ARIS Architecture and Reference Models for Business Process Management

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Abstract. In this article a general business process architecture is presented, which is based on the Architecture of Integrated Information Systems (ARIS) and which is composed of the four levels of process engineering, process planning and control, workflow control and application systems. The ARIS-House of Business Engineering encompasses the whole life-cycle range: from business process design to information technology deployment, leading to a completely new process-oriented software concept. At the same time, the architecture bridges the gap between business process modeling and workflow-driven applications, from Business Process Reengineering to Continuous Process Improvement.

1. New approaches of developing information systems

There are two fundamental ways of (re-)engineering information systems. The “formal driven” approach is based on the goal of developing and implementing a technical correct running system. The “content driven” approach is based on the goal of developing and implementing an organizational correct running system. By using reference models, content and technology can be combined in a new way.

The content driven approach starts with the design of the strategic business opportunities and the organizational requirements. The resulting models are the basis for an iterative business improvement and technological implementation. The content driven approach can be structured as a layer model and described in an architectural framework for business process management. Reference models as “blue prints” for business engineering can be used to model and optimize business processes.

The term "business process" is defined universally. A business process is described as a procedure relevant for adding value to an organization. It is viewed in its entirety, from beginning to end. Figure 1 illustrates the business process of order entry processing. The initial requirements of the customer lead to order acceptance by the manufacturer’s Sales department. Sales then relays information to Purchasing, in order for them to supply bought-in parts. Finally, Production plans and executes the work-order.

Figure1 illustrates this procedure by a series of events triggering functions. The initial event of the process is the customer requirement. The final event is the comple-

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tion of the product in Manufacturing. Events not only trigger functions, they are themselves the results of functions. Processes can be split into sub-processes. Conversely, sub-processes can be joined together. By introducing logical operators, the control structure with its event-driven process chain (EPC) can be expanded to accommodate variously complex procedures [1], [2], [3].

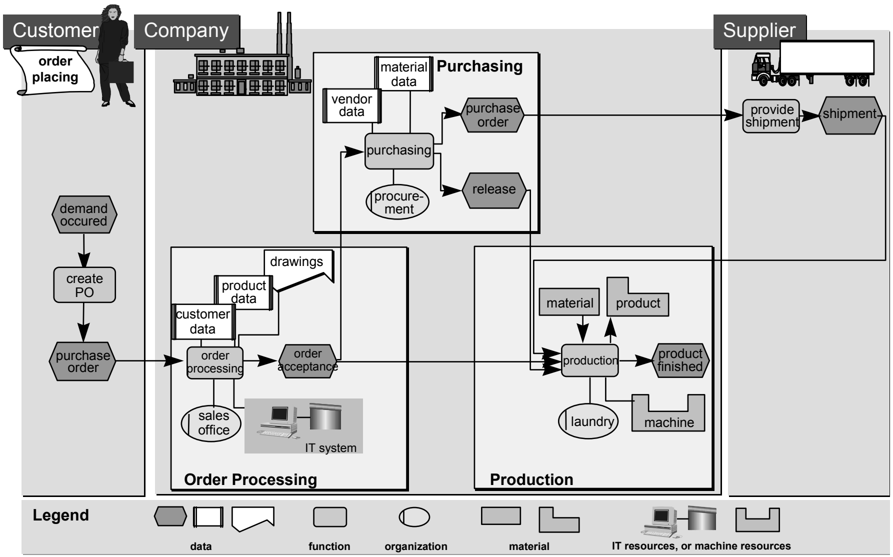

Fig. 1. Modeling of a business process, using event-driven process chains (EPC) [4]

Besides describing the procedural structure of events and functions, there must also be a focus on describing the organizational units assigned to the functions. Many reengineering projects are actually directed at re-allocating functions to organizational units.

Aligning the enterprise along its processes offers the possibility to hit several business targets. But a process-oriented business management not only requires a concept for the systematic design and organization of the business processes themselves (by means of so-called Information System Architectures).

Process-oriented business management also calls for tools and concepts to design the information systems supporting these processes. The aim is to design and control the organizational structures in a very flexible way so they can rapidly adapt to changing conditions (of the market, competitors etc.) [5].

2. ARIS-House of Business Engineering Architecture

Despite an abundance of various reengineering concepts in recent years, business processes have emerged as the focal point of business reengineering [6], [7], [8], [9], [10], [11].

