AN ENTERPRISE MODELING AND ANALYSIS TOOLKIT

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ABSTRACT

A fully integrated modeling and analysis toolkit, which facilitates multi-perspective knowledge capturing, sharing and reusing, is necessary for today's enterprises to meet the challenges of the ever more competitive global marketplace. In this paper we present a suite of software tools, designed and developed by Knowledge Based Systems, Inc., that can generate integrated solutions to complicated enterprise analysis including business process reengineering, activity based costing, and training. We start by providing a high level conceptual framework in which the individual tools with their roles and interrelations are presented. We then introduce each tool that make up the enterprise modeling and analysis toolkit in detail. The tutorial focuses on the ease and the user friendliness of (1) capturing domain knowledge into interchangeable multi-perspective models, (2) automatically generating and executing stochastic and deterministic analysis models from these multi-perspective models, and (3) publishing enterprise modeling and analysis results on the web.

1 INTRODUCTION

Ever increasing complexity of systems have stimulated the development of sophisticated methods and tools for modeling and analysis of today's enterprises. Recent advances in information technology along with significant progress in analytical and computational techniques have facilitated the use of such methods in industry. However, enterprise modeling and analysis methods (and tools that implement those methods) are yet to make a significant impact in the decision-making process of most companies and organizations mostly because of their lack of interoperability and reusability. Knowledge Based Systems, Inc. (KBSI) has been designing and implementing a complete set of software tools to provide today's businesses with innovative knowledge-based solutions for more than a decade. Figure 1 illustrates KBSI's holistic view to enterprise modeling

and analysis in a pictorial form. It shows the individual tools, their roles in the overall enterprise modeling and analysis effort, and their interaction with third party analysis tools as well as among themselves. KBSI's fully integrated toolkit supports the whole life cycle of enterprise modeling and analysis. It allows the user to capture the domain specific information in a suite of models. This enterprise model set may contain domain specific activity models, process models, data models, and cost models. Because KBSI's modeling tools are fully integrated, user can use one of the tools to capture the knowledge and by using the data interchange features of the tools, can easily reuse the same model and data in others. Once the enterprise model set is completed, user can automatically generate stochastic and deterministic analysis models using simulation, project management, and cost analysis extensions of the toolkit. KBSI's enterprise modeling and analysis toolkit also allows users to automatically generate and distribute models with standalone viewers and/or web browsers. In order to accomplish these advanced features, KBSI's enterprise modeling and analysis toolkit designed and implemented to support the following characteristics:

- **Easy Model Generation.** All of the tools in KBSI's enterprise modeling and analysis toolkit employ an extraordinary "Quickdraw" capability. Creating an activity box, entity, or Unit of Behavior (UOB) is as simple as clicking a button. All of the tools support the concept of "pool" where user can create the modeling components (e.g., activities, entities, UOBs, etc.) and then create the models by simply dropping this components on the modeling diagram. Once created, user can use the same modeling components in any number of modeling diagrams. If so preferred, user can also start creating the modeling diagrams directly within the modeling window without populating the "pool". Modeling diagrams support all kinds of graphical object insertions and user placement. KBSI's toolkit

makes the modeling process itself so simple that even a novice can generate professsional-looking models after only a few minutes.

- **Model Interchangeability.** All of the tools in KBSI's enterprise modeling and analysis toolkit allow user to take a model generated in one and import it into another. Furthermore, they also allow user to export and import models generated in other third party modeling packages through the use of specific file formats. This not only saves time for the user by reusing the existing models when creating one from scratch, but also allows user to merge, import and export models among a wide range of analysis tools by taking advantage of the various attributes and bridges provided.

- **Standardized, Rule-Based Environment:** All of the KBSI's tools are based around the Integrated Definition (IDEF) Family of Methods. These methods, developed, used, and even declared a standard by the United States Air Force, have been around providing benefits for numerous users since the early 1970's. IDEF provides a powerful, standardized language to model organizations. In other words, IDEF not only helps to define and analyze enterprises, but it also helps to communicate every aspect of the enterprise in a uniform manner across all models.

