Chapter 2: Decision Making, Systems, Modeling, and Support

- **Conceptual Foundations of Decision Making**
- **The Systems Approach**
- **How Support is Provided**

2.1 Opening Vignette:

How to Invest $1,000,000

2.2 Introduction and Definitions

Typical Business Decision Aspects

- Decision may be made by a group
- Several, possibly contradictory objectives
- Hundreds or thousands of alternatives
- Results can occur in the future
- Attitudes towards risk
- "What-if" scenarios
- Trial-and-error experimentation with the real system: may result in a loss
- Experimentation with the real system can only be done once
- Changes in the environment can occur continuously

- **How are decisions made???**
- **What methodologies can be applied?**
- **What is the role of information systems in supporting decision making?**

DSS

- ***Decision***
- ***Support***
- ***Systems***

Decision Making

- ***Decision Making***: **a process of choosing among alternative courses of action for the purpose of attaining a goal or goals**

- ***Managerial Decision Making is synonymous with the whole process of management*** **(Simon [1977])**

Decision Making versus Problem Solving

Simon's 4 Phases of Decision Making

1. **Intelligence**
2. **Design**
3. **Choice**
4. **Implementation**

Decision making **and** ***problem solving*** **are interchangeable**

2.3 Systems

- A ***SYSTEM*** **is a collection of objects such as people, resources, concepts, and procedures intended to perform an identifiable function or to serve a goal**

- **System Levels (Hierarchy): All systems are *subsystems* interconnected through *interfaces***

The Structure of a System

Three Distinct Parts of Systems (Figure 2.1)