The Architecture of Information Systems (ARIS) can be used as a keystone for Business Process Reengineering and Business Process Management [1], [4], [12]. ARIS-House of business engineering (HOBE) enhances the ARIS process architecture by addressing comprehensive business process management, not only from an organizational, but also from an IT perspective (see Figure 2) [12], [13].

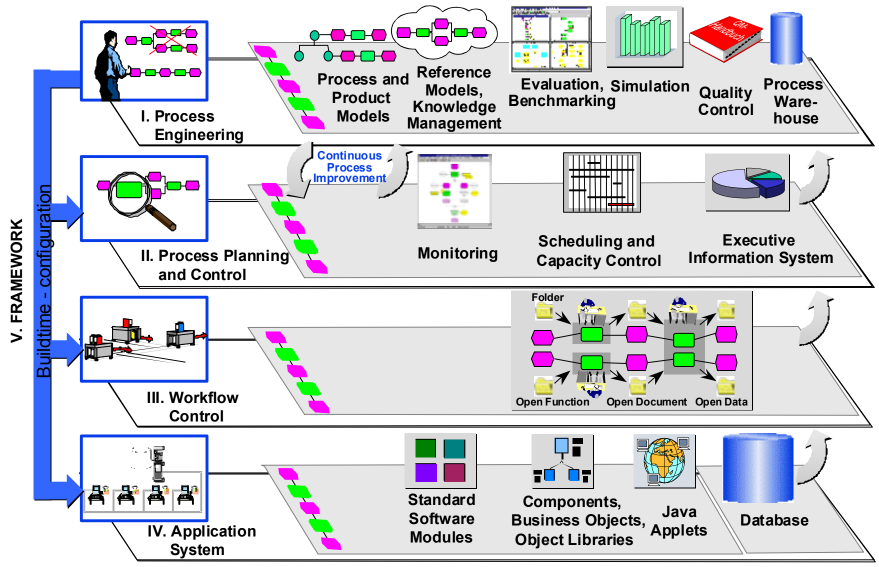

Fig. 2. The 'ARIS-House of Business Engineering' Architecture of Business Processes [4]

Because business process owners need to focus on the „one shot" engineering and description aspects of their business processes, ARIS HOBE provides a framework for managing business processes -- from organizational engineering to real-world IT implementation, including continuous adaptive improvement. HOBE also lets business process owners continuously plan and control current business procedures and devote their attention to continuous process improvement (CPI) [14], [15].

At level 1 (**process engineering**), business processes are modeled in accordance with a manufacturing work schedule. The ARIS concept provides a framework which covers every business process aspect. Various methods for optimizing, evaluating and ensuring the quality of the processes are also available.

Level II (**process planning and control**) is where business process owners' current business processes are planned and controlled, with methods for scheduling and capacity, and (activity based) cost analysis also available. Process monitoring lets process managers keep an eye on the states of the various processes.

At level IV (**workflow control**), objects to be processed, such as customer orders with appropriate documents or insurance claims, are delivered from one workplace to the next. Electronically stored documents are delivered by workflow systems.

At level IV (**application system**), documents delivered to the workplaces are specifically processed, i.e., functions of the business process are executed using computer-aided application systems -- ranging from simple word processing systems to complex standard software solution modules--, business objects and java applets.

The four Levels are interdependently connected. Information at Level II regarding the profitability of current processes, is the point of departure for continuous adjustment and improvement of the business processes at Level I. Workflow Control is linked to Level I, because Workflow Control at Level III requires the description of business processes. At the same time, Workflow Control reports actual data regarding the processes to be executed (amounts, times, organizational allocation) back to Level II. Applications at Level IV are executed from the workflow system at Level III and configured according to the business process models at Level I.

2.1 Engineering Business Processes

Business process engineering aims to achieve the greatest efficiency possible in terms of business-organizational solutions. Organizational departments, reengineering project teams or even business process owners can be responsible for process engineering. While work schedule development for manufacturing processes might be institutionally allocated to a certain department for years as job preparation, other kinds of business processes are not quite as regimented. We would recommend having the same entities responsible for engineering as are responsible for the business processes themselves.

Generally, enterprise business processes, such as a typical purchasing process, are engineered at the type level. Subtypes for certain subforms (orders for spare parts, normal parts or just-in-time parts, for example) can also be created. However, ordering processes are usually not modeled just because specific parts need to be ordered.

