IDEAL: A METHODOLOGY FOR DEVELOPING INFORMATION SYSTEMS

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ABSTRACT

As a result of improved capabilities obtained through current computer technologies, application programs and expert systems, Enterprises are being designed or upgraded to be highly integrated and automated information systems. To design or modify Enterprises, it is necessary to first define what functions are to be performed within the Enterprise, identify which functions are potential candidates for automation, and what automated or expert systems are available, or must be developed, to accomplish the selected function. Second, it is necessary to define and analyze the informational requirements for each function along with the informational relationships among the functions so that a database structure can be established to support the Enterprise.

To perform this type of system design, an integrated set of analysis tools are required to support the information analysis process. The IDEAL (Integrated Design and Engineering Analysis Languages) methodology provides this integrated set of tools and is discussed in this paper.

INTRODUCTION

The information age is upon us. More than half of the people going to jobs every workday are primarily information workers and the percentage is growing as the industrial sector becomes less labor intensive. Information in this paper is defined as being the integration of data and information. Those who are responsible for supporting these information workers with automated tools have steadily raised the importance of information. It has been transitioned from a much overlooked role in the early days of file processing to the lofty position of a resource deserving of the same attention as that given to the management of people, money, and materials.

The approach which recognizes that information is at the heart of our information systems design effort is identified as Information Resource Management (IRM). Before developing a particular view or implementation of an IRM system, an understanding must be gained as to what the information is, how it exists, and how it is used within Enterprises. From this understanding, the proper use of automated tools, computers, and robotics, can be perceived and implemented. Without this understanding, management decisions related to information handling capability will simply be directed at hardware and software, and will have gained little advantage over previous methods.

Each person working in an Enterprise perceives a subset of the Enterprise's information base within the context of the tasks he perform. This perception is called a "user view." (It is the total integration of all the user views that contribute to making up the information base of the Enterprise.) In order for a system to serve all users effectively, the information must capture the inherent nature of data as it exists and not pay particular attention to any one user view. Therefore, the abstraction of data reality captured by the model must be representative of the inherent structure of the data as it exists from an overall perspective and not be biased by any one perspective.

To support an effective IRM effort requires an integrated set of tools and techniques necessary to build and analyze an information model. This paper discusses a methodology called IDEAL which is composed of such a set of tools and techniques.

DISCUSSION OF IDEAL

The IDEAL methodology has been formulated and applied over a five year period. It has proven to be an effective approach through the integration of proven techniques (Figure 1). IDEAL provides a top-down, structured technique to define and document the system of interest; a knowledge engineering technique to collect and organize system descriptive information; a rapid prototyping technique to perform preliminary system performance and effectiveness analysis; a sophisticated simulation language to perform in-depth system performance analysis; and a data modeling technique to perform information analysis for developing data base design.

IDEAL is composed of three techniques that have been developed and proven as stand-alone capabilities. Among theses are IDEF(0), IDEF(1), SADT, and SAINT. The IDEF(0) technique was developed to provide a structured approach to defining or bounding the system of interest. IDEF(0) provides this definition initially as a general view in terms of the activity the total system is to accomplish, what is produced by the system, what materials and information are used by the system, and what criteria control how the system performs its activity. Through a knowledge engineering and a graphical presentation technique, IDEF(0) provides the structure for gradually detailing out the general system activity into subactivities, the informational requirements for each activity, and the informational relationships among the activities.

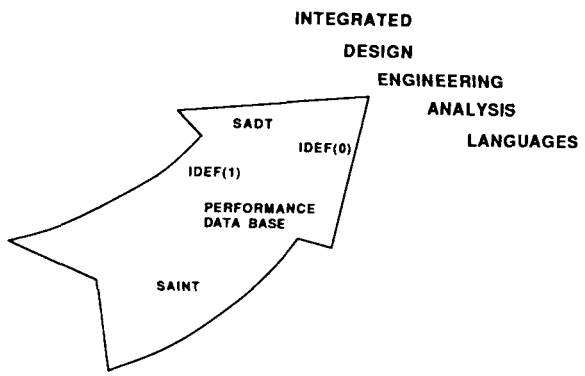

Figure 1. IDEAL Overview

The SAINT (System Analysis for Integrated Networks of Tasks) simulation language was developed to represent the dynamics performance of a system by defining and linking the activities performed within the system and by representing the performance relationships existing among the activities.

