Intelligent Decision Support Systems

(Part II - EVOLUTION OF DECISION SUPPORT SYSTEMS / INTELLIGENT DECISION SUPPORT SYSTEMS)

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PART 2 – EVOLUTION OF DECISION SUPPORT SYSTEMS / INTELLIGENT DECISION SUPPORT SYSTEMS

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EVOLUTION OF DECISION SUPPORT SYSTEMS

Historical Perspective of Management Information Systems

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Management Information Systems (1)

- **Transaction Processing Systems**
  - Early 70s
  - Electronic data processing
  - Large volumes of commercial transactions
  - Batch processing, *mainframe* computers
  - Non interactive

- **Decision Support Systems (DSS)**
  - Started in Middle 70s
  - Interactive systems, *workstations/personal* computers
  - Supporting business decision making
  - Early DSS
    - Late 70s
    - Very rudimentary (spreadsheet software)
  - Advanced DSS
    - 80s
    - Using Operations Research and Management Science Models
    - “what if” analysis

- **Intelligent Decision Support Systems (IDSS) [90s]**
Management Information Systems (2)
[Adapted from V. Dhar & R. Stein, 1997]

MANAGEMENT INFORMATION SYSTEMS

TRANSACTION PROCESSING SYSTEMS

AUTOMATIC MODEL-DRIVEN DSS

DECISION SUPPORT SYSTEMS (DSS)

MODEL-DRIVEN DSS

DATA-DRIVEN DSS

INTELLIGENT DECISION SUPPORT SYSTEMS (IDSS)

EXPLORATIVE MODELS (BOTTOM-UP APPROACH)

CONFIRMATIVE MODELS (TOP-DOWN APPROACH)

STATISTIC. NUM. METH. ART. INT. ML METH.

STATISTICAL / NUMERICAL METHODS
EVOLUTION OF DECISION SUPPORT SYSTEMS

Decision Support Systems

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Need for Decision Making Support Tools

- Complexity of the decision making process
- Accurate Evaluation of multiple alternatives
- Need for forecasting capabilities
- Uncertainty
- Data Analysis and Exploitation
- Need for including experience and expertise (knowledge)

- Computational tools: Decision Support Systems (DSS)
- Intelligent Computational Tools: Intelligent Decision Support Systems (IDSS)
Decision Support Systems

Definition

- A Decision Support System (DSS) is a system under the control of *one or more decision makers* that *assists in the activity of decision making* by providing an organised *set of tools* intended to impart structure to portions of the decision-making situation and to *improve the ultimate effectiveness of the decision outcome* [Marakas, 1999].

- A Decision Support System (DSS) is a system which lets *one or more people* to *make decision/s* in a concrete domain, in order to manage it the best way, selecting at each time the best alternative among a set of alternatives, which generally are contradictory.
Decision Support Systems

- **DSS in Business and Management**
  - Decisions on prices
  - Decisions on products
  - Decisions on marketing
  - Decisions on employees
  - Decisions on strategic planning

- **DSS in Engineering**
  - Decisions on product design
  - Decisions on process supervision / control

- **DSS in Financial Entities**
  - Decisions on loans

- **DSS in Medicine**
  - Decisions about presence/absence of illness
  - Decisions on medical treatments
  - Decisions on specialised medical machine control

- **DSS in Environmental Systems (EDSS)**
  - Decision about reliable and safe environmental system management
EVOLUTION OF DECISION SUPPORT SYSTEMS

Advanced Decision Support Systems

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Advanced Decision Support Systems (1)

Definitions

- DSS are a *model-based* set of procedures for *processing data and judgments* to *assist a manager in his/her decision* [Little, 1970]

- DSS couple the intellectual resources of individuals with the capabilities of the computer to *improve the quality of decisions*. It’s a *computer-based support for management decision makers* who deal with *semi-structured problems* [Keen & Scott-Morton, 1978]

- DSS is a system that is *extendable*, capable of *supporting ad hoc analysis and decision modelling*, oriented towards *future planning*, and of being used at irregular, unplanned intervals [Moore & Chang, 1980]
Advanced Decision Support Systems (2)

