficult to be comprehended and handled on screen. Support for efficient navigation of the process models produced by a tool is a definite advantage. Such GUI navigation support can take the form of hypertext links among different parts of a model or among different models, zoom-in/zoom-out facilities, fold/unfold whereby parts of a model are collapsed or uncovered at will, etc. However, the GUI support must be in accord with the conceptual modeling mechanisms provided by the tool, discussed below.

Modeling Considerations

The GUI can provide a very attractive and user-friendly interface for a Business Process Analysis and Design tool. However, there are specific modeling considerations that can impact the usefulness of the tool. We identify the following eight modeling considerations, which can make or break the usefulness of a BP modeling tool:

- Modeling philosophy
- Conceptual mechanisms
- Organizational structure
- Resource modeling
- Model annotation
- Representation of control, data and materials
- Flow type
- Flexible and explicit time modeling

The modeling philosophy refers to the paradigm or alphabet of patterns and methods used to communicate the BP ideas. The modeling philosophy is often advertised as the major feature of a product. It is certainly the case that BP modeling philosophy is an ongoing area of research and no definite results have been achieved. For example, Petri Nets (see Murata, 1989) or some form of data flow diagrams (see DeMarco, 1979), enriched with control information, are popular approaches. Given the lack of definitive research, the choice among different modeling philosophies cannot rest on any hard data. Personal factors, idiosyncrasies, enterprise culture, and other soft criteria are likely to play decisive roles. However, we have observed some degree of consensus aiming towards the use of object orientation and increased awareness of the human factors involved (whereby a process is not merely a collection of steps and resources, but an interlocking web of human agents) in the system being modeled.

Conceptual modeling tools are used to communicate concepts grounded in reality. BP modeling results in the construction of models, which attempt to represent aspects of reality. Therefore BP modeling is a type of conceptual modeling. Hence, requirements on conceptual modeling tools apply to BP modeling tools as well, the most prevalent of which are: 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 typically refers to the subsets of information that describe the business setting. The modeling of human resources in a process as simple agents may not be enough for conveying or embodying all relevant or essential information – that is, agents are suited more for delivering information (push technology). A more rigorous modeling of the organizational structure is needed, encompassing for example such entities as departments, actors, and roles that are assigned to carry out specific workflows, i.e. a push and pull technology. The resulting organization models must be suitable for integration with the BP models *per se*. For example, actor participation in specific activities, and actor permissions on specific resources (security specifications) are frequently needed.

Resources can be modeled simply as input and/or outputs of process steps. A more economical and comprehensive approach is to create a model of the resources in use, for example creating document type ontology, placing documents in a hierarchy, etc. Resource typing would inspire users to think more in terms of the actual BP or Workflow being modeled and a hierarchy would introduce a more defined and workable order to these resources.

Annotation can be thought of as an informal meta-model. No modeling formalism can capture all relevant details and pertinent facts. Models often need to be annotated with extra-model information such as designer comments and rationale, analysis and validation statements.

Processes use resources that can be explained in more meaningful detail than just data. Most BP modeling tools focus on the representation of data flow among process steps. Equally important is the representation of materials and control flow, which are however often found wanting.

Flow types refer to the idea of the models ability to capture the movement of resources amongst BPs. Most existing BP modeling tools are built around a 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. Rule-based formalisms can assist the tool user in selecting appropriate modeling components based on the user's requirements and data patterns. Also a rule-based tool can assist in analyzing and validating the models in a systematic fashion.

Flexible and explicit time modeling refers to the notation of the models ability to capture time in a sense familiar and meaningful to the users. Despite long and intense efforts, time has proved especially difficult to model; the repeated attempts of the database community bear witness to this. BP modeling tools are not an exception. However, a fitting representation of time, along with timing-constraints and precedence is invariably needed in BP modeling.