- **Standard Views.** All of the KBSI's tools offer three standard modeling views, making the switch from one tool to the next much easier on the
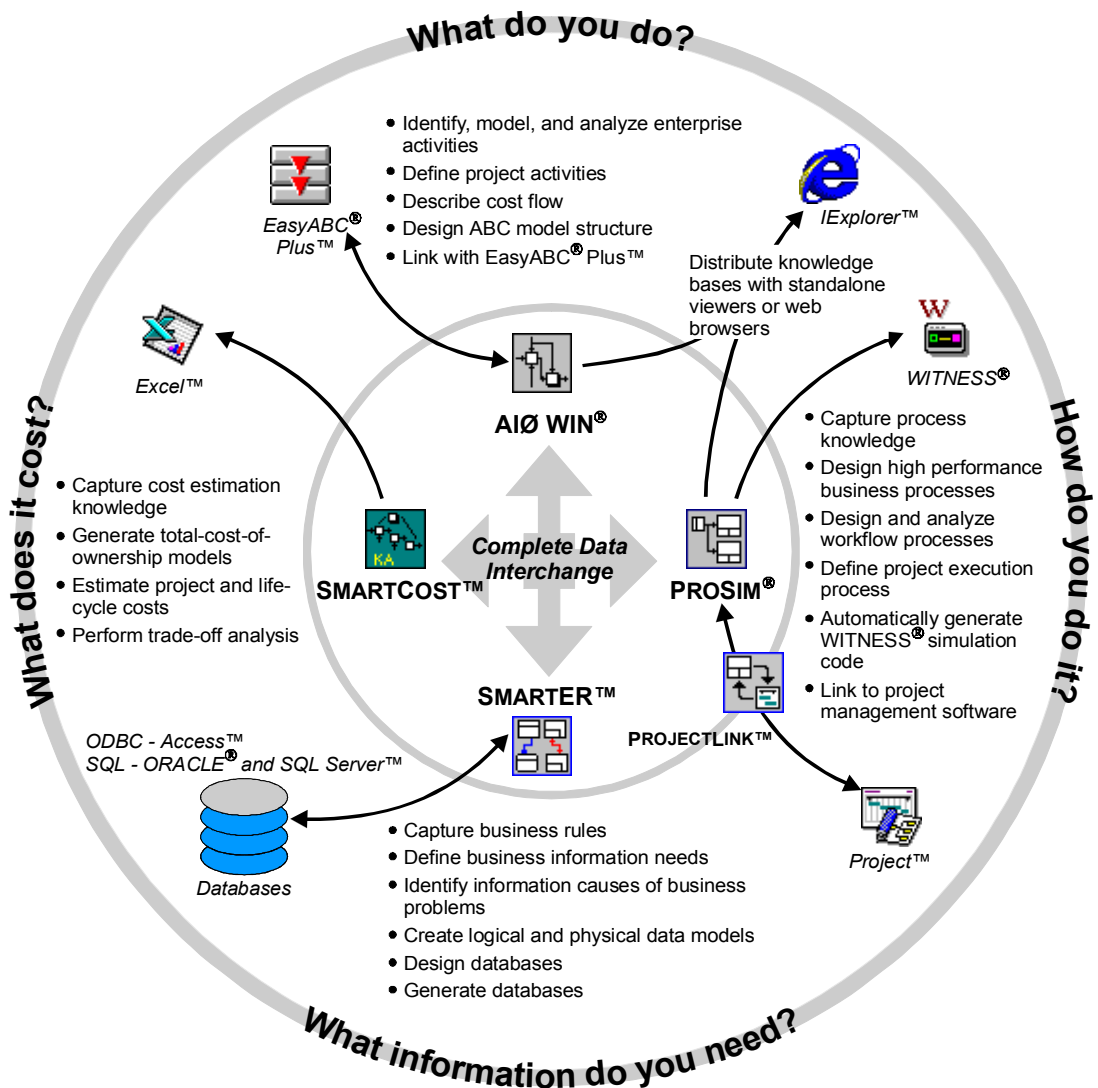

Figure 1: The Holistic View of Enterprise Modeling and Analysis Toolkit

modeler. These three standard views are: (1) the standard graphical view, which shows the model as a collection of interconnected graphical objects, (2) the node-list view, which shows the hierarchical breakdown of the model, and (3) the matrix view, which allows to track relationships between the various aspects of the model. Change in any one of view gets automatically propagated to all the other views.

