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Modeling, Simulation and Analysis of Business Processes in a Utility

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Introduction

Water and wastewater utilities (WWU) own and maintain an expensive and often complex infrastructure - especially in larger urban areas. The expenditures for water and wastewater treatment around the world exceed billions of dollars each year. In the US this amounts to about 4 percent of total state and local direct expenditures. It is in everyone's interest to ensure that these funds are used appropriately.

Powerful free market forces ultimately regulate the operation of private, for-profit enterprises, however, such performance "tuning" mechanisms do not apply to public agencies. Public agencies are subjected to imperfect market drivers, including environmental, political and fiscal pressures. They are not driven by pure market forces since in most cases utilities have a monopoly on their services. As a result, many WWU's have not felt the pressure to optimize their business systems to the same degree as private industry.

Recent changes in the industry are placing increasing emphasis on improving the efficiency of WWU's. Privatization and contract operations firms have successfully entered this market and demonstrated dramatic cost improvements in some cities. Public demand for better services at a lower cost, health and safety concerns and calls for tighter control of environmental pollution have raised awareness of the need for improvements in efficiency. Many WWU managers believe that change is needed and that there are significant opportunities for improvement, however, they lack the tools that would allow them to quantify changes, communicate the benefits of change and manage the process of change -in some cases massive change- that they are facing.

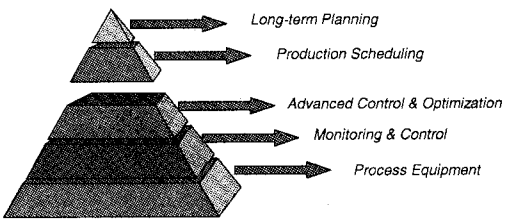

Figure 1. Hierarchy of information systems.

In the management science field, workers several years ago started to develop tools and related techniques for modeling business systems. Fueled by the need to invent better ways of doing business and the success of many 're-engineering' projects in industry, the field of business process modeling and business process analysis has grown

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substantially. Software applications designed to facilitate this work are now very mature. These applications enable rapid development of business process models, incorporate tools for performing analysis using the models and integrate readily with other software systems across the business enterprise. On-line, *operational management*, that is, achieving the integration of planning/scheduling and instrumentation/control levels of the automation pyramid shown in Figure 1, is the ultimate goal in the application of this type of software.

This paper introduces the reader to the field of modeling and simulation for business process analysis (BPA) and the software tools used for this purpose. This is a growing area in the water and wastewater field because of the intense pressure on utility managers to cut costs and increase efficiency. The trend is expected to continue around the world as developing nations look for the best ways to implement services and developed nations examine opportunities to improve service while updating an aging infrastructure. Moreover, successful business process analysis projects always involve, and provide justification for, information technology – including instrumentation, control and automation – that enable dramatic productivity gains. The substantial reductions in costs achieved in some of these studies, which often are measured in the millions of dollars, are a compelling reason to start with this kind of 'macro' level analysis before proceeding to development of the lower levels of automation shown in Figure 1.

Tasks in Utility Business Process Analysis

One of the foundations of business process re-engineering is the belief that traditional company (utility) organizations result in inefficiency from the standpoint of providing maximum value to customers. Inefficient organizations often are characterized by the existence of a number of departments that are motivated more by the need for self-preservation rather than the satisfaction of customers. Proponents of reengineering believe that it is business *processes*, which create value. These processes cut across the enterprise and are usually not the responsibility of any one department. Thus, business process analysis projects are concerned fundamentally with defining and optimizing processes such as "engaging the customer", "production" and "human resource management". Note that each of these processes (and many others) exists in a water or wastewater utility just as they do in a normal business.

Re-engineering consultants and specialists need to communicate important ideas about processes and focus their analysis on key business issues that improve these processes. Business process modeling and analysis software enables engineers to define utility processes in a structured way. This enables a more rigorous look at how the organization operates and can be improved. In particular, models enable investigation (comparison) of alternatives, development of benchmarks or metrics and even mathematical optimization. These tools are used for graphical *design, simulation* and *operational management* of business processes. Each of these tasks is an important component of a business re-engineering project.