On the other hand, work schedules for specific parts in manufacturing processes are indeed documented. This is due to the fact that process descriptions are not only used to support fundamental organizational rules, but also for direct process execution. The more process documentation is utilized for executing business processes, such as for workflow control, the more descriptions for process instances become necessary.

When engineering optimal business processes, reference models can be included, along with available knowledge on best practices. It is also possible to compare alternative procedures (benchmarking) or carry out simulation studies or quality evaluations.

Reference models, which can be developed in real-world situations (best practices) or theoretically, document process know-how that can be utilized for modeling. We can distinguish between procedural models or the implementation of standard software, and business models such as for order processing or product introductions. Models can be specialized for vertical markets (resulting in vertical market reference models). ARIS concept reference models, developed by consultancies with expertise gained in customer projects, are available for practically every vertical market. Thus, documented process expertise results in the development of commercial products.

Reference models can be quite comprehensive, consisting of hundreds or thousands of model objects. This is why various levels of aggregation are used. Reference models provide enterprises with an initial process engineering solution, letting them determine the degree of detail of the model and the business content. Adapted to company-specific requirements, reference models evolve into company-specific models. Actual case studies have shown that the use of reference models in organizational projects can reduce time factors and costs by more than 30%.

Reference models provided by software vendors as software documentation (the most comprehensive model being SAP's R/3 reference model) benefit the customer by utilizing business process know-how, providing the opportunity to compare business software solutions or pinpointing positive or negative implementation issues.

Process know-how is increasingly being regarded as an important component of overriding corporate knowledge management. Corporate knowledge includes know-how regarding the products, technologies, organizational procedures and rules as well as the individual know-how of each individual employee. Documenting, storing, utilizing and enhancing this basic know-how is a key task of knowledge management [16].

While it is essential to evaluate activity based costing and benchmarking results for a single business process, multiple alternatives are generated, studied and analyzed in simulation studies in order to engineer the best possible business process. No methodical enhancements of the business process model are necessary for defining and analyzing the various engineering alternatives in what-if-situations. After analysis, the existing process model serves as the foundation for the simulation. In dynamic simulations, on the other hand, the dynamic behavior of process alternatives is studied. Individual processes are generated in accordance with the process model, their processing is tracked. Thus, processes are defined at the instance level and their interrelationships are analyzed. This pinpoints any potential delays before any processing begins. As far as the process alternatives to be analyzed are concerned, it is possible to define various process structures, processes with different function times and operating behavior, respectively, of the respective organizational units. Alternatives are generated individually, in accordance with empirical studies, or randomly and automatically.

The structure of a simulation model can be derived directly from the general structure process (see Figure 3).

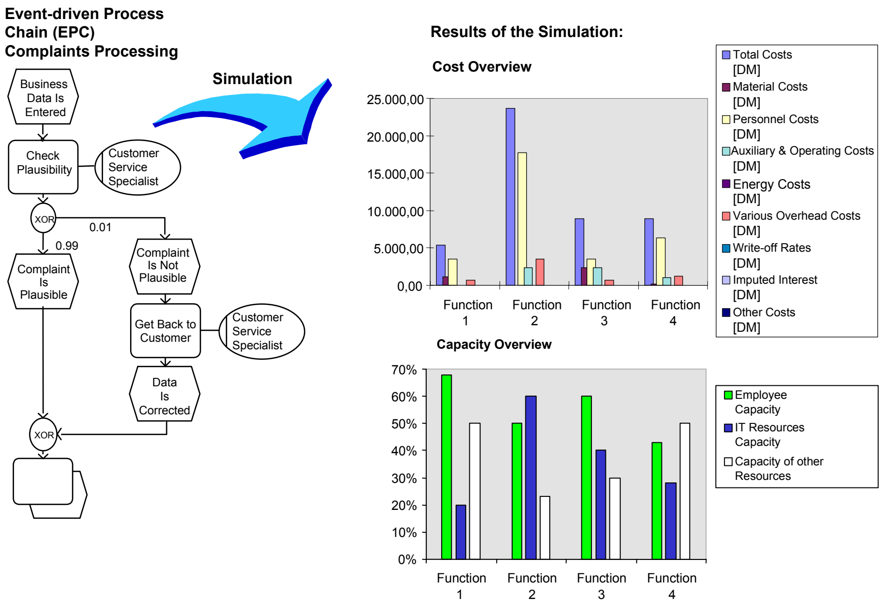

Fig. 3. Example of a simulation with EPCs [4]

ISO 9000 definitions include criteria for defining the quality of business processes. Companies can have their adherence to these standards certified. The main idea of these certifications is that the quality of the processes is an indication of the quality of the processes themselves.