- **Model Repositories.** All of the tools in the KBSI's toolkit are capable of storing every aspect of the model in a unique database that allows user to reuse those modeling components (activities, ICOMs, UOB's, or entities) in other models. Not only does this save user considerable modeling time, but it also allows user to access pertinent areas of models to make sure that the models are complete. In addition, this reuse of modeling components helps user to maintain uniformity of models throughout the enterprise.

- **Facilitate Communication.** KBSI's modeling and analysis toolkit offers numerous publishing capabilities and bridges to third party tools to help facilitate dissemination of the information contained in the enterprise models. KBSI's toolkit automates the process of putting enterprise models on the web, making them accessible to employees and customers, thereby cutting training time and confusion to a minimum. KBSI's toolkit also automates the process of taking the existing models to a number of third-party modeling and presentation tools, like MS Project, MS Excel, and Lanner Group's WITNESS simulation software.

In the following sections of this paper we will introduce the individual tools that comprises the enterprise toolkit.

2 GENERATING ENTERPRISE PROCESS MODELS USING PROSIM

PROSIM enables a modeler to capture processes or situations as an ordered sequence of events or activities. It is designed to capture process descriptions of the precedence and causality relations between events and situations in a form that is natural to domain experts in an environment. One of the primary goals of the tool is to provide mechanisms for expressing domain expert's knowledge about how a particular process works. A screenshot of the tool is presented in Figure 2.

Originally developed under a research contract from the National Science Foundation (NSF) (KBSI 1992a), PROSIM pioneered the concept of process model
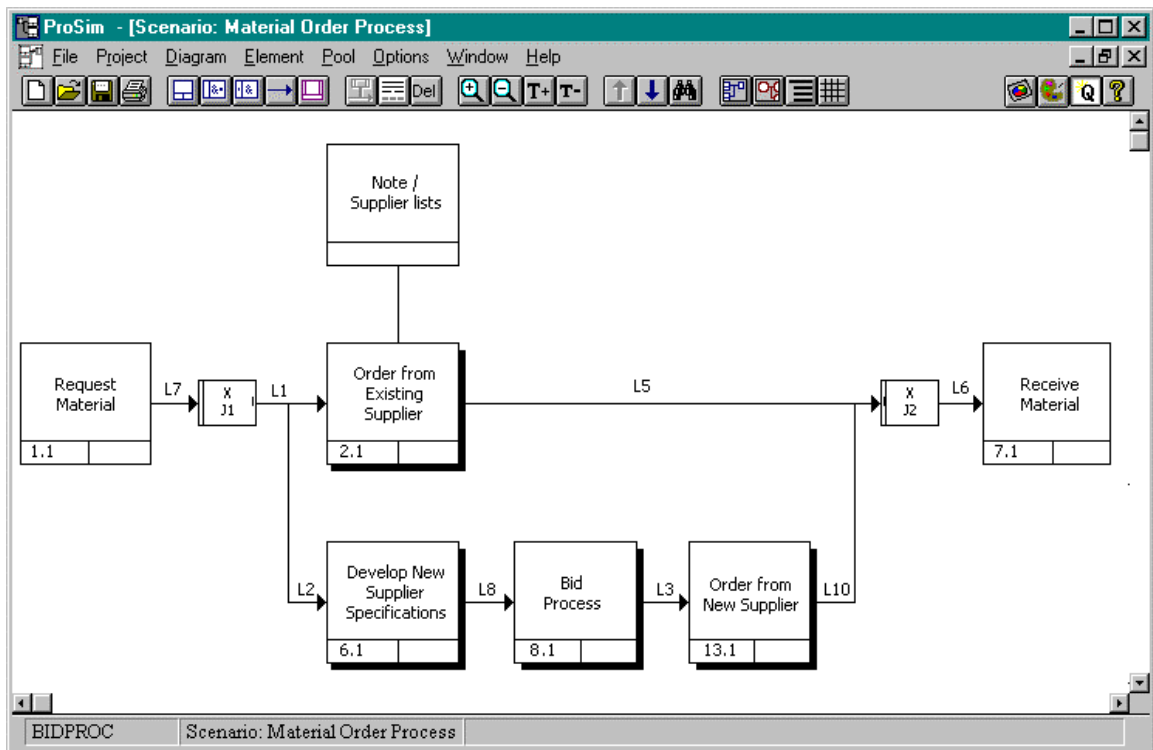