The IDEF(0) and SAINT techniques are closely related in that the activities defined by IDEF(0) are the same as those represented in SAINT. Also, the data relationships among the activities in both techniques are the same. The primary difference between the two techniques in that IDEF(0) is a static representation of the system whereas SAINT provides a dynamic representation of the system. To form the link between the static and dynamic representations, the Performance Data Base (PDB) was formulated. The PDB is filled by specifying dynamic information for each subactivity represented in the IDEF(0) model so as to define the performance characteristics of each activity along with the performance relationships among the activities. The dynamic representation of the system is then developed through the SAINT language by forming the basic network through the IDEF(0) model onto which the dynamic information from the PDB is integrated.

IDEF(1) is the third tool within the IDEAL methodology. IDEF(1) is a proven data modeling technique. The goal of IDEF(1) is to identify information that exist within the Enterprise, how and where the various aspects of the information exists, and the grouping of the information through a series of entity / attribute relationships. The resulting IDEF(1) model provides a means for understanding how the information should be organized and moved through the Enterprise and forms the basis for designing the databases that will eventually be developed within the Enterprise.

The one feature which provides IDEAL with its power as an analysis tool is its utilization of a team effort. IDEAL accomplishes this integration through its knowledge engineering

capability. The process of developing the functional model and the system performance characteristics is accomplished through an interviewing procedure during which the analyst collects information from system experts. The analyst then integrates the information and represents it in terms of the functional model and the system performance description documented in the PDB. This integrated process helps to identify discrepancies among information sources as well as missing information about the system. This integrated information is then reviewed by the system experts in order to verify the analyst's understanding of the system, to add additional information, or to clarify conflicts among the experts.

DEVELOPING AN ENTERPRISE

Performing an informational analysis on an Enterprise for the purpose of incorporating automation and expert systems is a seven-step procedure. There are slight variations in the procedure when applied to the initial design of an Enterprise as opposed to being applied to the upgrade of an existing Enterprise being upgraded to incorporate new technologies. When designing new Enterprises, the definition of the activities to be performed, the information definitions, and the performance specifications must be established by the designers through an understanding of what is needed to be done and what technology could be utilized to form the "TO-BE" model. When upgrading an existing Enterprise, the requirements of the upgraded Enterprise are defined by the upper-level management and used to form the "TO-BE" model. Assuming the current Enterprise will be modified as opposed to being replaced, the characteristics of the current Enterprise are defined and understood through the development of "AS-IS" models. By comparing the "TO-BE" and the "AS-IS" models, a plan of attack is then defined which will be the roadmap to upgrade the current Enterprise into the desired Enterprise.

An Enterprise is a system composed of facilities, personnel and equipment, within which products are produced through a set of processes made up of activities. A significant portion of activities within an Enterprise are those that process material goods. The material used within each activity is controlled by identification codes identifying the materials, where the materials are located, the activities to be performed on the material, and the materials' destination following the completion of each activity. Within this definition, an Enterprise can be any one of a wide variety of facilities. For example, a manufacturing facility transforms raw materials into subcomponents and the subcomponents are assembled into final products. As the raw materials and subcomponents proceed through the manufacturing facility, they are identified and tracked through identification numbers.

In a similar manner, an Enterprise can be an office environment. Within the office, a requested report involves the production, selection, and integration of information so as to tell a desired story. The general data, or raw material, is available to the authors through a defined access procedure and is manipulated to form segments of the report which, in turn, are integrated to form the final report, or product.

Performing the information analysis (requirements analysis) required to develop an efficient, automated Enterprise is accomplished through the following steps:

1. Interview Managers / Designers,
2. Identify Enterprise Functions,
3. Collect Performance Information,
4. Simulate the Enterprise Operation,
5. Identify Informational Relationships,
6. Perform Technology Assessment, and
7. Develop Physical Model.