Design

In this task, process teams work together to explore alternative business process designs with easy-to-use, hands-on modeling and simulation software tools. Using these tools, complex business process designs can be defined quickly and easily, typically using an electronic "canvas" metaphor. Graphical blocks are connected to describe the sequences and interdependencies among processing tasks. These blocks can be arranged in many combinations to describe processes at any level of detail. Modelers require flexibility in development of the design. BPA tools also provide access to lower-level programming languages, and inter-operability with other computing applications. Modelers can also build libraries of commonly used

business process objects and develop their own analysis methodologies.

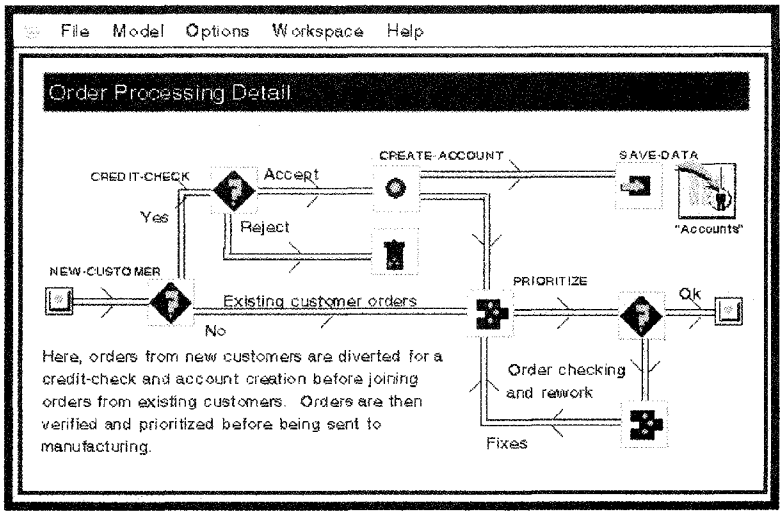

Figure 2. A simple order processing model.

An example of a simple business process model is shown in Figure 2. This figure shows an order-processing model. Notice how each block represents a single task that must be performed in the flow of work. You can see the parallels with a typical business process in a water utility such as the request for a permit or the opening of a new account.

Simulation

Simulation brings process designs to life. Some tools use computer animation techniques to make it easy to visualize complex business processes. BPA tools can automatically simulate and benchmark the performance of proposed business processes. "What if" analyses test re-engineering ideas before implementation. Questions like, "How will restructuring business processes impact my costs?" and "What percentage utilization can I expect to achieve with my manpower resources?" can be answered quickly and directly.

Simulation can also include optimization. Here optimization refers to the situation where one already has a model of a system and is interested in using the model to answer the question; What model inputs will result in a desired model output or behavior? In contrast to investigatory, or 'what-if', simulations, this kind of analysis suggests a need to 'run the model backward' to find out what inputs would be needed to obtain a desired output behavior. The desired behavior is obtained when important model indicator variables are maximized or minimized. For example, in a business process model we might ask; what combination of manpower, shift schedules and treatment efficiency results in the lowest plant operating cost? We might also want to constrain some of these variables (e.g., the treatment efficiency) to fall within a certain range.

Operational Management

Once a model is implemented and the actual business systems modified to improve costs, it is possible to bring the business process model on-line as a way to monitor and manage the actual processes. With some BPA tools, modelers create executive information systems, or workflow control applications. After re-engineered processes have

been implemented, clients can use the design model on-line to form the basis for valuable workflow management applications.

Process data can be simulated, but it can also be loaded from external files and databases, and received in the form of real-time data. The result is that live or historical process data drives the model. In this way, the model can be used on-line for process monitoring and executive information systems. The model can initiate actions by other applications and guide modules for supervisory control. Figure 3 shows an example of a work order model that could be placed on-line to manage this common utility business process. In this model, orders for work are received from an on-line request - from e-mail, database link or a request typed in by a secretary. The request results in automatic generation of an order and delivery of the order to each entity that must process the order. The order can be diverted along one or more paths based on characteristics of the order, such as the number of man-hours specified in the work request. Notifications can be received as e-mail or automatically processed by independent software modules. This is more than just an event-driven shuffling of documents among the affected individuals. The real-time engine has knowledge of and keeps track of each request and this has important consequences for intelligent management of this process. For example, lost or held-up requests can be acted upon to determine the reason for the delay in processing the request. Analysts may also want to experiment with changes to this model that would result in greater efficiency.