Figure 2: A Process Flow Diagram of the Purchase Order Process

simulation. PROSIM has since evolved into a process engineering workcenter providing assistance during all phases in the lifecycle of process management:

1. Modeling—descriptions of existing process are captured;
2. Analysis—performance metrics are estimated using simulation or static analysis;
3. Design—new "to-be" processes are developed, including integration of existing processes for formation of Virtual Enterprises.

PROSIM have been used to support the analysis and design of manufacturing systems, business systems, logistics systems, command, control, communication, and intelligence systems, service systems, and information systems (KBSI 1997a). It proved itself to be a critical tool for realizing the monetary benefits of business process re-engineering and activity based costing.

As a complete process-engineering environment, PROSIM empowers the domain expert and reduces their dependence on highly trained analysts. Additionally, it permits the domain expert to focus on describing or improving the process instead of abstracting the process into a simulation model.

PROSIM uses "*scenarios*" as the basic organizing structure for establishing the focus and boundary conditions for the process description. This feature is motivated by the tendency of humans to describe what they know in terms of an ordered sequence of observed activities within the context of a given situation.

The basic syntactic unit of PROSIM graphical process descriptions within the context of a scenario, is the *Unit Of Behavior* (UOB) represented by a rectangular box. Each UOB represents a specific view of the world in terms of a perceived state of affairs or state of change relative to the given scenario. Stated simply a UOB may represent an event, activity or process in the system of interest. UOBs are connected to one another via *junctions* and *links*. Junctions provide the semantic facilities for expressing synchronous and asynchronous behavior among a network of UOBs. Links represent temporal precedence, object flow, and relations between UOBs. Each UOB can have associated with it both descriptions in terms of other UOBs (a decomposition of a parent UOB) and a set of participating objects and their relations (an elaboration).

Let us consider a situation of an analyst interviewing a purchase department manager to capture main activities involved in generating purchase orders at the company. The purchase department manager is mainly responsible for the processing of purchase request forms, finding existing suppliers for the part, inviting bids from potential suppliers, receiving bids, evaluating bids, placing purchase orders, and acquiring the material. First, the initiating department (typically design or process planning) formally

requests the needed material. If the requested material has existing suppliers, a purchase order can be placed immediately. On the other hand, if the requested material is new, or the existing supplier no longer produces the part, then the purchase department has to invite bids from potential suppliers, receive the bids, evaluate the bids, and place a purchase order to the selected supplier. The process flow diagram that depicts the sequence of activities involved in the purchase order generation process can be captured using PROSIM and is shown in Figure 2.

2.1 Generating Simulation Models Using PROSIM

The intelligent support provided by PROSIM reduces the expertise required to design effective simulation models and perform simulation experiments. It provides an environment in which users can develop designs for discrete event simulation models from process descriptions and supports the conceptual modeling activities at various stages of the model design process. PROSIM can be used to support the analysis and design of manufacturing systems, business systems, logistics systems, command, control, communication, and intelligence systems, concurrent engineering systems, service systems, and information systems. It is a critical tool for realizing the monetary benefits of business process re-engineering and activity based costing.

PROSIM has a built-in simulation model design support environment. In other words, it has an expert system programmed to provide expertise at a level comparable to that of a simulation-modeling expert. Process flow diagram constructs, UOBs, objects, and junctions, are required to be detailed within PROSIM in order to generate a simulation model. Consider the *request for bids* UOB in the example process flow diagram in Figure 1. The real world objects that participate in the process of requesting bids are "Technical Package," "Purchase Department Manager," "Potential Supplier List," "Bid Package," and "Building 1." A "technical package" contains the technical data of the part to be ordered. The technical data of the part may include engineering specifications, tolerances, material to be used, special tools and jigs required to manufacture the part. A "Purchase Department Manager" requests a bid by sending a technical package along with the bid package to potential suppliers. The "Potential Supplier List" consists of details of all the potential suppliers such as "supplier code," "supplier name," "supplier address," "supplier manufacturing capabilities." The "Bid Package" consists of information about the requirements of the bid responses, financial details, and other contractual details. This activity is performed in the location "Building 1."