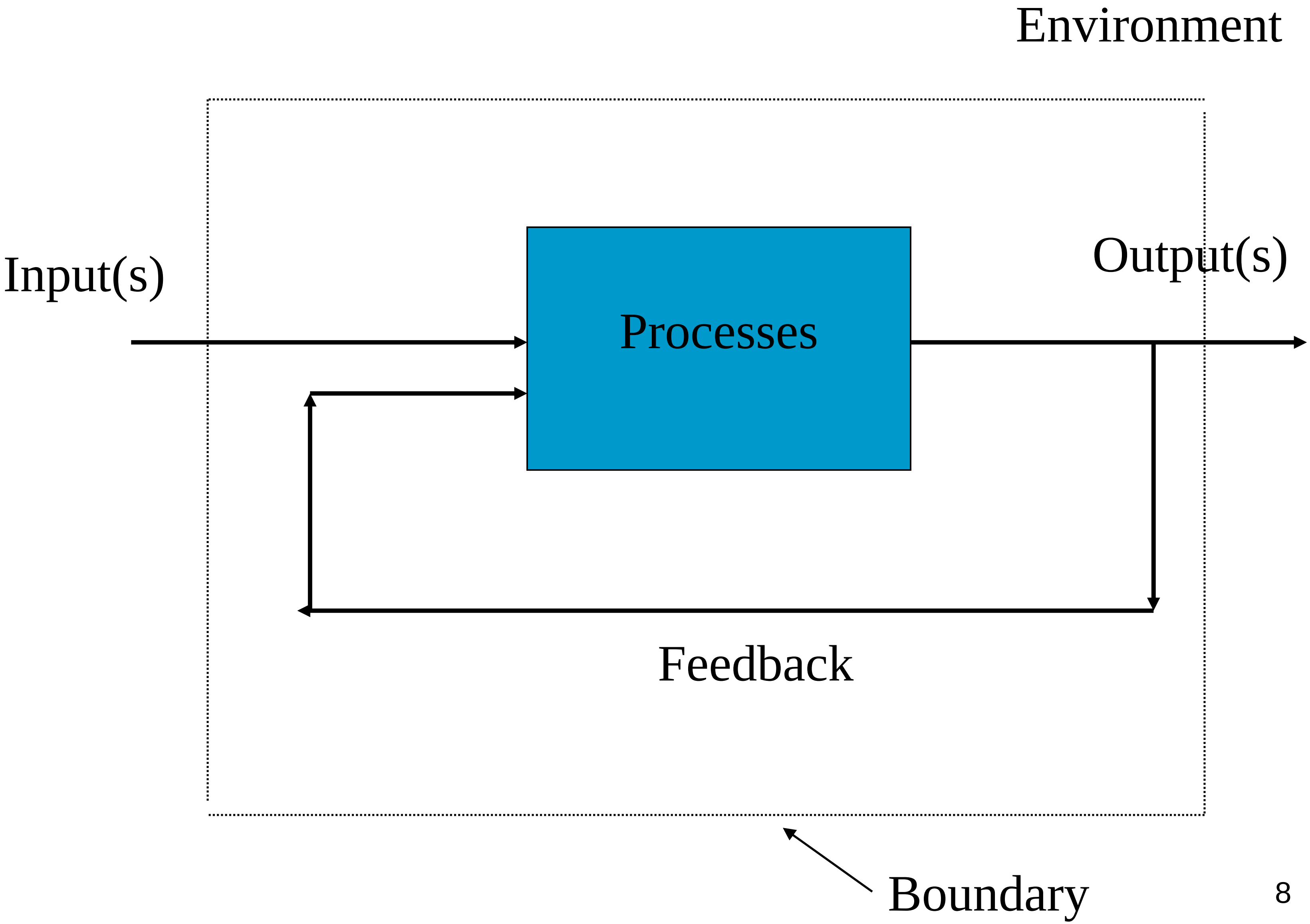
- Inputs
- Processes
- Outputs

Systems

- Are surrounded by an environment
- Frequently include a feedback mechanism

A human, the decision maker, is usually considered part of the system

System



- **Inputs** are elements that enter the system
- **Processes** convert or transform the inputs into outputs
- **Outputs** describe the finished products or the consequences of being in the system
- **Feedback** is the flow of information from the output to the decision maker, who may modify the inputs or the processes (closed loop)
- The **Environment** contains the elements that lie outside but impact the system's performance

How to Identify the Environment?

Answer <u>Two</u> Questions (Churchman [1975])

1. Does the element matter relative to the system's goals? [YES]
2. Is it possible for the decision maker to significantly manipulate this element? [NO]

Environmental Elements Can Be

- **Social**
- **Political**
- **Legal**
- **Physical**
- **Economical**
- **Often Other Systems**

The Boundary Separates a System From Its Environment

- **Boundaries may be physical or nonphysical (by definition of scope or time frame)**
- **Information System Boundaries are Usually Directly Defined!**

Closed and Open Systems

Defining manageable boundaries is *closing* the system

- **A <u>Closed System</u> is totally independent of other systems and subsystems**
- **An <u>Open System</u> is very dependent on its environment**

TABLE 2.1 A Closed Versus an Open Inventory System

Factors	Management Science, EOQ (Closed System)	Inventory DSS (Open System)
Demand	Constant	Variable, influenced by many factors
Unit cost	Constant	May change daily
Lead time	Constant	Variable, difficult to predict
Vendors and users	Excluded from analysis	May be included in analysis
Weather and other environmental factors	Ignored	May influence demand and lead time

An Information System

- **Collects, processes, stores, analyzes, and disseminates information for a specific purpose**
- **Is often at the heart of many organizations**
- **Accepts inputs and processes data to provide information to decision makers and helps decision makers communicate their results**

System Effectiveness and Efficiency

Two Major Classes of Performance Measurement

- ***Effectiveness*** **is the degree to which goals are achieved**
  Doing the right thing!

- **Efficiency is a measure of the use of inputs (or resources) to achieve outputs**
  Doing the thing right!

- **MSS emphasize *effectiveness***
  Often: several non-quantifiable, conflicting goals

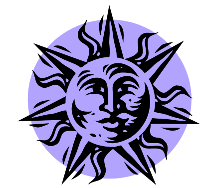
2.4 Models

- **Major Component of DSS**
- **Use Models instead of experimenting on the real system**

- **A *model* is a simplified representation or abstraction of reality.**
- **Reality is generally too complex to copy exactly**
- **Much of the complexity is actually *irrelevant* in problem solving**

Degrees of Model Abstraction

(Least to Most)



- ***<u>Iconic (Scale) Model</u>*: Physical replica of a system**
- ***<u>Analog Model</u>* behaves like the real system *but* does *not* look like it (symbolic representation)**
- ***<u>Mathematical (Quantitative) Models</u>* use mathematical relationships to represent complexity**
  Used in most DSS analyses

Benefits of Models

An MSS employs models because

1. Time compression
2. Easy model manipulation
3. Low cost of construction
4. Low cost of execution (especially that of errors)
5. Can model risk and uncertainty
6. Can model large and extremely complex systems with possibly infinite solutions
7. Enhance and reinforce learning, and enhance training.

