Decision Support Systems

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Outline

- DSS for Decision making
- Different Types of DSS
- DSS Tools
- DSS in Water Resources
  - River Basin Planning and Management
  - Water Quality Management in a River Basin

Introduction

- DSS is an interactive computer-based system to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems, complete decision process tasks, and make decisions.
- Geographic Information Systems (GIS), Enterprise Information Systems (EIS), Expert Systems (ES), On-Line Analytical Processing (OLAP), software agents, knowledge discovery systems and group DSS can all be lumped into the category of systems we call as DSS.

DSS for Decision-Making

- Decision Preparation
  - DSS environments provide data required as input to the decision-making process.
  - This is what all most all data mart and data warehousing environments do today.
- Decision structuring
  - DSS environments provide tools and models for arranging the inputs in ways that make sense to frame the decision.
  - These tools and models are not pivot tables and other aspects of data presentation found in query tools.
  - They are actual decision-making tools, like fault tree analysis, Bayesian logic and model-based decision-making based on things like neural networks.

DSS for Decision-Making – contd.

- Context Development
  - DSS environments again provide tools, and provide the mechanisms for capturing information about a decision's constituencies (who's affected by this decision), outcomes and their probabilities, and other elements of the larger decision-making context.
- Decision-making
  - DSS environments may automate all or part of the decision-making process and offer evaluations on the optimal decision.
  - Expert systems and artificial intelligence environments can do this

DSS for Decision-Making – contd.

- Decision Propagation
  - DSS environments take the information gathered about constituencies, dependencies, outcomes and drive elements of the decision into those constituencies for action.
- Decision Management
  - DSS environments inspect outcomes days, weeks and months after decisions to see if
    - The decision was implemented/ propagated and
    - If the effects of the decision are as expected

DSS Types

- Model-driven
- Data-driven
- Communications-driven
- Document-driven and
- Knowledge-driven

Model-driven DSS

- A model driven DSS emphasizes access to and manipulation of financial, optimization and/or simulation models.
- Model driven DSS use limited data and parameters provided by decision makers to aid them in analyzing a situation.
- Ex. Sprinter, MEDIAC and Brandaid.

Data-driven DSS

- A data driven DSS emphasizes access to and manipulation of a time series of internal company data and sometimes external and real time data.
- Simple file systems accessed by query and retrieval tools provide the most elementary level of functionality.
- Ex. WalMart's data driven DSS had more than 5 terabytes of online storage.

Communications-driven DSS

- Communications driven DSS use network and communications technologies to facilitate decision relevant collaboration and communication.
- In these systems, communication technologies are the dominant architectural component.
- Tools used include groupware, video conferencing and computer based bulletin boards.

Document-driven DSS

- Document-driven DSS uses computer storage and processing technologies to provide document retrieval and analysis.
- Large document databases may include scanned documents, hypertext documents, images, sounds and video.
- Examples of documents that might be accessed by a document-driven DSS are policies and procedures, product specifications, catalogs, and corporate historical documents, including minutes of meetings and correspondence.

Knowledge-driven DSS

- Knowledge driven DSS can suggest or recommend actions to managers.
- These DSS are man machine systems with specialized problem solving expertise.
- The "expertise" consists of knowledge about a particular domain, understanding of problems within that domain, and "skill" at solving some of these problems.

Knowledge-driven DSS – contd.

- Artificial Intelligence (AI) and expert systems have been used for scheduling in reservoir operation and web based advisory systems.
- In recent years, connecting expert systems technologies to relational databases with web based front ends has broadened the deployment and use of knowledge driven DSS.

When to build a DSS ?

- Can the problem be solved effectively by conventional programming?
- Is the domain well-bounded?
- Is there a need and a desire for an expert systems?
- Is there at least one human expert who is willing to cooperate?
- Can the expert explain the knowledge so that it is understandable by the knowledge engineer?
- Is the problem-solving knowledge mainly heuristic and uncertain?