In PROSIM, a dedicated resource is categorized as either a *location* or a *queue*. The location label is provided whenever a non-waiting activity is represented by the UOB. If the UOB is used to represent a waiting activity,

the dedicated resource is associated as a queue. Flow objects that participate in UOBs are called *entities*.

Once the necessary simulation specific information entered in the process modeling interfaces, PROSIM automatically validates and generates an equivalent simulation model in the WITNESS Command Language. After the model has been generated, the user can load the simulation model into WITNESS by using the *Read Commands* option in the Model menu (see Lanner Group 1997). After the WITNESS model has been loaded, the user can run the model and generate the desired performance metrics. WITNESS provides state-of-the-art capabilities for simulation-based analysis and experimentation. An analyst knowledgeable in the WITNESS language may customize the PROSIM-generated model if necessary.

2.2 Managing Projects Using PROSIM and PROJECTLINK

PROJECTLINK (KBSI 1997b), an add-on module to PROSIM, enables information in a PROSIM process model to be leveraged for analysis using a project management tool, e.g., MS-Project. PROJECTLINK facilitates an alternative approach to process analysis since a detailed simulation-based analysis is often unnecessary in order to obtain an estimate of metrics such as resource utilization. Static analysis using the resource leveling function in project management tools may be adequate for identifying resource contention problems resulting from the process design. Additionally, Critical Path analysis may help identify process steps that need to be performed in parallel with other activities so that the overall cycle-time is reduced. A link between process modeling and project planning is also useful during the implementation of large, perhaps infrequently occurring processes such as a shuttle-launch at NASA.

Since PROJECTLINK is a two-way bridge between process modeling and project planning, it gives rise to other useful and interesting possibilities. Project planning analysis can identify limitations and mandate changes to the project plan. The resulting changes can then be brought back to the process model in PROSIM. Alternatively, an existing project plan can be imported into PROSIM for performing dynamic analysis using the PROSIM-generated WITNESS simulation model.

The implementation of PROJECTLINK makes the exchange of information between a process model and project plan (in either direction) transparent to the user. In most cases, only one piece of additional information is needed to go from a process model to a project plan: the user selects one path from the options available at each "OR" or "XOR" junction. The process model is then exported using the Export menu item in the File menu. PROJECTLINK is then activated from the Launch Application menu item. A file containing the project plan is generated in the Microsoft Project Export format (.MPX

file) and the project management tool is launched using this file. Figure 3 shows the PROJECTLINK-generated project plan for the Purchase Order process model described earlier.
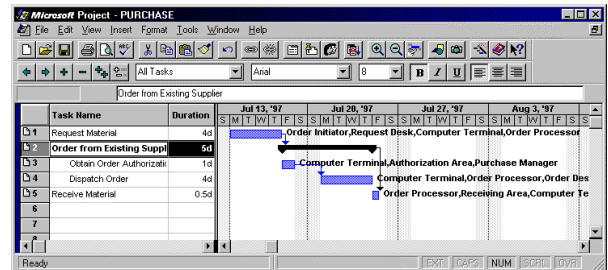

Figure 3: A Project Plan of the Purchase Order Process

Converting a project plan into a PROSIM process model is just as easy to do. The file is saved in the .MPX format and PROJECTLINK is launched by selecting the "Launch ProjectLink" menu item (appended to the Tools menu in MS-Project during installation.) When bringing in a project plan into an existing process model the user has the option of merging the changes with the older process model, or creating a new process model.