All around the world, standards such as ISO 9000 and 9xxx, as well as the more rigid QS-9000 in the automotive industry, are now well established. In addition to certifying adherence to basic standards like ISO 9001, they stress management aspects and pave the way for total quality management (TQM). Efforts towards enhancing quality do not grind to a halt, however, once adherence to ISO 9000 standards has been certified. In order to optimize enterprise processes in accordance with certain goals, TQM requires people to think and act in a process oriented manner and to constantly review and improve existing procedures.

The result of systematically capturing, storing and maintaining business process know-how in a repository is called a process warehouse. Process warehouses are fed from a wide range of project sources in which business processes are analyzed. These projects can include reengineering tasks, ISO 9000 certification, implementation of standard software, activity based costing, etc. When various methods and tools are used in these projects, the content of the models in the process warehouse needs to be consolidated and then merged with other models. In consistent and transparent organizational guides, this process know-how can then be made available to additional projects. Finally, Internet and intranet technology enables distribution in global enterprises.

2.2 Planning and Controlling Business Processes

Engineering a business process concludes in a kind of template for individual business processes (process instances). In order to be able to plan and control current business processes, the appropriate information must be made available to the persons responsible for the process.

Process monitoring provides the employees involved in and responsible for the business processes with up-to-date status information regarding the current business processes. In addition to the processing status, current process times and process costs can be shown ad hoc. This provides the persons responsible for the business process with transparent information for answering customers' questions and manipulating the remainder of the process if necessary.

Project and production scheduling systems also provide information on "to-be" and "as-is" deviations from the schedule and costs of the business processes that are to be executed. This, as well as other information, is utilized to continuously improve business processes.

Every method used in describing Level I, such as process analysis, model comparison, ISO 9000 certification or simulation, can be employed for CPI. BPR and CPI should be regarded in the same vein. When a certain situation arises, causing a company to reflect on its structures, this in turn can lead to a BPR project. However, even after resolving the problem, processes still change. New organizational concepts can arise. New Best Practice cases become available as reference models. New technologies are invented. New knowledge is obtained from processes, which have just been implemented, leading to an adjustment of the process. Hence, Process Design is a continuous process. Frequently, conflicts of interest lead to apparent disparities between BPR and CPI: applications vendors are sometimes blamed for the lengthy procedure occasionally necessary to implement their software. They are concerned that their product could be held responsible for any additional delay if they are connected with a BPR project. Therefore, they oppose BPR strategies and recommend rapid installation of their software and subsequent CPI. Due to their interest in selling consulting services, consulting companies, on the other hand, recommend the opposite approach: first, develop a new engineering (organizational) concept and then support it with the new software. This prevents unnecessary and awkward procedures from being carried over into the new software concept. The contradictions of these two approaches are resolved in the 'ARIS-House of Business Engineering' because BPR and CPI are so closely intertwined.

The integration of a process costing component within ARIS is important for implementing a permanent Improvement Process (see Figure 4).

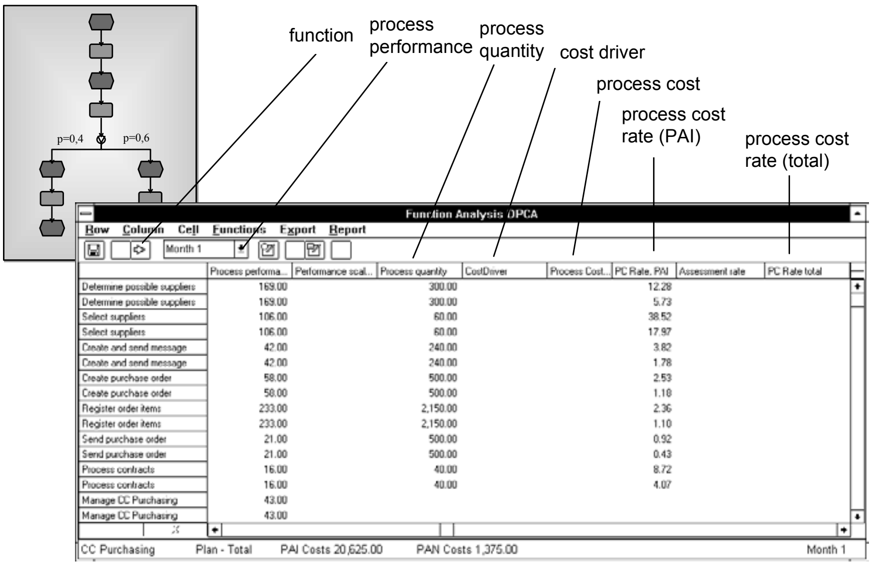

Fig. 4. Supporting process costing with EPCs [13]