<u>Computer graphics</u> advances: more iconic and analog models (visual simulation)

2.5 The Modeling Process-- A Preview

Example: How Much to Order for the Ma-Pa Grocery?

- **The Owners: Bob and Jan**
- **The Question: How much bread to stock each day?**

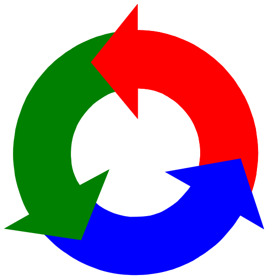
Several Solution Approaches

- **Trial-and-Error**
- **Simulation**
- **Optimization**
- **Heuristics**

The Decision-Making Process

Systematic Decision-Making Process (Simon [1977])

- **Intelligence**
- **Design**
- **Choice**
- **Implementation**



(See Figure 2.2)

Modeling is <u>Essential</u> to the Process

- **Intelligence phase**
  - Reality is examined
  - The problem is identified and defined
- **Design phase**
  - Representative model is constructed
  - The model is validated and evaluation criteria are set
- **Choice phase**
  - Includes a proposed solution to the ***model***
  - If reasonable, move on to the
- **Implementation phase**
  - Solution to the original problem

Failure: Return to the modeling process

Often Backtrack / Cycle Throughout the Process

2.6 The Intelligence Phase

Scan the environment to identify problem situations or opportunities

Find the Problem

- **<u>Identify</u> organizational goals and objectives**
- **<u>Determine</u> whether they are being met**
- **Explicitly <u>define</u> the problem**

Problem Classification

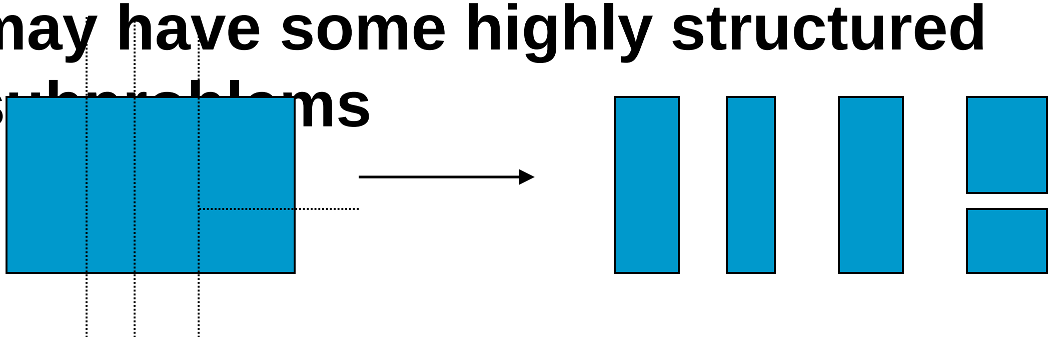
According to the Degree of Structuredness

Programmed versus Nonprogrammed Problems
Simon [1977])

Nonprogrammed Problems ⟷ **Programmed Problems**

- **Problem Decomposition:** Divide a complex problem into (easier to solve) subproblems Sometimes called Chunking - (Salami Approach)

- **Some seemingly poorly structured problems may have some highly structured subproblems**



- **Problem Ownership**

Outcome: Problem Statement

2.7 The *Design* Phase

- **Generating, developing, and analyzing possible courses of action**

<u>Includes</u>

- **Understanding the problem**
- **Testing solutions for feasibility**
- **A model is constructed, tested, and validated**

<u>Modeling</u>

- **Conceptualization of the problem**
- **Abstraction to quantitative and/or qualitative forms**

Mathematical Model

- **Identify Variables**
- **Establish Equations describing their Relationships**
- **Simplifications through *Assumptions***
- **Balance Model Simplification and the Accurate Representation of Reality**