2.3 Improving Processes Using PROCESS DESIGN ASSISTANT

The most recent extension to PROSIM is the Process Design Assistant (PDA): a knowledge-based design assistant that facilitates process design by analyzing process models for consistency, completeness, and potential improvement opportunities (KBSI 1997b). A process designer can use the PDA to diagnose possible errors in the model and identify areas for improvement. Given a process model, PDA will check whether the information is complete and consistent with respect to the process design intent. It performs different kinds of qualitative and quantitative analysis and produces a variety of metrics that are useful for process improvement and re-design.

PDA consists of a repository of rules that can be executed on selected process models. Each of the rules checks for some desired feature of a complete, comprehensive and valid process model. PDA was developed in a manner to facilitate addition of new rules and customization of how the rules are organized. The screen below provides a means to organize, manipulate, select and execute rules. The rules in PDA are organized into two classification schemes: based on Rule Class and based on Rule Domain. Rule Domain refers to the domain of application such as BPR, CPI, lean logistics, concurrent engineering, CALS/EDI, etc. Rule Class refers to the basic rule types such as completeness, consistency, cycle-time improvement, quality improvement, coordination, metrics, etc. These two classification schemes are used to help browse

through the rules and select the most appropriate rules for execution. The PDA rules may be customized for different domains by indicating which rules classes are relevant.

3 GENERATING ENTERPRISE ACTIVITY MODELS USING AI∅ WIN

AI∅ WIN, based on the powerful IDEF0 method for activity modeling, helps user to better understand what exactly it is that the organization does by providing a stringent, rule-based environment in which to model the enterprise. AI∅ WIN provides a hierarchical structure to modeling, allowing user to see at greater levels of detail the activities that combine to form a high-level activity. This hierarchical structure allows user to evaluate their business activities by gaining an understanding of the ones that are driving your costs. It facilitates user to re-evaluate their enterprise activities and streamline them to increase profits by cutting costs and eliminating non-value-added activities. AI∅ WIN helps alleviate the guess-work of traditional ABC methods by allowing user to input their costing information and perform reliable, rule-driven Activity Based Costing (ABC) using the costing features included in AI∅ WIN.

AI∅ WIN provides numerous import/export options for the activity models generated. Links to various third party ABC tools allow user to leverage the power and reporting capabilities of those tools. AI∅ WIN also supports links to MS Excel to carry further analyses. The user is allowed to import an existing AI∅ WIN model repository into another providing the benefit of all the knowledge that has been gathered for previous modeling projects. AI∅ WIN, as a member of the KBSI's fully integrated modeling analysis toolkit, allows user to take existing models into PROSIM, SMARTER, and/or SMARTCOST.

AI∅ WIN also supports model merging and splitting. When the situation warrants for it, merging two activity models or splitting an existing activity model are only a few mouse clicks worth of effort in AI∅ WIN. Some of the other superior features of AI∅ WIN are as follows:

- **Provides ABC Matrix Window for Easier Data Entry.** Beyond offering the entire standard KBSI tool views (Node List view, Matrix View, and Graphical View), AI∅ WIN also offers a unique ABC Matrix view. As with all the other windows, modeling can be performed just as easily from this view as any other view, and the changes will be reflected in all the other views. This view makes it easier for the user to allocate enterprises cost drivers and resources, allowing him/her to perform ABC modeling in a concise view. Furthermore, it allows user to see how the resources flow through the model, as well as where the cost drivers appear to effect the model.

- **Provides Links to Third-Party Tools.** AI∅ WIN extends the power of the activity modeling with links to ABC Technologies' ABC modeling and analysis tools. Once the ABC information is entered into the AI∅ WIN model, the rule-based methodology of AI∅ WIN assure the user that the activities being assigned costs are the actual activities that drive those costs and can be export to ABC. Once done, the analysis results and the detailed reports can be generated in ABC Technologies' tools. Alternatively, user can export activity models to any of the KBSI's tools to take advantage of the simulation bridges, links to project management packages, MS Excel, and database generation capabilities.