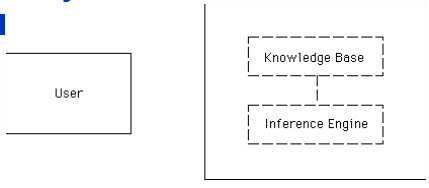
Some Knowledge based DSS

- DENDRAL: Interpret molecular structure
- MYCIN: Medical Diagnosis
- PROSPECTOR: Interpret geologic data for minerals
- REACTOR: Diagnosis/remedy reactor accidents
- XCON: Configure DEC computer systems
- PEIRS: Pathology report system

Elements of Expert System

- Knowledge Base
- Inference Engine
- Working Memory
- Explanation Facility
- Knowledge Acquisition Facility
- User Interface

Expert System



The expert system is specific to one problem domain

However, it is not for domain modeling but for problem solving

Language, Shells and Tools

- **Language**: A translator of commands written in a specific syntax.
  - An expert system language will also provide an inference engine to execute the statement of the language.
  - Ex. LISP is not a language but PROLOG is a Language
- **Shells**: A special purpose tool designed for certain types of applications in which the user must only supply the knowledge base. (Eg. MYCIN)
- **Tools**: A language + utility programs to facilitate the development, debugging, and delivery of application programs

CLIPS (C Language Integrated Production System)

- Basic Components of rule based expert systems
  Fact list; Knowledge base; Inference engine
- Multi-paradigm programming language that provides support for rule-based object-oriented, and procedural programming
- CLIPS was designed at NASA/Johnson Space Center
- CLIPS was designed with the specific purpose of providing high portability, low cost, and easy integration with external systems.
- CLIPS has been installed on a wide variety of computers ranging from PCs to CRAY supercomputers

CLIPS

- Expert system shell
- It has an excellent external language integration
- Uses forward chaining based on Rete's algorithm
- Allows both rule-based and procedural programming paradigms
- CLIPS: A Tool for Building Expert Systems
  http://www.ghg.net/clips/CLIPS.html

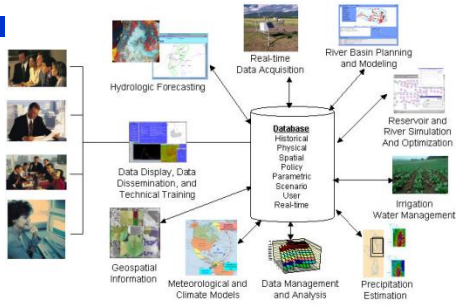
Decision Support Tools

- **Multi-Dimensional Analysis Software**
  - **Also Known as Multi Software or OLAP (On-Line Analytical Processing) Software that gives the user the opportunity to look at the data from a variety of different dimensions.**
- **Query Tools**
  - Software that allows the user to ask questions about patterns or details in the data.
- **Data Mining Tools**
  - Software that automatically searches for significant patterns or correlations in the data.

DSS in Water Resources

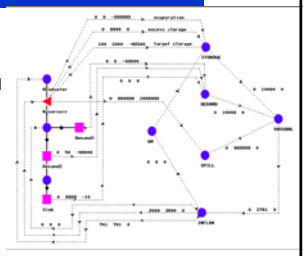
- DSS is extensively used in Hydrology, water resources planning and management and environmental engineering for data analysis and decision making.
- Considerable number of DSS were developed for river basin planning and management with number of features and attributes specific to a specific river basin under consideration.
- DSS can consider multiple reservoir system with multiple purposes for optimal operation in real time.

Components of DSS for River Basin Planning and Management



MODSIM DSS

MODSIM (Labadie et al, 2000) is a generic river basin management decision support system developed in Colorado State University, USA.



MODSIM contd.

- MODSIM is designed for developing basin-wide strategies for short-term water management, long-term operational planning, drought contingency planning, water rights analysis and resolving conflicts between urban, irrigation, hydropower and environmental concerns.
- The most recent version, MODSIM 8.0, is developed under the MS .NET framework and is comprised entirely of native code written in MS Visual C++.NET.
- The MODSIM graphical user interface (GUI) is developed in Visual Basic.NET, and includes both native code and software requiring a developer license.

MODSIM contd.

- Advantage of the .NET Framework is providing users with the ability to customize MODSIM for any specialized operating rules, input data, output reports, and access to external models running concurrently with MODSIM, all without having to modify the original MODSIM source code.
- MODSIM data sets can be developed for daily, weekly, and monthly time steps.
- Streamflow routing can be handled through the use of lag coefficients.
- There is considerable flexibility in representing consumptive use demands and flow requirements and their associated water rights, including exchanges.

MODSIM contd.