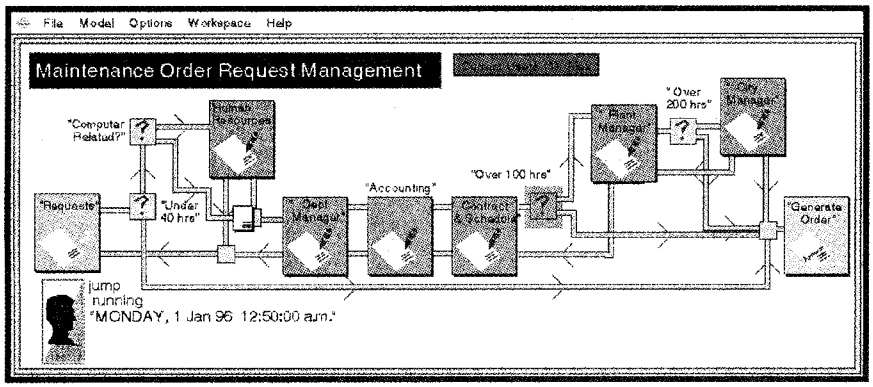

Figure 3. Models of utility business processes can be used on-line to manage daily operations.

Stages in Business Process Analysis

To see how BPA tools can be applied in a utility reengineering project, it is helpful to look at the stages that these projects go through and the value that business process modeling brings to each step. Projects typically go through five different stages as described below.

Justify Change (Why?)

In this step the modeler builds the business case for change. This usually involves looking at the current situation (As-Is) with an eye towards understanding the time, costs, and resources required for processes. Different approaches to solving the business problem can then be sketched. Looking at the differences through a lens defined by a model gives a clear picture of the opportunities (problems) and the magnitude of change required. A secondary use of the model is as a benchmark or base case to compare against other models.

Define Change (What?)

In this step the modeler proposes new ways of approaching the envisioned (Vision) processes. This is done in such as way as to quantify the savings in terms of time, cost, and resources. The main objective of the model at this stage is a conceptual design of the new process. It is helpful, although not always easy with available metrics, to be able to directly compare the As-is and Vision models. Usually designing the model to convert metrics of organizational costs and times into activity-based transactions does this.

Refine Change (How?)

Here the Vision process is adapted from the conceptual to an actual, high-level design (To-Be). Current factors such as legacy systems, budgets, etc. are introduced as limitations to the vision. Organizational and system interfaces are defined and agreed upon. The overall design is taken to enough detail to be confident of the project risk, financial returns, and performance of key process metrics. Blueprints of the process and systems are the significant deliverables at this stage. In addition, agreements or contracts between groups, both internal and external, are specified. If the difference between the As-Is and Vision is great enough, the transformation may require multiple phases. In this situation models help bring clarity to the extent and size of each phase.

Implement (Build!)

In the implementation stage, components of the new process are assembled, built, or transformed. The To-Be blueprints and contracts evolve from high-level design documents into systems, procedures, and available resources. Pilot implementations may occur before full deployment to test and resolve critical issues. The end results of this stage include documented processes, systems, interfaces, and trained resources. Modeling may play one of two distinct roles. In the first, the model is used as the central repository for design specifications and process details. In the second role, the model is a functional part of the process in either an active or passive role. In the active role, the model functions as the workflow controller. In a passive role, the model functions as a management tool to monitor current status and simulate future possible scenarios.

Operational (Run!)

As utility business demands and technology evolve, changes to the process will occur. Backlogs, processing rates, and seasonal fluctuations should be monitored to ensure proper process performance based on the established metrics. Resource utilization should be controlled to ensure lowest cost operation. Adherence to new requirements or regulations will force carefully considered trade-offs to avoid sub-optimal operation of the new business processes. Using the model as a management monitor, process metrics can be measured and stored easily. Having the ability to forward simulate the process in time allows "what-if" scenarios and optimizations permits examination of "if-what" analysese.