Definitions

- DSS enable managers to use data and models related to an entity (object) of interest to solve semi-structured and unstructured problems with which they are faced [Beulens & Van Nunen, 1988]

- Main feature of DSS rely in the model component. Formal quantitative models such as statistical, simulation, logic and optimisation models are used to represent the decision model, and their solutions are alternative solutions [Emery, 1987; Bell, 1992]

- DSS are systems for extracting, summarising and displaying data [McNurlin & Sprague, 1993]
Advanced Decision Support Systems (3)

Tasks

- Data Analysis
- Monitoring / Control
- Prediction
- Planning
- Management
- Data Recording / Retrieval
Advanced Decision Support Systems (4)

Models

- Statistical /Numerical Models
  - Linear Models, Logistic Regressions
  - Clustering
  - Data Analysis (PCA, DA, SCA, MCA...)
  - Markovian Models

- Simulation Models

- Control Algorithms

- Optimization Techniques
  - Linear Programming
  - Queue Models
  - Inventory Models
  - Transport Models
  - Multiple Criteria Decision Analysis/Making (MCDA/MCDM)
Advanced Decision Support Systems (5)
From observations to decisions [adapted from A.D. Witakker, 1993]
Intelligent Decision Support Systems (6)

Intelligence Density [V. Dhar & R. Stein, 1997]

- **Intelligence Density**: the amount of useful decision support information that a decision maker gets from using the output from some analytic system (IDSS) for a certain amount of time.
- How much of the IDSS output do you have to examine before you can make a decision of a specified quality?
- How quickly can you get the essence (knowledge) of the underlying data from the IDSS output?
- Conceptually, **Intelligence Density** can be viewed as the ratio of the number of utiles (utility units) of decision-making power gleaned (quality) to the number of units of analytic time spent by the decision maker.
INTELLIGENT DECISION SUPPORT SYSTEMS
Intelligent Decision Support Systems (1)

Definitions

- An IEDSS is an intelligent information system that reduces the time in which decisions are made in an environmental domain, and improves the consistency and quality of those decisions [Haagsma & Johanns, 1994]

- A DSS is a computer system that assists decision makers in choosing between alternative beliefs or actions by applying knowledge about the decision domain to arrive at recommendations for the various options. It incorporates an explicit decision procedure based on a set of theoretical principles that justify the “rationality” of this procedure [Fox & Das, 2000]
Intelligent Decision Support Systems (2)

Definitions

- The use of *Artificial Intelligence tools and models* provides direct access to expertise, and their flexibility makes them capable of *supporting learning and decision making processes*. Their *integration with numerical and/or statistical models* in a single system provides higher accuracy, reliability and utility [Cortés *et al.*, 2000]
Intelligent Decision Support Systems (IDSS) [1]

Typology

● Static IDSS
  ▪ IDSS giving punctual support to decision-making (off-line), and are mainly used to justify multi-criteria decisions of policy-makers more than to make real decisions on a day-to-day basis.
  ▪ Examples: Industrial process design systems, Training systems for emergency management

● Dynamic IDSS
  ▪ IDSS aiming at controlling or supervising a process in real-time (on-line), facing similar situations on a regular basis.
  ▪ Example: Wastewater Treatment Plant Supervisory System, Patient Disease Management System

● Hard-Constrained Dynamic IDSS
  ▪ Dynamic IDSS facing hard real-time constraints or hard possible catastrophic consequences
  ▪ Examples: Automatic Supervisory System in a Medical Intensive Cure Unit, Environmental Emergency Management System
Static IDSS

- What-if scenarios
- Exploration of the response surface and the stability of the solution
- How sensitive our decision is to small variations in the given weight and value of the relevant variables (sensitivity analysis)?
- The role of socio-cultural and economic issues limits the use of standard databases.
- Confidence can not be increased in the results when facing similar situations, because these IDSS are very specific and sometimes are only built to make or justify one decision.
Dynamic IDSS

- Guarantee robustness against noise
- Manage missing data, typos and any combination of input data
- Past experience can be used to help in the decision-making problem
- The end-user is responsible for accepting, refining or rejecting system solutions