Analysis and Validation

Formal, static analysis and validation refer to the study of the derived BP models using specific algorithms and analysis approaches (not simulation). Such analysis and validation should be able to derive results on process metrics, identify constraints, and evaluate resource cost, etc. This entails some kind of mathematical formalism along which the relevant models are structured. Identifying deadlock in a business model can be a complex task. However, Maruta, Onoda, Ikkai, Kobayashi and Komoda (1998) propose a deadlock detection algorithm for business processes workflow models. Subsequently, Onoda, Ikkai, Kobayashi and Komoda (1999) reduce the complexity further by defining five patterns that generate deadlock in business and workflow models. Absence of such a foundation does not render static analysis and validation infeasible. However, tools that are not based on mathematical formalism are more difficult to use and depend more on *ad hoc* approaches.

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. Such simulation should be carried out in real time: producing simultaneous graphical output; identifying deadlock, bottlenecks and constraints; performing automatic resource allocation; etc.

What-if analysis, which is familiar from other types of systems for supporting businesses, is an essential part of prospective design. What-if scenarios can be characterized by hypothetical situations. Different tools are likely to vary greatly in their support for effective what-if analysis, apart from the ubiquitous simulation facilities.

If-what analysis is less familiar than the previous requirement, it refers to backward reasoning from desired outcomes to proposed alternatives for their attainment. Existing tools are especially lacking in this aspect.

Technical Considerations

The technical considerations focus on the complete (both vertical and horizontal) compatibility and the implementation of an object oriented toolset and repository.

Vertical interoperability is a notion of interoperability with workflow and design tools. As discussed in Chapter 2, BP modeling and Workflow modeling are different areas of concern, usually catered by separate tools. It is often the case that output from the one level of analysis should be input to the next (when BP models should be further refined in specific workflows). Product suites offered by the same developer usually offer this type of interoperability.

Horizontal interoperability is a notion of interoperability with other BP modeling tools; this refers to the ability of the product to handle (import/export) models created by other BP modeling tools.

We refer to objects as the units of things used in designing a model. Object orientation is useful in BP modeling 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 as objects, thus reducing redundancy and enhancing re-use of model components.

All BP 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 by providing inheritance, methods, and user-definable data types.

C H A P T E R 4

TOOL REQUIREMENTS FOR ANALYSIS AND DESIGN OF WORKFLOWS

As analyzed in Chapter 3, workflow modeling is a distinct activity from BP modeling, and therefore demands different tools. Still, the process of developing a workflow model is similar to BP modeling. Specifically, in both cases conceptual models of work structures are designed, analyzed, and reasoned upon. Since, therefore, comparable procedures are followed with different aims and outputs, workflow modeling places similar demands on its tools. This permits us to abbreviate the discussion of requirements since most of them have already been expanded in Chapter 3. The application of these requirements in the new context is mostly clear. As a result, we shall discuss in detail only the instances where notable differences or points of particular interest arise.

User Interface

The user interface is concerned with providing a highly interactive and preferably graphical, user interface. As in Chapter 3, the provision of a GUI does not imply that all aspects of workflow analysis and design can be carried out graphically. It is usually the case that a broad solution can be designed using a graphical representation of process steps and resources, while the details must be filled in using some kind of high level programming language. GUI Navigation, as in Chapter 3, may entail hypertext links, zoom-in/out, fold/unfold and other facilities, in accordance with the conceptual modeling mechanisms, discussed below.

Modeling Considerations

As with a Business Process Analysis and Design tool, there are specific modeling considerations that can impact the usefulness of a Workflow Analysis and Design tool. We identify the same eight modeling considerations as in Chapter 3 with the addition of one item (Ad Hoc Workflow). The following considerations can make or break the usefulness of a Workflow Analysis and Design tool:

- Modeling philosophy
- Ad Hoc Workflows
- Conceptual mechanisms
- Organizational structure
- Resource modeling
- Model annotation

- Representation of control, data and materials
- Flow type
- Flexible and explicit time modeling

Two different philosophies can be discerned in the field. One is workflow oriented, where the main concept employed is the flow of work. The other is document management oriented, where the main concept employed is the flow of documents, or generally input, output and products. This distinction can be somewhat subtle; a useful analogy is the distinction between data and function-oriented models in information systems modeling.