The relationship among these tasks are illustrated in Figure 2.

Step 1. Interview Managers / Designers

Using IDEAL's knowledge engineering aspects of IDEF(0) and IDEF(1), the interview of the top-level management is the most critical phase because it forms the requirements analysis for the Enterprise development in terms of the limits, direction, scope, and authority. Through these interviews is determined the current mission goals for an existing or new Enterprise and future mission goals of the Enterprise, an identification of the critical factors for success within the Enterprise, and a top-level understanding of the activities performed within the Enterprise. From Step 1

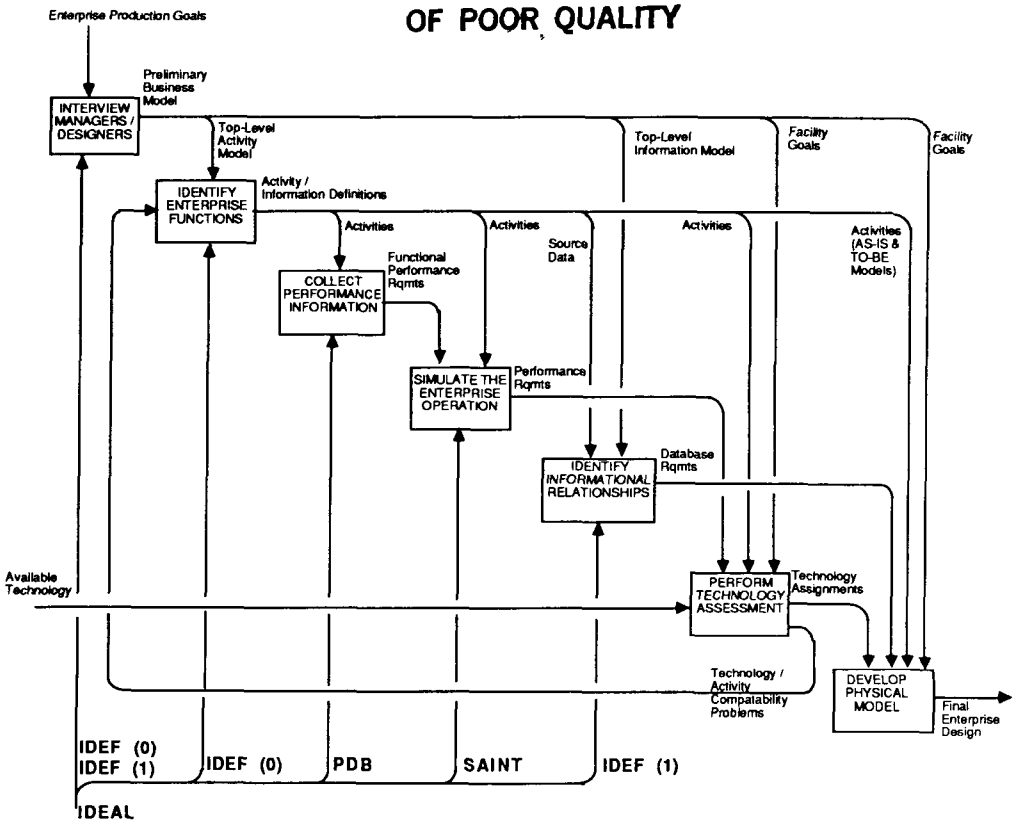

Figure 2. The Approach for Developing an Information System

is produced a top-level model (referred to by some as a Preliminary Business Model) that does not include specifications for technology and organization, and the viewpoint and purpose for performing the activities for the overall Enterprise development effort.

Step 2. Identify Enterprise Activities

Through the continuing use of IDEAL's knowledge engineering capability, the top-level activity model developed during Step 1 is expanded through a series of interviews with individuals, at various levels or Enterprise responsibility to gain an understanding as to what activities must be performed to produce the desired products and what informational relationships exist among the activities. This expanded activity model is developed to a level of detail sufficient to respond to the purpose identified in Step 1. This activity model is often referred to as a logical model because, like the Preliminary Business Model, it does not include specifications for technology, individuals, equipment, and organization. It provides a description of what the Enterprise does and what information is used rather than how the activities are accomplished.