The intense debates in business administration circles in recent years regarding process costing generally dissipate if one adheres to this basic view of business processes [17], [18]. Process costing has always been around, however, only in areas in which process descriptions are available, such as in calculating manufacturing processes. That is why we use terms like concurrent calculation, where as-is costs of a manufacturing order, and thus of a manufacturing process, are determined in parallel with an ongoing process.

Process data can also be summarized in an executive information system (EIS) or data warehouse, supporting process management.

2.3 Workflow Control

Business process engineering and business process planning levels, respectively, are geared to business oriented managers. Workflow control converts business processes into IT tools.

Generally, it is not possible to administer an entire business process with one application software system. Very often, a variety of systems for sales, purchasing, manufacturing or accounting is necessary. Even integrated standard application packages have gaps which have to be filled by custom systems or standard applications from other vendors. None of these systems is individually capable of determining the status of the entire process (for example, every processing state of a particular order). It therefore makes sense to allocate the responsibility for comprehensive process control to an explicit system level rather than distributing it across several systems. This level is called „workflow“.

Workflow systems pass the objects (documents) to be processed from one work place to the next. Ideally, they do this electronically, from the computer system of one workplace to the next operation step’s system. This requires a detailed description of the procedure, customized for the individual process type, and of the respective employee [19].

Figure 5 illustrates how a specific process in the execution level is derived from the procedure defined in Level I. Instead of the general attributes of the organizational unit, we now find actual business users. Instead of the general term, we find an order that is linked to an actual customer.

After the conclusion of a workstep, the workflow system retrieves the document from the electronic out-bin of the business user and transports it into the electronic in-bin of the next business user. If several business users are involved in processing, the procedure can be placed in several in-bins. As soon as a business user has begun with the process, the procedure is deleted in the other in-bins. The workflow system is informed of the process status, execution time and the appropriate business user of every business process. Thus, the workflow procedure is also the foundation for Process Management in Level II. It reports the data for cost and scheduling evaluations and provides process information for process monitoring. An agreement by the Workflow Management Coalition, a group of Workflow vendors, has standardized interfaces. Now, various workflow systems can be linked with one another [20].

The process representation of workflow systems can also be used to guide business users. This increases their knowledge of the interrelationship of organizational business processes.

The specific procedure in Figure 5 (right box) follows from the general business process procedure. You create a specific procedure by giving information on particular business users and by selecting a certain path outlined in the general business process description. Thus, business users can always see how their activity is embedded in the process, who will precede and who will succeed them within the process. For example, they can also see that only the left branch of a business process is relevant for them; the control flow of the right branch might be deleted. Since a particular process has not been created for the business user of the succeeding activity, only the department name, "Warehouse", is listed. Depending on the capacity situation at that time, the business user of the next workstep is not determined until the conclusion of the task. During Process Workflow, processes with precisely defined procedural structures can be differentiated from processes with only roughly defined procedural steps.

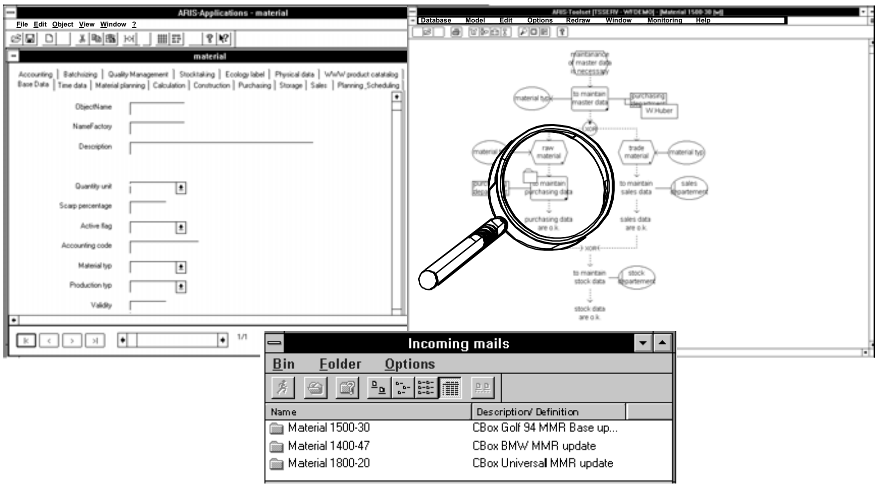

Fig. 5. The workflow component guides users according to processes [13]