Not observed with Business Process Analysis and Design tools is the need for Workflow Analysis and Design tools to support both *ad hoc* and production workflow. Production workflows are workflows of stable and relatively structured work processes, where the basic layout and sequence of steps can be laid out in advance. *Ad hoc* workflows are workflows (of usually informal work processes), where a group of people assembles and co-operates to address an emerged need without following predefined work rules or practices. Neither the basic layout, nor the sequence of steps can be laid out in advance. IT enthusiasts sometimes refer to this as *firefighting*. Fabio, Casati, Ceri, Paraboschi and Guiseppe Pozzi (1999) discuss design criteria for *ad hoc* workflows. Also, Eder, and Liebhart (1996) investigate recovery from *ad hoc* workflow.

The conceptual mechanisms should include abstraction and structuring mechanisms, as discussed for Business Process Analysis and Design tool concepts in Chapter 3.

The Workflow Analysis and Design tools should support a means for modeling organizational structure – that is, departments, actors, roles, etc., as discussed in Chapter 3.

In terms of document types, document hierarchy, etc., resource modeling should be supported by the Workflow Analysis and Design tool as discussed for the Business Process Analysis and Design tool in Chapter 3.

Model annotation or extra-model information, designer comments, analysis and validation comments, etc. should be easily incorporated in workflow models as discussed for the Business Process Analysis and Design Tool Chapter 3.

Even more importantly than was the case for Business Process Analysis and Design modeling, mechanisms for representing material flow, and not only control and data flow in Workflow Analysis and Design, should be supplied.

Similar to Business Process Analysis and Design tools, Workflow Analysis and Design tools are predominately based around a sequential flow type. But, increasingly more rule-based, and concurrent formalisms are being adopted for Workflow Analysis and Design tools as discussed for Business Process Analysis and Design tools in Chapter 3.

Time modeling is more complicated and important at the Workflow Analysis and Design than at the Business Process Analysis and Design level. The complexity is inherent in the lower level of detail where workflow resides. The Business Setting is usually concerned about more precise timing constraints at this level. The problems incorporating flexible and explicit time modeling mechanisms in a Workflow Analysis and Implementation tool are just as difficult as the ones discussed for a Business Process Analysis and Design tool in Chapter 3.

Analysis and Validation

As is the case with Business Process Analysis and Design tools, Workflow, Workflow Analysis and Design tools should support: Static Analysis and Validation; Dynamic Analysis and Validation; What-if Analysis; If-what Analysis.

Static Analysis and Validation needs to be supported, so that process metrics can be established, constraints identified, resource cost evaluated, etc., as in Chapter 3.

Dynamic Analysis and Validation needs to be supported, so as to permit running live simulations and producing real-time graphical output, identification of bottlenecks and constraints, automatic resource allocation, etc., as in Chapter 3.

What-if analysis should be supported for the same reasons as in Chapter 3.

An if-what analysis facility would permit a Workflow Analysis and Design tool to identify factors pertaining to specific situations and propose alternatives for particular goals, etc., as in Chapter 3.

Technical Considerations

As in Chapter 3 with our discussion of Business Process and Design tools we identify four technical considerations for Workflow Analysis and Design tools. These technical considerations are Vertical Interoperability, Horizontal Interoperability, and Object Oriented Toolset and Repository.

Vertical Interoperability allows the integration of layers of development abstraction, the workflow analysis and design tool should communicate with higher and lower levels of abstraction, i.e. BP modeling and workflow implementation tools, respectively. Workflow Analysis and Design tools should be capable of reading Business Process Models and writing Workflow Implementation language. This interoperability is typical with product suites as discussed for Business Analysis and Design tools in Chapter 3.

Horizontal Interoperability with other workflow analysis and design tools provides a means for transferring knowledge at the same level of abstraction.

An object-oriented toolset is more difficult to define for Workflow Analysis and Design tools than for Business Process Analysis and Design tools. The level of detail where workflow resides has many more classes of objects to consider. It is just as useful to provide such a toolset for the same reasons discussed for Business Process Analysis and Design tools, in Chapter 3. Such a toolset should at least provide for object-oriented workflow modeling, object-oriented resource modeling, and object-oriented organization modeling.

