DESIGN OF THE OASIS ADVISORY SYSTEM

By Gary F. Goforth, M. ASCE

ABSTRACT: Once the decision was made to develop an advisory system for the operation of water control structures within the South Florida Water Management District, a schedule of activities leading to the completion of a prototype was generated. The initial element of the schedule was a prework conference which brought the system developers together with the operations experts, control system engineers, control room radio operators and District management. Subsequent tasks included formalizing a conceptual system design, assembling a detailed scope of work, allocating development work among internal staff and external consultants, taking an inventory of the data and data analysis tools used by the experts, documenting the various operational rules, and testing various knowledge representation paradigms.

INTRODUCTION

The South Florida Water Management District (District) operates more than 200 water control structures along 2000 miles of primary canals within its 18,000-square mile domain. Seasonal demand for agricultural and municipal water supply, year-round flood protection and protection of coastal well fields from salt water intrusion, environmental quality enhancement, as well as site-specific legal and other constraints, combine to create a very complex decision making arena for the Operations staff at the District.

The District is developing a comprehensive decision support system to aid in the operation of its water control structures. The advisory system will monitor and display real-time hydrologic and meteorologic data and structure status, provide multiple levels of current and projected high and low water alarm detections, incorporate a versatile data plotting package, and features an operations advisor expert system. The prototype includes 31 stations and is scheduled for completion by summer 1988; full implementation of the program is scheduled for December 1989.

An analysis of operational needs and an evaluation of available hardware and software development environments led to the selection of a Symbolics 3640 computer and the Automated Reasoning Tool (ART) from Inference Corp. In contrast to the well-defined and documented capabilities of the newly acquired computer resources, albeit, completely alien to project staff, the design process for such a comprehensive system as envisioned for the operations advisor was extremely vague and ill-defined.

Sr. Water Resources Engr., Resource Operations Dept., South Florida Water Management District, P.O. Box 24680, West Palm Beach, FL 33416.

THE FIRST STEPS

A schedule of project activities was developed which appeared to lead logically to the successful completion of the prototype within 12 months. The initial task was to define the objectives of the advisor system. A conference was held which brought together the operations experts, control systems engineers familiar with the existing Control and Communication system, control room operators and other potential end users, District management and the advisor system developers. Individuals presented their ideas of the desired goals and end products of the advisory system. From this interaction came the first comprehensive definition of what the new system should be capable of, the specific domains of expertise to be embodied, how the advisory system should be integrated into the existing operation control room environment, what decision support tools should be provided, and an idea of the available data sources for the advisor. Shortly thereafter, a conceptual design document was prepared, complete with sketches of the various screens and examples of user interaction.

During the development of the conceptual design, it was recognized that a distinctive name for the advisory system was needed to help coalesce the set of objectives into a tangible entity. Through a rather pragmatic yet productive exercise of etymologic gymnastics, the South Florida Water Management District's OASIS (an acronym for Operations Assistant and Simulated Intelligence System) came into being.

The OASIS package is composed of four functional elements:

1. Operations Status would display real-time data;
2. Operations Assistant would be capable of displaying current and historic time series of data for trend analysis;
3. Operations Advisor would be the embodied expert system, suggesting appropriate control structure operations; and
4. Alarm Status would provide continuous background data analysis for detecting present and anticipated alarm conditions, complete with suggestions for ameliorating the identified alarm conditions.

Consistent with other major applications of a new technology, reduced scale prototype was designated for OASIS to evaluate the technical feasibility of the advisory concept. The prototype would concentrate on the development of OASIS features for a subset of the District's water control stations and telemetry network. The Everglades Agricultural Area (EAA) is one of the 12 major hydrologic basins that comprise the District's 18,000 square mile jurisdiction, and was selected as the prototypical region because of the variety and operational complexity of its component stations. The EAA is bounded by Lake Okeechobee on the north and three large everglades water conservation areas to the south and southeast. In all, 31 stations are located within the EAA, encompassing over 80 sensors, more than 50 control gates, and 8 major pump stations located on four primary conveyance canals.