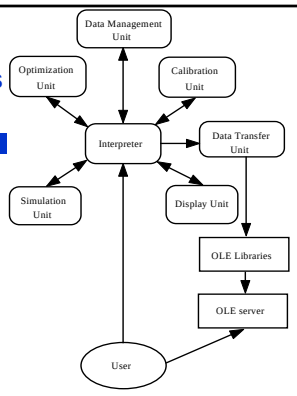
- Reservoir operations include target storage, hydropower, tail water effects, evaporation, and seepage.
- Optimization model in MODSIM provides an efficient means of assuring that all system targets and rule curves are achieved according to user-specified priorities based on water rights or economic valuation, while insuring that water is allocated according to physical, hydrological, and institutional/ legal/ administrative aspects of river basin management.
- A powerful GUI connects MODSIM with database management components and an efficient network flow optimization model.

MODSIM GUI

DESERT DSS

- **DEcision Support system for Evaluation of River basin sTrategies**
- DESERT (Ivanov et al, 1996) is highly integrated tool for decision support for water quality management in a river basin.
- Computing river hydraulic characteristics, such as depth, cross-sectional area and travel time, is necessary for the simulation of water quality.
- The hydraulic models used in DESERT for rivers and open channels are based on mass continuity and momentum equations of fluid mechanics.
- It models river hydraulics through the one-dimensional shallow water equations (Saint Venant's equations).

Components of DESERT



DESERT - Features

- Integration of most important stages of decision support, namely:
  - data management
  - model calibration
  - simulation
  - optimization
  - plotting results of simulation
- Friendly user environment based upon Microsoft Windows interface
- Unified data formats and data processing
- Flexible structure of water quality model

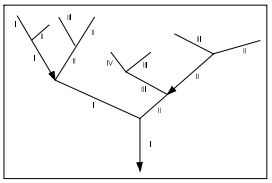
DESERT – Features contd..

- Object oriented programming (C++), easily extended
- Several variants of hydraulics
- Possibility for on-line linkage to OLE servers, like Microsoft Excel, Lotus 1-2-3, etc
- Easy-to-use data handling module with a dBase style database engine
- Simulation and calibration of hydraulics and water quality models
- Display of computed data with the help of external spreadsheet software; and
- Optimization is based on Dynamic Programming algorithm

DESERT

Representation of a river system as a binary tree

- Arrows indicate the main direction of the flow.
- Roman numerals indicate the order of the reaches
- Water quality management problems can be formulated as a search for suitable waste-load allocation policies.



DESERT

Optimal wastewater treatment alternatives

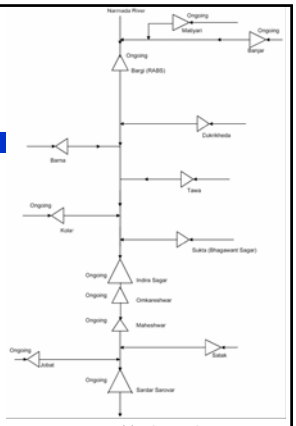
- Selection of optimal wastewater treatment alternatives in a river basin is a temporally and spatially sequential decision problem.
- Spatially, decisions are made at a series of locations in a river basin.
  - Due to the downstream propagation of river pollutants, the water quality at a particular location along a river is entirely determined by the water quality at the immediate upstream discharge/control point (or at several discharge/control points where the location is below a confluence).
- When investigating investments over a temporal horizon, managers take decisions at points in time.
  - Decisions taken at one time directly affect those to be taken at the next time step.

Other DSS for River Basin Management

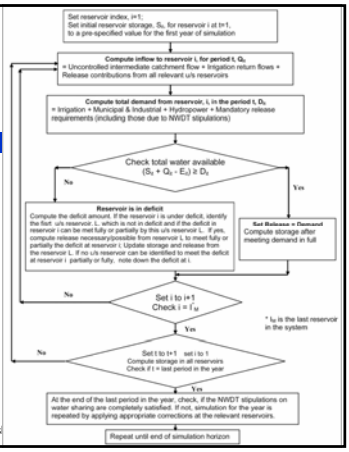
- RiverWare
  - Developed in Univ. of Colorado, USA
- WaterWare
  - Developed in Europe

Integrated Reservoir Operation Studies for Reservoirs in the Narmada Basin

System of Major and Medium Reservoir Projects Considered in the Simulation Model



Flow Chart for the Simulation Model



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