All Workflow modeling tools offer some kind of repository as discussed with BP modeling tools in Chapter 3.

CHAPTER 5

WORKFLOW IMPLEMENTATION

Workflow implementation tools must be able to support the processes and workflows defined with the help of the tools examined in the previous two sections. In effect, they must be capable of sustaining and enhancing collaborative group processes, both structured and *ad hoc*, while offering the management sufficient control and command to ensure alignment with enterprise objectives. In this context, four areas of concern are identified:

- User interface
- Human resource management
- Information flow management
- Technical aspects

User Interface

Workflow Implementation tools deserve even more flexibility than we mentioned for BP and Workflow modeling tools in regard to the user interface. Besides supporting GUI

Definition and GUI Navigation – see Chapter 3 for details – the workflow Implementation tool should be customizable by the end user.

The users of workflow implementation tools must be able to customize their work procedures to their particular needs and preferences; this, however, must not compromise general design and Business Setting goals. This consideration is often crucial when personal processes are dubiously or not completely captured.

Human Resource Management

There are specific human resource management considerations that can impact the usefulness of the Workflow Implementation tool. We identify the following six human resource considerations, which can make or break the usefulness of a Workflow Implementation tool: Work-in-Process Tracking; Automatic Resource Allocation; Manual Resource Allocation; Ad hoc and Production Workflow Support; Security; Statistics.

All objects of a workflow must be monitored by the system, so that the process status is visible to management whenever required. This is called Work-in-Progress Tracking.

Automatic resource allocation refers to an intelligent (that is, intelligent within reasonable limits) balancing of work among different employees, depending on particular persons' or groups' workload and responsibilities. This may, for example, involve the following:

- *Task monitoring and "pushing" tasks to employees.* Tasks may be assigned automatically to employees for handling, based on the states of the employees and the tasks.

- *Identification of inactive human resources.* Identification of unproductive work agents can be realized by using appropriate statistical measures.

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, that is, manual resource allocation. Such intervention may take the following forms:

- *"Pull applications".* Such applications permit employees to choose their next piece of work from a pool of tasks to be completed.

- *Negotiation of work among people in the organization.* This covers the exchange of allocated work chunks, the splitting and/or sharing of work among related agents, etc.

- *Assignment of specific tasks to specific employees.* Usually carried out by the management, this is akin to "command-driven" practices in non-automated work settings.

Ad hoc and Production Workflow needs to be supported. Both kinds of workflow described in Chapter 4 can be met in the same business setting, so Workflow Implementation tools must support both.

Security issues must be addressed. Permissions must be potentially granted for initiating workflow processes, viewing status reports, re-routing a document, end-user customization, etc. Bertino, Ferrari, and Atluri (1999) extend beyond the *de facto* role-based access model and address the separation of duties by: (1) presenting a language that expresses both static and dynamic authorization constraints as clauses in a logic program; (2) providing formal notions of constraint consistency; (3) proposing algorithms to check the consistency of constraints and assign users and roles to tasks that constitute the workflow in such a way that no constraints are violated.

As already hinted above, comprehensive statistical measures and status reports are indispensable for giving a clear and succinct picture of the workflow execution. Such statistics may provide the incentive for a new work redesign, if significant shortcomings are detected.

Information Flow Management

Information flow management is the idea that Workflow Implementation tools should be capable of handling certain types of common data control methods. Specifically, we identify the following four considerations: Information Routing, Parallel Processing, Document Rendezvous, and Deadlines. We distinguish between two types of Information Routing: Static Routing and Dynamic Routing.

Static routing involves information transfer from one person to the next according to a predefined schedule. Static routing cannot be altered at will during operation: sequential routing is a typical example of a static routing scheme.

Dynamic routing attempts to bring feedback and responsiveness to information flow. Techniques (among which rule-based routing related to specific events is the most well-known) are used to describe not a mere sequential list of actions, but pairings of situations with the appropriate system responses. Lack of consensus in the description of dynamic systems has resulted in an assortment of different proposals, many of them differing in small ways.