Step 3. Collect Performance Information

The goal of this aspect of the IDEAL methodology is to begin specifying performance requirements for the Enterprise. Using the activity model as the activity definition, Step 3 overlays performance information onto each identified activity. The performance information identifies such items as performance times desired for each activity and backlogs allowable at each activity. The dynamic information defined in this step represents an initial set of performance requirements for subsystems that will eventually perform each activity.

Step 4. Simulate The Enterprise Operation

Within the IDEAL methodology, the capability has been developed which allows for the development of a simulation model by integrating the activity model and the performance information through the use of a network simulation language. By exercising the simulation model, insight into the performance characteristics of the Enterprise can be obtained. This insight includes an analysis of the workload at each activity, chokepoints within the Enterprise processing based on the process performance requirements specified in Step 3 as a function of potential automated capabilities. By exercising the simulation model, a more detailed set of performance requirements can be specified for each activity and potential areas for automation can be identified.

Step 5. Identify Informational Relationships

Having formed a solid understanding of what the Enterprise is to accomplish through the previous four steps, Steps 5 changes the direction of the analysis goals by concentrating on the information aspect of the Enterprise. The goal of this step is to describe the Enterprise from an information viewpoint and the data required by the Enterprise, but like Steps 2,3, and 4, does not depend on either the organizational structure or technology.

The Information model is analyzed to identify natural groupings of information. The groupings will eventually become the basis for the design of the databases to be developed in support of the overall Enterprise. Subsequent analysis results in the database design for each application system along with how and where the information will reside in the specific hardware and software environment.

Step 6. Perform Technology Assessment

The objective of Step 6 is to analyze the technologies, software, hardware, automation, expert systems, etc., available in an attempt to satisfy the Enterprise performance requirements established during the previous steps. As mention earlier, Step 6 is not performed using the tools within the IDEAL methodology but rather uses the models developed by the previous sets as the basis for establishing the requirements for determining what types of automation, technologies, and expert system should be considered and a preliminary judgement as to which of these will satisfy the performance requirements of the Enterprise. The results of the Step 6 assessment may be fed back into the activity model if it is found that no technology exists to accomplish a given activity This will require a decision to either develop the capability or revise the activity so that the necessary technology does exist. It may also be realized that a given technology is available to accomplish a group of activities. Therefore, the activity model may be modified to combine the activities to better represent how the automation will be implemented into the Enterprise.

Step 7. Develop the Physical Model

The objective of this step is to transform the results of the analysis performed up to this point into a physical representation or design for the Enterprise. This involves the designation of how each activity will be performed, how the databases will be structured, and how the organizational structure for the Enterprise will appear.

The procedure for accomplishing this will vary depending on whether a new Enterprise is being developed or whether an existing Enterprise is being upgraded. When designing a new Enterprise, only the considerations for what the Enterprise should be need to be consider with respect to the activities performed, the technologies available, the database requirements, and the goals of the Enterprise.

When upgrading an existing Enterprise, it would be impractical to simple replace all of the existing information processing procedures and capabilities. Instead, automation and information systems must be integrated at appropriate points in the Enterprise. To accomplish this, an analysis must be made between the current and desired Enterprise design. By understanding these differences in terms of activities performed, database requirements, and available techniques, a plan is developed which specifies the approach to be used in upgrading the Enterprise. Through the information generated with the IDEAL methodology, such factors as the criticality of a given activity, impact of automating one activity on those activities interfacing with

it, and the overall modernization goals of the Enterprise can be considered.

CONCLUSIONS

IDEAL is a proven, general purpose methodology for modeling a wide variety of system types. IDEAL forms the foundation needed to understand, document, and analyze the requirements for the Enterprise. IDEAL's power lies in its integrated set of techniques which utilize a knowledge engineering approach in conjunction with a top-down modeling and simulation approach to collect, integrate, and verify the information within an Enterprise through a team effort. Based on the understanding of the interprise provided by through the IDEAL technique, areas for automation and improved information processing can be identified and eventually implemented as appropriate to satisfy the modification goals of the Enterprise.

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