Typology

- Model-driven DSS / Model-centric DSS
  - First-Principle / Mechanistic Models
  - Decision Analysis Models
    - Analytical Hierarchical Process (AHP) Models
    - Decision Matrix & Decision Table Models
    - Decision Tree Models
  - Optimization Models
    - Multi-attribute & Multi-criteria Models
  - Simulation Models
    - Monte Carlo Simulation Models
    - Discrete-Event Simulation Models
    - Agent-based Simulation Models
- Expert-based Models
- Model-based Reasoning Models
- Qualitative Reasoning Models

Typology

- Data-driven DSS / Data-centric DSS
  - Direct-data Exploration Models
    - Data-reporting DSS (averages, totals, data distributions, etc.)
    - Data-analytic / Data-intensive DSS
      - Database querying Models
      - Executive Information System (EIS) Models (front-end for fixed predefined database queries & reports)
      - Data warehouse & OLAP system Models (open database queries & reports)
  - Data Model Exploration Models (Data Mining Models) [IDSS]
    - Unsupervised Models
      - Descriptive Models
      - Associative Models
    - Supervised Models
      - Discriminant Models
      - Predictive Models
Conceptual Components of an IDSS

**Artificial Intelligence Techniques**
- Temporal Reasoning
- Uncertainty Management

**Statistical / Numerical Methods**

**Geographical Information Systems / Complementary Systems**
- Spatial Reasoning

**Environmental / Health / Management / Business Ontologies**

**Intelligent Decision Support Systems**
- Validation of IDSS
- Economical Costs

**Temporal Reasoning**

**Validation of IDSS**

**Economical Costs**
IDSS Analysis and Design
Requirements, advantages and limitations
IDSS Requirements

- Type of decision problem (policy, operations, resource allocation, etc.)
- Domain and scope of the decision problem
- Data and knowledge availability
- Organizational and structural boundaries
- Decision-making process
- Impact on and synergy with the existing systems
- Expected consequences of decision execution
- Profiles of decision-makers (users of the system)
- External constraints and contexts
- Objectives of the IDSS
Kind of Support provided by an IDSS

[Marakas, 1999]

- Identify the need for decisions
- Identify specific problems that require attention
- Solve or assist in solving problems
- Help compensate for cognitive limitations of human decision makers
- Provide assistance in the form of advice, analysis, or evaluation
- Enhance user creativity, imagination, or insight
- Facilitate interactions in multiparticipant decision maker settings
IDSS Requirements and Analysis
IDSS Architecture
Dynamic Intelligent Decision Support System (IDSS)

[Sànchez-Marrè et al., 2000]
IDSS Design and Development
A possible framework
Cognitive-oriented approach for IDSS development (1)
[Sànchez-Marrè, 2008]

● Analysis tasks
  ■ Most of interpretative processes are run.
  ■ Data gathering processes,
  ■ Knowledge discovery process by means of some data mining techniques
  ■ Getting *diagnostic models*.

● Synthesis tasks
  ■ This layer wraps all the work necessary to *synthesize possible alternative solutions* for the different diagnostics found in the previous step.

● Prognosis tasks
  ■ Inherent ability of IDSS to *decision support* tasks.
  ■ The several *predictive models*, which can be numerical (mostly simulations) or rather qualitative (qualitative reasoning or qualitative simulations), are used to estimate the consequences of several actions proposed in the previous step by the solution generation methods.
Cognitive-oriented approach for IDSS development (2) [Sànchez-Marrè, 2008]
Design and Building of an IDSS
IDSS Validation

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IDSS Validation Criteria (1)
Adapted from [Klein & Methlie, 1995]

- System Performance
  - Efficiency and response time
  - Data entry
  - Output format
  - Hardware
  - Usage
  - Man-machine interface

- Task performance
  - Decision-making time, alternatives, analysis, quality and participants
  - User perceptions of trust, satisfaction and understanding
IDSS Validation Criteria (2)
Adapted from [Klein & Methlie, 1995]

- Business Opportunities
  - Costs of development, operation, and maintenance
  - Benefits associated with increased income and reduced costs
  - Value to the organization of better service, competitive advantage, and training

- Evolutionary Aspects
  - Degree of flexibility, ability to change
  - Overall functionality of the development tool
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