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 with parallel processing, as well as handling of multi-user access problems, also encountered with databases.

Document rendezvous refers to the automatic matching of new incoming documents with existing documents that pertain to them, already in the workflow; the resulting set of documents is then clipped together before being routed to the next action step.

Deadlines 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).

Technical Considerations

Except for the addition of one new consideration we identify the same technical considerations for the Workflow Implementation as we did for Business Process and Workflow modeling. These technical considerations are Integration, Vertical Interoperability, Horizontal Interoperability, and API Support. The new consideration is API support.

Workflow implementation tools must operate transparently and unobtrusively with other productivity tools, so that corporate investment is not squandered and so that flexibility and choice are enhanced for future tool integration. Specifically, integration may refer to integration with different clients, integration with different networks, ability to use standard DBMSs, and integration with communication tools.

Integration with different clients refers to the ability of a workflow server to support different clients, not necessarily from the same vendor. The Workflow Management Coalition (see the Glossary, WfMC, 1994) has projects underway that attempt to address compatibility problems. The Coalition's mission is to promote and develop the use of workflow through the establishment of standards for software terminology, interoperability and connectivity between workflow tools.

Support for integration using different networks is needed. Companies who sell networking software also offer many workflow products. Therefore it is not surprising that such products favor specific networks as the underlying structure. This imposes limits on the prospective workflow users. All other things being equal, open solutions are preferable.

The ability to use standard DBMSs is needed. As with networks, companies that produce workflow tools often promote products that are compatible with their own DBMS. Compatibility with other vendors' DBMS is usually only offered in the case of strategic alignment between companies.

Integration with communication tools is essential. Communication, such as via e-mail, is an indispensable component of corporate-wide networking. Smooth integration between workflow and communication tools should be demanded. In cases where companies sell workflow products to be embedded in a larger communication system, they are well integrated with the communication tools, since the flow of work is viewed as a special kind of communication to coordinate among agents.

Vertical Interoperability is concerned with the capability of a Workflow Implementation tool to read workflow models and generate at least partially working applications. This consideration is necessary as explained in Chapter 3 and Chapter 4 for the modeling tools.

Horizontal Interoperability is not as common with Workflow Implementation tools as with BP and workflow modeling tools and involves the same, proprietary, issues as those found with networking. Companies are reluctant to develop this type of compatibility because they want to lock their customers in. Though difficult to achieve, Horizontal Interoperability should be pursued, for the same reasons considered in Chapter 3 and Chapter 4.

Workflow API Support is concerned with supplying an interface to common workflow functions provided by workflow engines. Although graphical specifications of workflow are friendly to users and usually effective, one frequently needs a fine-tuned or more detailed specification than can be constructed graphically. Workflow vendors provide APIs to accommodate this need. Such APIs can be judged in terms of comprehensiveness, ease of use, libraries provided, workflow engines provided, etc.

C H A P T E R 6

GENERAL REQUIREMENTS

All three categories of tools presented in Chapter 3 through Chapter 5 share some requirements in common with most industrial-strength software products. Although familiar and widely accepted, such requirements are frequently overlooked, because of commercial hype, advertising, fashion, etc. Workflow tools represent a large investment with considerable impact in corporate structure and culture. This makes it essential to remember the following general requirements: Availability in Specific Platforms, Compliance with Industry Standards, Version Update and Customer Support, Case Studies, and Product Maturity.

Workflow tools are available for specific platforms. Each platform provides a different application program interface for different system services. Thus, a tool developed to run on one platform needs considerable development effort to port to another platform. Although these platform differences continue to exist and there will probably always be proprietary differences in API's, new open or standards-conforming interfaces now allow some programs to run on different platforms or to interoperate with different platforms through mediating or *broker* programs.

Compliance to industry standards of Workflow tools is of benefit to the Business Setting. By making standards we reduce variation and choice. We do this because it saves time and money. Thus, being compliant to a standard is a good thing. However, it is debatable whether standards arrived at through market dominance (or even monopoly) are also good things.

