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THE IDEAL MODELING METHODOLOGY: CAPABILITIES AND APPLICATIONS

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The IDEAL (Integrated Design and Engineering Analysis Languages) modeling methodology has been formulated and applied over a five year period. It has proven to be a unique, integrated approach that utilizes 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 analysis; and a sophisticated simulation technique to perform in-depth system performance analysis.

The use of modeling and simulation as a tool within the system analysis process is becoming an ever increasingly important capability. As part of this trend, the IDEAL methodology is making modeling and IDEAL provides these improvements in two ways. First, IDEAL permits the user to concentrate primarily on the nature of the system being anayzed rather than the simulation effort itself. Second, IDEAL permits more accurate models to be developed resulting in a better understanding and a more thorough anaysis of the modeled system. IDEAL is the unique anaysis capability it is because, above all else, it provides a communication and documentation vehicle. The design and analysis of any system (program scheduling and management; software and/or hardware systems; man-machine systems; large or small systems) requires, to one degree or another, an integrated team effort. For example, the development of a man-machine system could reasonably involve hardware and software engineers, human factors engineers, psychologists, design engineers, and program managers. IDEAL provides the features needed to integrate or blend these varied backgrounds into an effective working team. It is through this team effort that the best possible system is developed in the most efficient manner.

IDEAL has been effectively applied to a wide range of system types. Examples of these applications are a man-in-the-loop Surface-to-Air Missile (SAM) system, data base development programs, software development programs, aircraft radar systems, automated communications systems, and computer bus architectures.

This paper will discuss the capabilities of IDEAL, the types of system insights received while developing an IDEAL model, and the types of system analysis that have been performed using IDEAL.

INTRODUCTION

Simulation techniques are used to model or duplicate the behavior aspects of real-world or conceptual systems. These techniques are applicable to all phases of a systems life cycle. Simulation is a powerful method of analysis or evaluating a system without requiring the time and cost of building or modifying the actual system. The development of a simulation model requires a system description in the form of a functional model which is combined with timing and precedent relationships to form a dynamic computer simulation.

Current simulation techniques are highly dependent upon the experience and skill of those applying them. However, the techniques do not integrate all the personal critical to the success of the systems analysis and design. The lack of personnel integration results in the simulation expert having to define the system as he understands it, to define the analysis goals, to solve the problem as he understands it, and to exercise the simulation and interpret the results as he understands them. This usually results in a biased and limited view that is inadequately, verfied, validated, and communicated. Poor and imcomplete problem definition and system description results in an incomplete and inaccurate performance analysis of the system.

The IDEAL (Integrated Design, Engineering, and Analysis Languages) technique was developed to provide the features necessary to define or bound the problem, to develop a validated functional model of the system, to build a simulation model based on the functional model, and to communicate and discuss the analysis approach and results via the funtional model. It is through team efforts that the best possible system simulation is developed and the most complete system analysis performed.

SIMULATION PROCESS

The development of a simulation for analyzing a system requires a team effort. The larger and more complex the system is, the more difficult is the team effort. The team is normally composed of analysts, system experts, and project managers. The system analyst is the focal point for the entire effort. It is the analyst's responsibility to identify the purpose for the proposed simulation from the viewpoint of both the system experts and the project management.

Guided by the viewpoint and agreed upon purpose, the analyst, working as the team's focal point, steps through a systematic approach to identify and collect the information necessary for a system description and operation scenarios, to develop the system simulation from the system description, to exercise the simulation in a manner controlled by the operational scenario, and to recommend a proposed solution for satisfying the simulation purpose.

This general view of the simulation process is illustrated in more detail by the model in figure 1. The simulation process, upon which IDEAL is based, is divided into six major activities. The Describe System activity uses the system description portion of IDEAL to construct a validated static system model. The Generate Performance Data Base activity uses the static system model as a guide to identify and collect the appropriate dynamic characteristics of the system. The Determine Simulation Objectives acitivty identifies the objectives, or goals, of building and exercising the simulation and establishes the criteria which will be used to evaluate system performance. The Construct System Simulation Model activity develops a dynamic model of simulation of the system. This activity is accomplished by translating the system information described in the static model and the dynamic characteristics into the simulation using the structures defined within the IDEAL simulation technique. This model defines the way in which the elements of the system interact to cause changes in the state of the system over time. The Exercise Model activity verifies and validates the dynamic model. Verification determines that