***Modeling*: An Art and Science**

Quantitative Modeling Topics

- Model Components
- Model Structure
- Selection of a Principle of Choice (Criteria for Evaluation)
- Developing (Generating) Alternatives
- Predicting Outcomes
- Measuring Outcomes
- Scenarios

Components of Quantitative Models

(Figure 2.3)

- Decision Variables
- Uncontrollable Variables (and/or Parameters)
- Result (Outcome) Variables
- Mathematical Relationships

  or
- Symbolic or Qualitative Relationships

Results of Decisions are Determined by the

- Decision
- Uncontrollable Factors
- Relationships among Variables

Result Variables

- Reflect the level of effectiveness of the system
- *Dependent variables*
- Examples - Table 2.2

Decision Variables

- Describe alternative courses of action
- The decision maker ***controls*** them

TABLE 2.2 Examples of the Components of Models.

Area	Decision Variables	Result Variables	Uncontrollable Variables and Parameters
Financial investment	Investment alternatives and amounts How long to invest When to invest	Total profit Rate of return (ROI) Earnings per share Liquidity level	Inflation rate Prime rate Competition
Marketing	Advertising budget Where to advertise	Market share Customer satisfaction	Customers' income Competitors' actions
Manufacturing	What and how much to produce Inventory levels Compensation programs	Total cost Quality level Employee satisfaction	Machine capacity Technology Materials prices
Accounting	Use of computers Audit schedule	Data processing cost Error rate	Computer technology Tax rates Legal requirements
Transportation	Shipments schedule	Total transport cost	Delivery distance Regulations
Services	Staffing levels	Customer satisfaction	Demand for services

Uncontrollable Variables or Parameters

- **Factors that affect the result variables**
- ***Not under the control*** **of the decision maker**
- **Generally part of the environment**
- **Some constrain the decision maker and are called *constraints***
- **Examples - Table 2.2**

Intermediate Result Variables

- **Reflect intermediate outcomes**

The Structure of Quantitative Models

- **Mathematical expressions (e.g., equations or inequalities) connect the components**

- **Simple financial-type model**
  $P = R - C$

- **Present-value model**
  $P = F / (1+i)^n$

Example

The Product-Mix Linear Programming Model

- **MBI Corporation**
- **Decision: How many computers to build next month?**
- **Two types of computers**
- **Labor limit**
- **Materials limit**
- **Marketing lower limits**

Constraint	**CC7**	**CC8**	**Rel**	**Limit**	
Labor (days)	300	500	<=	200,000 / mo	
Materials $	10,000	15,000	<=	8,000,000/mo	
Units		1		>=	100
Units			1	>=	200
Profit $	8,000	12,000	Max		

Objective: Maximize Total Profit / Month

Linear Programming Model

(DSS In Focus 2.1)

- **Components**
  Decision variables
  Result variable
  Uncontrollable variables (constraints)

- ***Solution***
  $X_1 = 333.33$
  $X_2 = 200$
  Profit = $5,066,667

DSS In Focus 2.2: Optimization Models

- Assignment (best matching of objects)
- Dynamic programming
- Goal programming
- Investment (maximizing rate of return)
- Linear programming
- Network models for planning and scheduling
- Nonlinear programming
- Replacement (capital budgeting)
- Simple inventory models (such as, economic order quantity)
- Transportation (minimize cost of shipments)

The Principle of Choice

- What criteria to use?
- Best solution?
- Good enough solution?

Selection of a Principle of Choice

A decision regarding the acceptability of a solution approach

- Normative
- Descriptive

Normative Models

- The chosen alternative is demonstrably the best of all
- *Optimization* process

- Normative decision theory is based on ***rational*** decision makers

- Humans are economic beings whose objective is to maximize the attainment of goals; that is, the decision maker is rational
- In a given decision situation, all viable alternative courses of action and their consequences, or at least the probability and the values of the consequences, are known
- Decision makers have an order or preference that enables them to rank the desirability of all consequences of the analysis

Suboptimization

- Narrow the boundaries of a system
- Consider a part of a complete system
- Leads to (possibly very good, but) non-optimal solutions
- Viable method

Descriptive Models

- **Describe things as they are, or as they are believed to be**
- **Extremely useful in DSS for evaluating the consequences of decisions and scenarios**
- **No guarantee a solution is optimal**
- **Often a solution will be "good enough"**
- ***Simulation*: Well-known descriptive modeling technique**