It is important that vendors of workflow tools provide updated versions and adequate customer support. It is inevitable that that workflow tools will suffer from defects, like any software application. There should be a straightforward method for reporting and fixing these defects. New versions of Workflow tools should be released periodically, including fixes for defects and modifications to reflect Business Setting changes. In addition there should be a source for customers to easily obtain additional support.

The true test of any workflow tool is applying it. Case studies can serve as application evaluations. Case studies usually include testimonial reports from unbiased sources about specific products applied to solve a particular problem. Case studies help protect investments and identify new considerations.

Product maturity is the notion that a workflow tool has stood the test of time. A mature workflow tool has been rigorously scrutinized by the industry, has been updated regularly, is compliant with industry standards, and is available for multiple platforms.

C H A P T E R 6

EXAMPLE

Awareness of the preceding model for analysis of requirements is extremely valuable to prospective users, developers and researchers. To demonstrate this we have set forth a simple example. In this example we show how the Tool Requirements for Business Process Analysis and Design can be used to evaluate and compare commercial business analysis and design products. The example is our own opinion and serves to illustrate a use of the model and is not intended to define any aspect of the preceding model.

In this example we assign a score ranging between zero and five – five being the best – for each of the required considerations for each of the three commercial products we evaluate. The three products we evaluate in our example are GDPro, Rational Rose and MetaEdit+. GDPro and Rational Rose are touted in the IT industry as leading business process analysis and design tools and support UML. MetaEdit+ is a more novel business process tool that uses a less common, but appealing, modeling strategy.

Our example uses a table consisting of the following four columns: Requirements, Considerations, GDPro, Rational Rose and MetaEdit+. The four Business Process Analysis and Design tool Requirements are listed adjacent to their respective

Considerations. The last three columns display the points each product scored for each Consideration for this example evaluation.

Requirements	Considerations	GDPro	Rational Rose	MetaEdit+
User Interface	GUI Definition	5	5	3
	GUI Navigation	5	3	1
Modeling Considerations	Modeling Philosophy	4	4	5
	Conceptual Mechanisms	3	3	5
	Organizational Structure	4	4	5
	Resource Modeling	4	4	5
	Model Annotation	4	4	5
	Representation of Control, Data and Materials	4	4	5
	Flow Type	4	4	5
	Flexible and Explicit Time Modeling	4	4	5
Analysis and Validation	Static Analysis and Validation	5	5	3
	Dynamic Analysis and Validation	5	5	0
Technical Considerations	Vertical Interoperability	2	2	5
	Horizontal Interoperability	2	2	4
	Object Oriented Toolset and Repository	5	0	5
General Requirements	Availability in Specific Platforms	3	5	4
	Case Studies	4	4	4
	Product Maturity.	5	5	1
	Compliance with Industry Standards	5	5	5
	Version Update and Customer Support	5	3	5

The rationale for the ratings for each consideration is explained below:

GUI Definition: All three products provide a window-based graphical user interface to address the high-level presentation. GDPro and Rational Rose both provide an intuitive, graphical user interface that presents typical objects, pictures and language found in contemporary desktop productivity products, and so they earned 5's in for this Consideration. MetaEdit+ consistently came up flawed by showing overlapped text and primitive artwork and so it earned it a 3 for this Consideration.

GUI Navigation: All three products provided a zoom-in/zoom-out facility for diagramming. GDPro has a very sophisticated GUI Navigation feature, letting the user set up link-navigation. Link-navigation lets the user jump from diagram to diagram in whatever way the user finds appropriate. This navigational feature earned GDPro a 5 for this Consideration. Rational Rose has a more limited navigation feature that lets a user drill down into a package which earned it a 3 for this Consideration. MetaEdit+ provides a poor navigation feature that is driven by control flow, which earned MetaEdit+ a 1 for this Consideration.

Modeling Philosophy: GDPro and Rational Rose provide an object-oriented approach to modeling business processes, which earned them each a 4 for this Consideration. MetaEdit+ not only provides an object-oriented approach, but also provides a utility that allows the user to implement Incremental Method Engineering, a method where the user has the ability to change the philosophy according to the problem at hand. This additional capability earned MetaEdit+ a 5 for this Consideration.