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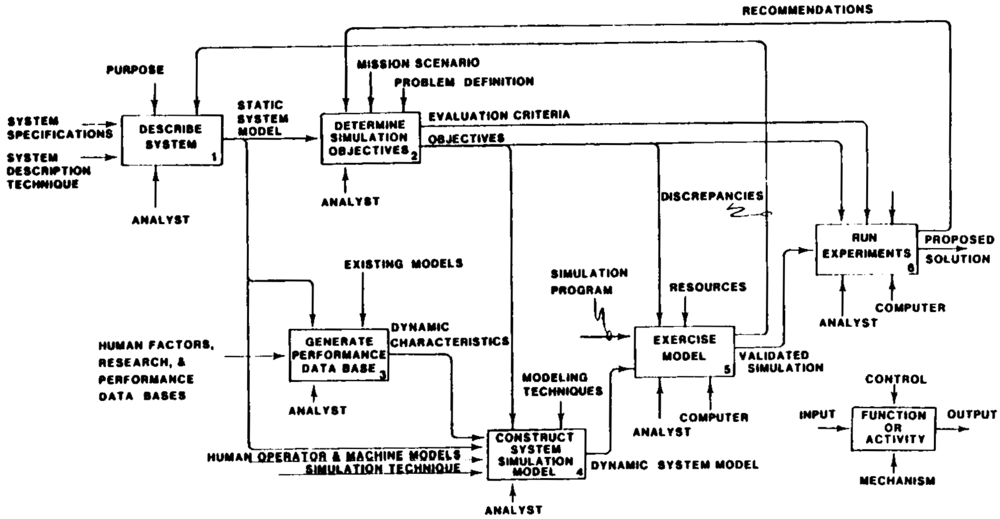

Figure 1. The Simulation Process

the model executes on the computer as the modeler intended. Validation determines that the model is a reasonable representation of the system. The Run Experiments activity exercises the model on the computer and interprets the results. The results of this activity are either recommendations for additional analysis or a proposed solution to the problem definition.

IDEAL is a step-wise technique in which each step maps into either the Describe System, the Generate Performance Data Base, or the Construct Systme Simulation Model activities. IDEAL uses a hierarchical, functional decomposition approach to describes the system in terms of a static system model. The approach provides the means for bounding the system of interest in terms of identifying what overall function the system is to perform, inputs to the system, outputs produced by the system, what controls and relationships are used to transform input into output, and what equipment, software, and humans are required to perform the transformation. Once the system has been bounded, the decomposition activity of IDEAL provides the structures necessary to gain a gradual, controlled graphic representation and understanding of the system (figure 2).

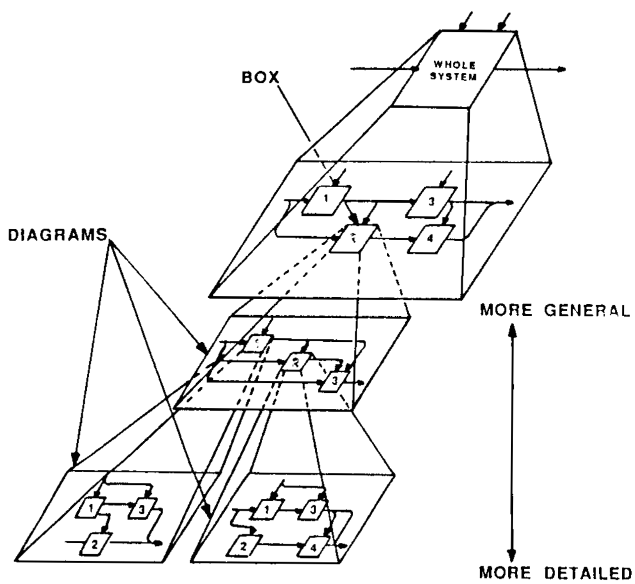

Figure 2. Functional Decomposition Concept

IDEAL uses a data base approach in which each function identified in the functional decomposition has an associated template for storing the dynamics data needed to provide a complete operational description of that function. To develop the final simulation, IDEAL uses a network simulation approach which links the functions together and integrates dynamic data to form the operational representation of the system.

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 sytem 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. This integrated process helps to identify discrepencies 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.

This knowledge engineering approach is an interactive process which requires communication among all members of the team which and causes IDEAL to be both a management tool and a technical tool (figure 3). The management members of the team are provided the vehicle through which they can understand the simulation being developed as well as being able to plan, organize, control, and coordinate the resources required for the effort. The technical members of the team are provided the vehicle to have their information and analysis desires integrated into the simulation and to monitor and understand the simulation as it is being developed. The ultimate effects of developing a model using IDEAL are that the model will be understood and accepted by the team, will be a fully documented model, will be much easier to maintain and engance, and can be used as a training tool with respect to the operation of the system.