- **Facilitates Better Costing with SMARTABC.** SMARTABC is a program that takes the costing information entered in AI∅ WIN models and puts it in an easy-to-use, familiar format--an MS Excel spreadsheet. Once exported, user can analyze the cost drivers and resource allocations, make whatever changes that might benefit the enterprise, and take those changes back into the AI∅ WIN model. Furthermore, SMARTABC does not limit user solely to ABC, which is largely a *re*active method of costing. With SMARTABC, user also have the ability to do Activity Based Budgeting (ABB). User can analyze what costs will incur if future trends continue, and see how any changes to your organization would effect those costs. Then, plan the budget for the future using the solid knowledge base developed.

- **Supports Risk Analysis with SMARTSTAT.** SMARTSTAT allows user to make informed decisions about changes within the organization by running discreet, Monte Carlo simulation with the models that are generated in AI∅ WIN. This allows modeler to analyze the risk factors and output expectations before implementing any changes. SMARTSTAT runs through MS Excel, and it allows user to decide which factors should be tracked and how many times those factors need to be tested. It even allows user to set the parameters on each of the factors so that the simulation may be tailored to any environment for accurate predictions.

4 GENERATING ENTERPRISE DATA MODELS USING SMARTER

SMARTER facilitates the modeling and analysis of the data and the information managed in the enterprise. By using SMARTER, which is based on the IDEF1/1X methodology, user can learn what information the organization is currently processing, what information it needs to process, and how that information should flow through it. SMARTER

helps user to understand how the corporate information combines with business logic to form its knowledge assets. User can discover which aspects of the knowledge base are in data and which aspects of the knowledge base is information which can walk out the door when a promising job offer arrives. It helps user to drive the enterprise data standards from business information requirements. He/she can then quickly build visual information asset designs and automatically translate these designs into data specifications with SMARTER. He/she then details these designs with business rules, relationships between information elements, and enterprise's system information logic. Finally, he/she can graphically display the results and can analyze them for completeness and consistency.

Data modeling helps to create a physical model of the corporate data and the manner in which that data flows through the organization. SMARTER's graphical interface shows how data is inherited from one source to the next and using this information helps to warehouse your data in a more efficient manner. It helps user to gain an in-depth understanding of what information is needed in what location of your enterprise and see how well the organization is currently addressing these needs. Then, if necessary, further analyze to see how the data should flow through organizations so that it does meet the needs, and implement those changes. Finally, user can make these physical models a physical reality by using SMARTER to automatically generate the specific code for SQL and Oracle databases.

Information modeling helps to create conceptual models of the information contained in the organization and how the flow of that information effects day-to-day business. SMARTER helps user to gain an understanding of what knowledge repositories exist in what location, whether this be a person or filing cabinet, manual or electronic file. It helps to document what information is vital for the enterprise to operate successfully so that user can maintain those assets and guard against their loss, thereby maintain competitive edge for both the present and the future. User can also gain a complete understanding of how information flows through the organization and what objects the organization need in order to maintain that information.

SMARTER helps user to design first, second, and third normal form databases. It automates the process of validating integrity of the data model according to any of these forms, and in doing so ensure that the data stores contain only the data they need to contain and that data redundancy does not occur across the organization. Import and export capabilities of SMARTER helps user to gain a solid foothold and cut modeling time on your modeling effort by importing pre-existing models from any of the tools comprising KBSI's toolkit, or even those of the competitors. Alternatively, user can leverage the effort put into building SMARTER models by exporting them into the other KBSI tools. From there, he/she can take advantage of the many links to third party tools, such as simulation software, links to project management packages, web-publishing capabilities, and links to Microsoft products.

5 GENERATING ENTERPRISE COST MODELS USING SMARTCOST

SMARTCOST is a tool that facilitates fast track cost estimation, knowledge capture and delivery. It helps user to easily identify the significant cost elements in a domain and the attributes that drive their costs. It helps to capture rules that encode experts' experience in how costs are realized. It facilitates the visually organizing the knowledge bases within a product or work breakdown structure (WBS). It is easy to dynamically pivot to view the knowledge in different ways in SMARTCOST. It is flexible enough to allow creating reusable knowledge modules of an entire knowledge base or just pieces of the knowledge base. It also allows assembling composite knowledge bases from these reusable components. It supports generating multi-level cost models, supporting estimation summaries, and drill up/down to details.