Conceptual Mechanisms: GDPro and Rational Rose both depend on pre-defined modeling languages – such as BOOCH, OMT and UML – to express business process concepts. Though these languages support high-level object-oriented expressions, simple solutions can come across as cumbersome for specific problem domains. GDPro and Rational provide about the same level of conceptual modeling mechanisms, which earned them each a 4 for this Consideration. MetaEdit+ allows the user to define conceptual mechanism besides providing twelve different common business-modeling languages, which earned MetaEdit+ a 5 for this Consideration.

Organizational Structure: GDPro and Rational Rose both earn a 4 for utilizing UML to capture organizational structure. MetaEdit+ provides extensive organizational support, in addition to predefined relationships such as communication and responsibility. It also provides a user-definable relationship builder, which earned MetaEdit+ a 5 for this Consideration.

Resource Modeling: GDPro and Rational Rose both earn a 4 for utilizing UML to capture resource elements. MetaEdit+ provides user-definable and predefined resources for tasks, people and organizations, which earned MetaEdit a 5 for this Consideration.

Model Annotation: GDPro and Rational Rose both earn a 4 for utilizing UML to capture model annotation. MetaEdit+ provides default annotation elements in addition to user definable model annotation elements, which earned MetaEdit+ a 5 for this Consideration.

Representation of Control, Data and Materials: GDPro and Rational Rose both earn a 4 for utilizing UML to capture control, data and materials. MetaEdit+ earns a 5 for this Consideration for giving the user the option to define their own representation of control, data and materials.

Flow Type: GDPro and Rational Rose both earn a 4 for utilizing UML to capture flow types. MetaEdit+ earned a 5 for this Consideration for it gives users the capability of constructing their own flow types.

Flexible and Explicit Time Modeling: GDPro and Rational Rose both earn a 4 for utilizing UML to capture timing elements. In addition to this MetaEdit+ provides the user with the ability to define timing elements, e.g., duration and wait-states, which earned it a 5 for this Consideration.

Static Analysis and Validation: GDPro and Rational Rose provide limited validation utilities. However, they both provide robust scripting capabilities to address this Consideration. Scripts can be written to carry out any analysis or validation algorithms. This scripting capability earned both GDPro and Rational Rose a 5 for this Consideration. MetaEdit+ has it's own model reporting and analysis language that can be used to complete limited validation and analysis tasks, which earned MetaEdit+ a 3 for this Consideration.

Dynamic Analysis and Validation: GDPro's and Rational Rose's scripting capability allow the user to perform dynamic validation, which earned them each a 5 for this Consideration.

MetaEdit+ does not provide any mechanisms to perform dynamic analysis or validation, which earned it a 0 for this Consideration.

Vertical Interoperability: GDPro and Rational Rose address vertical portability only within their own product, which earned them 2s for this Consideration. MetaEdit+ handles vertical Interoperability within itself and also gives the user the ability to define their own API for other products, which earned it a 5 for this Consideration.

Horizontal Interoperability: GDPro and Rational Rose export into obscure formats, but have plans to follow XML, which earned them each a 2 for this Consideration. MetaEdit+ also provides some obscure export formats, but gives the user the ability to define their own, which earned MetaEdit+ a 4 for this Consideration.

Object Oriented Toolset and Repository: GDPro and MetaEdit+ store all model information in an object-oriented repository, which earned them each a 5 for this Consideration. Rational Rose is a file-based tool, storing all model information in text files making collaboration work difficult, which earned it a 0 for this Consideration.

Availability in Specific Platforms: GDPro is available for Windows 95, 98, 2000, NT and Solaris, which earned it a 3 for this Consideration. MetaEdit+ is available for Windows 95, 98, NT, 2000, Linux, HP-UX, and Solaris, which earned it a 4 for this Consideration. Rational Rose is available for Windows 95, 98, NT, Solaris, HP-UX, AIX, IRIX, and DEC UNIX, which earned it a 5 for this Consideration.