Table 1. Summary of Modeling's role in business process reengineerin

Stage	Major Value
Justify Change	Improvement opportunities Problem identification Benchmarks
Define Change	Conceptual design Process communication
Refine Change	Inter-group contracts Process blueprints High-level system specification Resource requirements
Implement	Documented processes Process behavior Change management
Operational	Maintain performance Automate process Monitor process

Types of models

During a BPA project there are several types of models created. Each is built to satisfy specific goals and audiences. Their information sources and

sequence follow a logical pattern.

As-Is

This is a model of a current process, usually developed using a bottom-up approach. These models are usually hard to build as the level of information used in their construction is quite detailed and may not match the desired output (i.e., organizational costs are known but production unit costs are desired). Also, the levels of abstraction needed to understand the process from a general point of view, as opposed to a specific department or plant, may not be well defined. It is also necessary to create and transform information that may be desired for the model but is not readily available in a direct form. For example, the unit cost of treatment per man-hour or on some other basis that is not commonly calculated.

Vision

The vision model of a proposed process, in contrast to the As-Is model, is normally developed using a top-down approach. Vision models begin simply and become more detailed in a gradual, iterative manner. They are used to communicate and bring out major process features and changes, including new systems, interfaces between groups and systems, and organizational responsibilities.

To-Be

The To-Be model is a model of a process that will be built and is constructed as an intersection between the As-Is and Vision models. Depending on the amount of change from As-is to Vision processes, it may be necessary to implement the revisions and systems in phases. One especially powerful approach is to start from the As-is model and document the changes needed to transform it into the Vision. The amount of effort required to change the model will be related to the amount of effort required to change the process and systems.

Operational

Operational models are actually a set of detailed models that contain full specifications of all aspects of the reengineered processes. The model may be transformed from a description of the process into a functional component of the process. If the process is suitable for automated workflow, the model can be enhanced to actively perform that function. The main issues in deciding how to use the model as an application are performance, system integration, and user interface. Also, the model may be used as a means of monitoring the process, that is, as an executive dashboard to gather, store, and analyze current process behavior. If the process is such that the model can control the process, then it can be used as an active system. An example of this is shown in Figure 3.

BPR stages and model types

Figure 4 shows the relationships between stages and model types. As-Is, followed soon thereafter by Vision models are developed first. These enable the modeler to get started quickly by defining the important issues. A second version of the Vision model follows the first as new, idealized business processes resolve the key business issues. This can result in a return to the As-Is model, because the current process is clarified a more thorough attention to the way processes are actually carried out. Alternatively, the modeler may choose to move directly to a first version of the To Be model that demonstrates how the new processes will work. The To Be model(s) may then evolve through several versions, ultimately resulting in development of the Operational models (if desired) that automate the workflow. Continuous improvement dictates that the entire cycle begin again with as new As-Is model as business needs or technology changes.

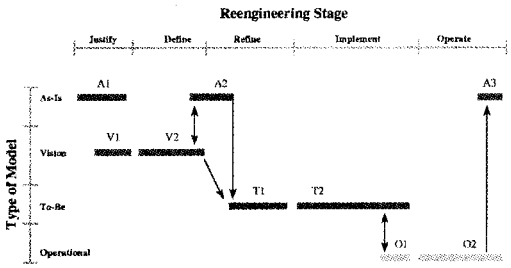

Figure 4. The relationship between model types and reengineering stages

Summary

Today there is a greater emphasis on the interactions among the engineered and business systems that comprise the wastewater enterprise. Lower level automation layers in the information system hierarchy are important, but they can only be justified when they contribute to the primary objective of delivering the necessary water quality at the lowest cost. Business process analysis (BPA) studies can significantly improve the cost effectiveness of the enterprise and there are now available many software tools that assist users in a structured analysis of business process alternatives. Benchmarking studies, change management and on-line management are just a few of the areas where BPA software has been applied. These projects can suggest changes that result in substantial savings in a large utility - savings that are usually realized through the implementation of information technology. Instrumentation, control and automation layers play an important role in this process of improving the efficiency of water and wastewater systems operations.