In many operational or repetitive procedures (such as order or loan processing), functions, their procedural branches and organizational units are determined from the start. Thus, the process is well-structured and can be described with the EPC method. On the other hand, other processes can only be described partially since functions become apparent during the process. This is also the case when the sequence of the process steps is determined ad hoc or the organizational units to be processed become apparent on an ad hoc basis. In these cases, we define the process as being poorly structured. It can only be modeled in an imperfect way. For example, functions can only be presented in a "TO DO" list; the sequence will be determined by the project team during the process. It is at this time that the person to whom the task has been assigned, is also determined.

Workflow systems seem to be more suitable for controlling well-structured processes. Likewise, less structured processes are supported by groupware systems, which only offer tools such as electronic mail, video conferencing, shared conferencing etc., but which do not require logical knowledge of the processes. In real-life situations, we will always find a mix of these two structure forms. Thus, workflow systems are capable of "exception handling", that is, procedure control can be changed ad hoc during processing. This functionality can be linked with groupware tools, complementing workflow and groupware. In the future, these two systems will even grow together.

2.4 Application Systems

Current vendors of integrated software systems are splitting their systems into smaller modules. Many of them are now just loosely coupled. This makes it possible to release upgrades for each individual module and not across-the-board for the entire system. On the whole, there is a strong tendency today towards splitting application software into individual components (componentware). These modules are reassembled into complete solutions according to process models. The operational data in these applications are managed by database systems.

In the object-oriented approach, data and functions are encapsulated and communicate via a messaging system, which performs material handling for the workflow system. The objects correspond to the "folder" and provide references to data and functions. It is important to note that Level III is responsible for the entire process of the operation. It calls up objects to be processed, such as electronic forms for filing insurance claims, loan application forms for loan processing operations or customer orders for customer order processing. It then passes them on to the appropriate processing station and calls up the program modules.

This separation of the control flow of programs and function execution is bringing about tremendous changes in the software market. Vendors of conventional application software will have to decide whether they want to be brokers' at Level IV and just provide "componentware" with some editing functionality - or if they want to move up to the rapidly growing workflow systems market. Conversely, software manufacturers without much experience in applications are reaching a new point of departure, now that workflow systems are being developed. Particularly in service applications, the processing rules in Level IV can be so simple that they only involve data entry or document editing. Many functions could therefore be executed at this level, such as calling up a spreadsheet or a word processing program. This makes workflow systems that control the coherence of a procedure all the more important.

What this means for users is that a new architecture for application software is on its way. Service providers, such as banks and insurance companies, do not have a large selection of standard applications at their disposal to support their operational procedures. Now they can document (model) their business procedures in Level I and can control their procedures by implementing a workflow system in Level III. In Level IV, they can still use their existing software to support the processing rules. Nevertheless, today it is necessary to split software in Level IV and make it accessible to workflow control. By separating procedure control from function execution statements, information systems are split into data management, procedure control and function execution.

Figure 6 shows a prototype of such an integrated process-oriented information system. The left window represents the user interface of the modeling tool and the features that can be used to design and analyze information models on Level I and II. The models stored in the repository can be used to configure and activate workflow processes. The window in the middle shows an activated workflow process on Level III. The application software on Level IV is pushed by the workflow management system and represented in the right window.