Case Studies: Rational Rose and GDPro are cited in several successful case studies published by their manufacturer, which earned them a 4 for this Consideration. MetaEdit+ received two favorable reviews from two third parties who used MetaEdit+ to solve their business reengineering problems, which earned MetaEdit+ a 4 for this Consideration.

Product Maturity: GDPro and Rational Rose have been around for about five years and have been released in a new version about every year, which earned them each a 5 for this Consideration. MetaEdit is very new and has limited versions released, which earned it a 1 for this Consideration.

Compliance with Industry Standards: GDPro, Rational Rose and MetaEdit+ support the industry standard UML and popular programming and scripting languages, which earned them each a 5 for this Consideration.

Version Update and Customer Support: The manufacturers of MetaEdit+ and GDPro provided excellent pre-sales support and demonstration copies, which earned them a 5 for this Consideration. The manufacturers of Rational Rose where somewhat lacking in pre-sales support, but offered a demonstration copy, which earned it a 3 for this Consideration.

Remember, the example is our own opinion. It serves to illustrate a use of the model and to show that the model can be used pragmatically. There is certainly room for debate over the appropriate method for applying the model to evaluate tools. Following a use of the model in such a way as in the example there might be a corporate review with open discussion and debate. For example, ideas for further work could argue that the meaning of the scoring points should be made more explicit and that maybe a checklist of features should be used to compute a score, or that subjective judging might be more meaningful if done via consensus of several evaluators. Detailing such work is beyond the scope of this paper.

CHAPTER 7

CONCLUSION

A thorough examination of the subject area reveals that BP modeling and workflow products are still in their infancy. They have generated high levels of expectation along with comparable levels of disappointment, since most of them fall short of the customers' wishes. Yet, the accelerating pace of change and the increased volatility of the business world require progressively better and more efficient responses. This ensures that automated support for business change will increase in importance.

In the present work we have defined several categories of tools, with associated requirements, which constitute a model for the next generation of tools to assist business change. The modular approach enhances the conceptual usability of our model, even if some of the requirements defined are subject to debate.

As we admit in Chapter 1 we have not have aimed to achieve a perfect or complete set of requirements. The value of what we have achieved can best be judged in terms of pragmatics. That is, how useful it is to the users, purchasers, and researchers in the area. Since it is the outcome of our own active involvement in the field, we believe this model will be of help to others.

A P P E N D I X

GLOSSARY

Activity	A description of a piece of work that forms one logical step within a process. An activity may be a manual activity, which does not support computer automation, or a workflow (automated) activity. A workflow activity requires human and/or machine resources(s) to support process execution; where human resource is required an activity is allocated to a workflow actor.
Actor	A resource that performs the work represented by a workflow activity. This work is normally manifested as one or more work items assigned to the Actor via a list.
Business Process	A set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships.
Business Process Re-engineering (BPR)	The process of (re-) assessment, analysis, modeling, definition and subsequent operational implementation of the core business processes of an organization, or other business entity.
Information Technology	IT (Information Technology) is a term that encompasses all forms of technology used to create, store, exchange, and use information in its various forms (business data, voice conversations, still images, motion pictures, multimedia presentations, and other forms, including those not yet

conceived). It is a convenient term for including both telephony and computer technology in the same word. It is the technology that is driving what has often been called "the information revolution."

Workflow
The automation of a business process, in whole or part, during which documents, information, or tasks are passed from one participant to another for action, according to a set of procedural rules.

Interoperability
The ability of a system or a product to work with other systems or products without special effort on the part of the user.

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BIOGRAPHICAL SKETCH

Michael Ranney was born in Willimantic, CT on January 4th, 1972. In 1994 he received a Bachelor of Science from Eastern Connecticut State University where he double majored in Computer Science and Mathematics. Mr. Ranney has conducted research in advanced computer science topics such as Parallel Processing, Real-Time Systems, and Temporal Databases. He has also worked professionally in the Information Technology industry for several years as a software engineering consultant where much of his work focused on business process re-engineering.