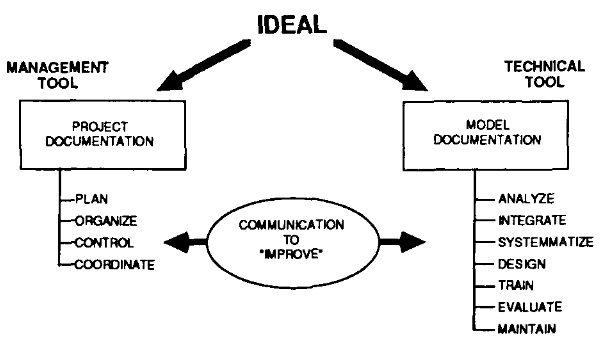

Figure 3. Project Integration Using IDEAL

IDEAL is a general purpose system analysis/design tool. It is applicable to any type of system and is beneficial even if only portions of the methodology are applied. There are natural breakpoints after the functional description and the Performance Data Base (PDB). At each breakpoint, a significant amount of new information will be available about the system. This may be enough information to answer the specified question. As more system insight is desired, the additional steps can be exercised or the current steps and be iterated.

The methodology has been applied to a number of system types. Examples of these applications have included man-machine systems, automated message processing systems, data base design, manufacturing analysis, software design, and the integratin of existing simulations.

MAN-MACHINE SYSTEMS

IDEAL has been used to develop a simulation of a Surface-to-Air Missile (SAM) system [1]. This effort required the integration of knowledge from three experts types. From the system operators, an expert system data base was developed by identifying tasks each operator performed, what information they used and how they used it, and how well they were able to perform their performance. From the hardware engineers, an understanding of the hardware capabilities was established. From other modeling and simulation experts, submodels of the same system were identified, evaluated, and assessed for integration into the IDEAL simulation.

This simulation was used to analyze the ability of the SAM crew to intercept threat aircraft that were operating under a variety of flight profiles and using a combination of countermeasure techniques.

AUTOMATED MESSAGE PROCESSING SYSTEMS

IDEAL has been used on a number of message processing systems. Two of the most in depth analysis were performed on the AE-9B High Speed Ring Bus (HSRB) Protocol [2] and the Central Processing Communication (CPCOM) system for the Precision Location and Strike System [3]. In both cases, the performance information was obtained from appropriate documents for the preliminary model. The system designers and the software developers were then incorporated into the IDEAL process to expand system understanding and perform model validation.

The results of these analysis provided very useful. For CPCOM, it was found that major interface problems existed between the communications system and subcomponents that was linked to CPCOM. Also identified were some minor process timing problems that when changed caused substantial improvements in the processing capability.

For the HSRB, most of the design parameters were verfified but one design parameter was determined to be less than optimal and significant recommendations were made as to the message from that would be best transmitted on the bus.

DATA BASE DESIGN

IDEAL was applied to the specification of a large data base design and for proving that the design would operate within the specified requirements [4]. This model was used to define, document, and communicate the original design and continue to be used to test additions before they are implemented.

MANUFACTURING

IDEAL has been applied to a variety of manufacturing capabilities. One model involved the analysis of an existing manufacturing facility and was aimed at identifying what processes were being accomplished, what information was common among the processes, what equipment and personnel were required to perform the functions, and how well each operator was being performed [5]. The goal of this effort was to develop a plan for upgrading the facility.

A model was developed to analyze the process flow of an oil refinery. This model development involved the analysis of the flow rates, storage capabilities, and process monitoring requirements. The goal of the model was to recommend an approach for optimizing the process monitoring capabilities of the refinery.

SOFTWARE DESIGN

IDEAL has been used on numerous program to either aid in the design of large, complex software systems or to analyze an existing system. One significant model involved the model ing and analysis of the software for the radar mode interleaving process of the B1-B aircraft [6]. The results of this simulation were used to identify a number of operational restrictions as well as some design errors. The results of the analysis were that problems were identified during the design stages and corrections were made without any major impact on the development schedule.

CONCLUSIONS

IDEAL is a proven, general purpose methodology for modeling a wide variety of system types. IDEAL's power lies in its capability to utilize knowledge engineering techniques to collect, integrate, and verify system information from a team of people. IDEAL provides the capabilities to build a system simulation in a top-down, structured manner, in a notation that communicates and documents the system, and in a form executable on a computer. The graphical notation of the technique aids in the debugging, testing, modifications, and communication of the system. It allows the various system subfunctions to be modeled at different levels of detail in order to meet the needs of the problem statement and has the framework necessary to effectively integrate existing subsystem models.

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