PROTOTYPE SELECTION

Once the conceptual design of OASIS was complete, external review and advice were solicited as an expeditious way to acquire information relevant to the design and startup of the advisor system.

Consultants, knowledge engineers and other related professionals from Symbolics, Inc., Inference Corp., McDonnel Douglas, NASA, A.D. Little, and the University of Florida were briefed on the project and asked to comment on the overall scope of the project as well as technical aspects which they may have had direct experience. Programming techniques, knowledge acquisition, telecommunications, expert system development and verification, and other fundamental programming elements were discussed during these conferences.

ALLOCATION OF WORKLOAD

It was apparent after the development of the conceptual design that the District could not devote sufficient resources to complete the prototype within the 12-month project timeframe. The workload was allocated between available staff and Inference Corporation. District staff conducted the knowledge acquisition interviews, formalized and tested several knowledge representations and established the critical communication links between the Symbolics and the existing telemetry system and archive data base computers. Inference Corporation provided the functional framework of OASIS, encoded District and basin maps, generated the screens based on the sketches contained in the conceptual design, and designed the preliminary data storage format. Many aspects of OASIS were discussed and resolved with mutual efforts of both parties.

IMPLEMENTING THE DESIGN

One of the fundamental objectives of the OASIS program was to recreate the domain experts' toolkit used in the operational decision making. This included access to available data sources, appropriate data analysis techniques, and a compilation of the extensive set of operational rules which govern the operation of the water control structures.

Date Inventory.- Operation of the District's water control structures has required the development and maintenance of an extensive data collection network throughout the 16-county jurisdiction. The current network includes over 200 stations which provide information of meteorologic and hydrologic conditions between once and 120 times per day. The bulk of the data is collected from the District's Communication and Control System, a microwave-based telemetry network of 45 stations which house over 600 sensors generating an average of 65,000 records of information per day. The data interrogation frequency can be increased during storm events, with an estimated capacity of over 500,000 records per day. Supplementing this remote data collection system are approximately 150 sites that are read daily, and 15 stations that are accessed by means of telephone lines.

Rule Inventory.-The general operational strategy of the District's water control system is to provide adequate flood protection during the wet season (June through October) by placing water into storage and discharging excesses to the ocean, and to draw from the storage areas for water supply during the dry season (November through May).

This strategy must also incorporate protection of the environmental and water quality values of the lakes, wetlands and estuaries in south Florida. There are two fundamental operational modes: normal operations and severe weather-induced operations. Generally, severe weather operations, such as hurricane or drought conditions, take precedence over the normal operations of the system. As part of the design of the Central and Southern Florida Flood Control Project, the U.S. Army Corps of Engineers developed general operating guidelines for each of the project's water control structures. These guidelines suggest appropriate gate levels and pumping conditions for specific objectives, namely, to safely pass the design flood, to supply water during the dry season, to prevent salt water intrusion and to provide discharge to the Everglades National Park. The complete set of guidelines provided by the Corps of Engineers design comprises approximately 2000 rules.

Concurrent with these design guidelines are various local operating policies which have been derived from basin-wide considerations, environmental concerns, development pressures and agricultural demands. An additional set of operating guidelines has arisen from effective communication with, and analysis of, the local users of the water supply/flood control system. The operations are inherently flexible to respond as needed to temporal and spatial perturbations.

SUMMARY AND CONCLUSIONS

Once the decision was made to develop an advisory system for the operation of water control structures within the South Florida Water Management District, a schedule of activities leading to the completion of a prototype was generated. The initial element of the schedule was a prework conference which brought the system developers together with the operations experts, control system engineers, control room radio operators and District management. Subsequent tasks included formalizing a conceptual system design, assembling a detailed scope of work, allocating development work among internal staff and external consultants, taking an inventory of the data and data analysis tools used by the experts, documenting the various operational rules, and testing various knowledge representation paradigms.