SMARTCOST is superior tool to capture best-practice cost estimation knowledge and make it available when and where it is needed. By facilitating the integration of multiple knowledge sources, it helps to generate total-cost-of-ownership predictions. It is easy to perform cost/risk trade-off studies across multiple alternatives. It helps enterprises to arm their purchasing agents and business managers with powerful should-cost estimating tools, thereby providing automated support for better negotiations with the enterprise's vendor community. It also helps to augment the lifecycle engineering activities by providing the means and the tools to model and analyze the total lifecycle cost.

SMARTCOST automatically generates executable models in Microsoft® Excel spreadsheets from the knowledge base. Users of these models can enter values for cost drivers through user-friendly forms and menus provided by SMARTCOST. It helps to instantly view the effects of changes in the models at any level of detail from the individual elements to the top-most rollup. It supports investigating and documenting any number of estimate scenarios—from cost trade-off analysis to accurate estimation of product pricing and project costs.

6 PUBLISHING ENTERPRISE MODELS USING VISIOBRIDGE, KNOWLEDGEBUILDER, AND KNOWLEDGENAVIGATOR

In this section we briefly describe a few extension tools to KBSI's modeling and analysis toolkit.

6.1 VISIOBRIDGE

VISIOBRIDGE provides user with the ability to enhance existing PROSIM process models and AIØ WIN activity

models with Visio's drawing power. Working from data-bases of model information, the VISIOBRIDGE produces a Visio drawing, which can be customized in any way the user wishes. Such as:

- Create custom stencils for mapping process to Visio elements.
- Designate translation of elements to drawing objects and vice versa.
- Print in custom page sizes.
- Place background pictures on the diagrams.
- Place additional text or legends into the process de-signs in Visio that IDEF model rules won't allow.
- Define custom shapes, colors, and layouts.

VISIOBRIDGE helps user to get the best presentations possible. It helps modelers to combine the modeling power of PROSIM, the leading process analysis tool, and AIØ WIN, the leading activity and ABC modeling tool, with the superior drawing power of Visio. VISIOBRIDGE makes the process and activity models as visually exciting as they are knowledge-packed.

6.2 KNOWLEDGEBUILDER

KNOWLEDGEBUILDER enables user to automatically generate and distribute the domain-specific information captured in the process, activity, and information models. KNOWLEDGEBUILDER compiles the domain specific know-ledge captured into models in indexed forms in which all-key concepts are hyperlinked to their definitions. It uses a wide variety of visual mediums (such as text, graphics, multimedia, etc.) to better display and convey the know-ledge captured into the models. KNOWLEDGEBUILDER can be successfully used to:

- Build consensus on models.
- Train users on redesigned processes.
- Annotate personalized model feedback.
- Distribute established ISO 9000 standard process knowledge across the organization.

6.3 KNOWLEDGENAVIGATOR

KNOWLEDGENAVIGATOR displays an enterprise-wide directory of processes (with description, owner, and modification dates) from an ODBC-compliant database repository. It dynamically displays process models directly from the repository data so that up-to-date information is always available to the users. KNOWLEDGENAVIGATOR can be used to:

- Link multimedia directly to your models using the active Java™ base.
- Maintain active hyperlinks to other web pages.

- Populate the repository from any KBSI tool or using ODBC links.
- Store all your enterprise models and their knowledge sources in a single ORACLE®, Microsoft® Access, or SQL Server® database repository.
- Support/Facilitate
  - powerful knowledge distribution,
  - one-time publishing; unlimited access on www,
  - easy version control and change management,
  - thin client access infrastructure, and
  - platform-independent viewing.

7   SUMMARY

This paper described salient features of KBSI's Enterprise Modeling and Analysis Toolkit. Individual tools that com-prise the overall suite are briefly introduced. An example of purchase order processing system is provided to demon-strate the ease of building models from domain experts' descriptions and then generating a simulation model from this model. The paper also described the specifics of the extensions to the tools, including PROJECTLINK, SMARTABC, VISIOBRIDGE, PDA, KNOWLEDGEBUILDER, and KNOWLEDGEBROWSER. Software demonstration during the tutorial will provide a better understanding of the superior capabilities of the KBSI's fully integrated enterprise modeling and analysis toolkit.

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