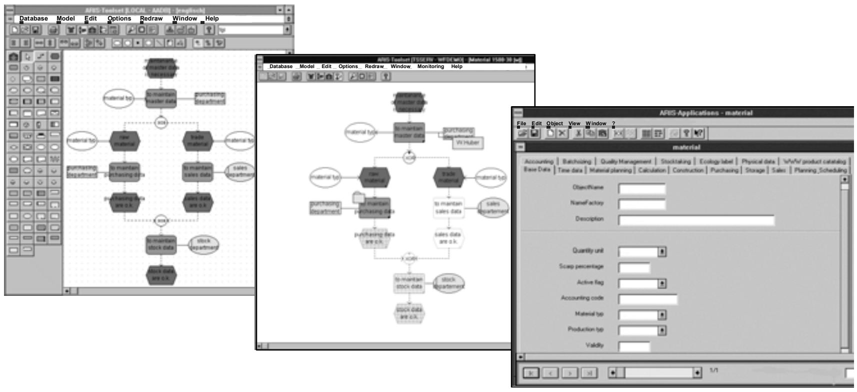

Fig. 6. Process-oriented, workflow-supporting application software [13]

3. Customizing and Configuration with Reference Models

When supporting business processes in their entirety, it is not sufficient to simply split the whole process into the four parts intellectually or as a physical system, as described above. We must also separate their links with one another. We have already noted that the individual business events in the Process Workflow Level are generated by copying the business process design in Level I. The generating of this business design is thus a link between the business process modeling tool and the workflow system. In the Workflow Management Coalition, experts are working on creating accepted standards for this link [20]. The same goes for delivering workflow results to Level II, for example, by delivering details regarding as-is schedules or as-is amounts to Level II for evaluation purposes.

These two links make it possible to immediately update a business process procedure, even in execution and evaluation levels. This occurs without having to manipulate any computer programs. Thus, organizational Design Level I plays a tremendous role within the whole architecture.

From an organizational point of view, the link between Level I and Level IV is equally important. Thus, the modeling level not only generates procedure control, but also processing rules and data transformation. After starting with a group of processing rules that are only very roughly defined, for example, it is possible to filter and adapt only those that are really important for the business procedures.

Application Systems of the future have to be consistent in carrying through this concept of model-driven customizing:

Changing the attributes of the data model in Level I alters the data tables in Level IV (see Figure 7). Modifying process models, in turn, varies the sequence of function procedures. Changing function models either switches off or activates functions. Finally, employing the organizational model allocates functions to certain organizational units and determines the screen sequence. Application Systems are derived directly from industry-specific market reference models described according to the ARIS Method. Using the Modeling tools, they can then be developed into company-specific "to-be" models.

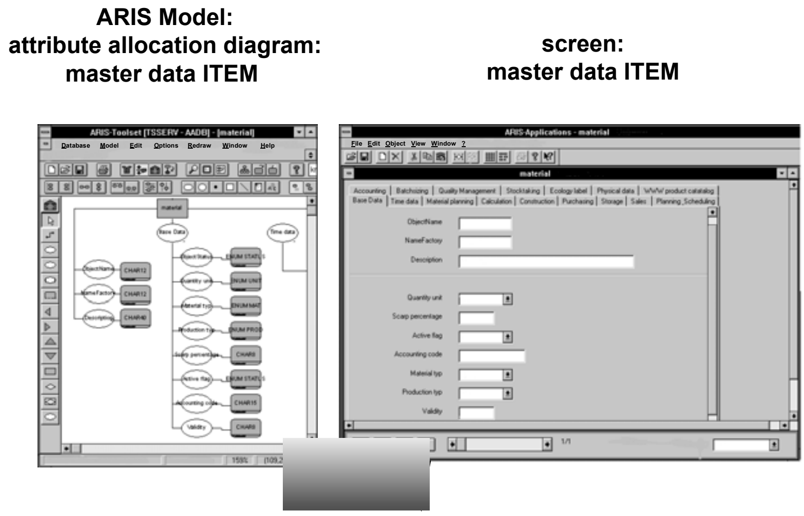

Fig. 7. Model-based customizing with ARIS-House of Business Engineering [13]

In order to transfer the model into application software, a build-time-system, class library and configuration model is relevant. The build-time-system converts the company-specific ARIS model, based on object-oriented programming, into an operational application system (run-time system). The build-time system utilizes a class library consisting of predefined business administration and data processing classes. The processing rules for this conversion are comprised in the configuration model. Here is an example: Processing rules guarantee the DP-conversion of the ARIS models into database objects. They further govern the description of database objects and links between external and internal identifiers (e.g. for tables and columns). Besides modifying procedure rules, model-based customizing enables the adjustment or expansion of data models, dialogue masks and process organization. Thus, the application is derived directly from the process model of the enterprise and then configured from business-objects.

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