DSS In Focus 2.3: Descriptive Models

- Information flow
- Scenario analysis
- Financial planning
- Complex inventory decisions
- Markov analysis (predictions)
- Environmental impact analysis
- Simulation (different types)
- Technological forecasting
- Waiting line (queueing) management

Satisficing (Good Enough)

- Most human decision makers will settle for a good enough solution
- There is a tradeoff between the time and cost of searching for an optimum versus the value of obtaining one
- A good enough or satisficing solution may be found if a certain goal level is attained

(Simon [1977])

Why Satisfice?
Bounded Rationality (Simon)

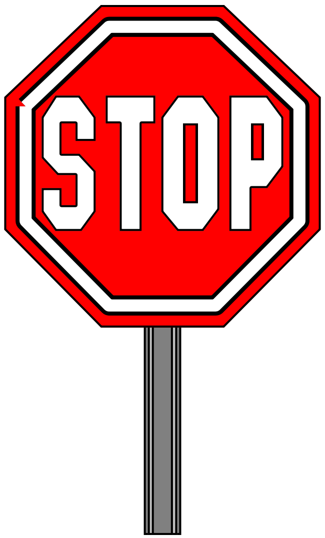
- Humans have a **limited capacity** for rational thinking
- They generally construct and analyze a **simplified model**
- Their **behavior** with respect to the simplified model may be rational
- But, the rational solution for the simplified model may **NOT BE** rational in the real-world situation
- Rationality is **bounded** not only by limitations on human processing capacities, but also by individual differences
- Bounded rationality is why many models are **descriptive, not normative**

Developing (Generating) Alternatives

- **In Optimization Models: Automatically by the Model!**

  Not Always So!

- **Issue: When to Stop?**



Predicting the Outcome of Each Alternative

- **Must predict the future outcome of each proposed alternative**
- **Consider what the decision maker knows (or believes) about the forecasted results**
- **Classify Each Situation as Under**
  - **Certainty**
  - **Risk**
  - **Uncertainty**

Decision Making Under Certainty

- *Assumes* that complete knowledge is available (deterministic environment)
- Example: U.S. Treasury bill investment
- Typically for structured problems with short time horizons
- Sometimes DSS approach is needed for certainty situations

Decision Making Under Risk (Risk Analysis)

- (Probabilistic or stochastic decision situation)
- Decision maker must consider several possible outcomes for each alternative, each with a given probability of occurrence
- Long-run probabilities of the occurrences of the given outcomes are assumed known or can be estimated
- Decision maker can assess the degree of risk associated with each alternative (*calculated* risk)

Risk Analysis

- **Calculate the expected value of each alternative**
- **Selecting the alternative with the best expected value.**
- **Example: Poker game with some cards face up (7 card game - 2 down, 4 up, 1 down)**

Decision Making Under Uncertainty

- Situations in which several outcomes are possible for each course of action
- *BUT* the decision maker does not know, or cannot estimate, the probability of occurrence of the possible outcomes

- More difficult - insufficient information
- Modeling involves assessing the decision maker's (and/or the organizational) attitude toward risk
- Example: Poker game with no cards face up (5 card stud or draw)

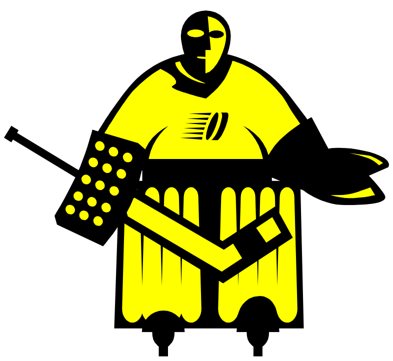
Measuring Outcomes

- **Goal attainment**
- **Maximize profit**
- **Minimize cost**
- **Customer satisfaction level (Minimize number of complaints)**
- **Maximize quality or satisfaction ratings (found by surveys)**

Scenarios

Useful in

- **Simulation**
- **What-if analysis**



Importance of Scenarios in MSS

- **Help identify potential opportunities and/or problem areas**
- **Provide flexibility in planning**
- **Identify leading edges of changes that management should monitor**
- **Help *validate* major assumptions used in modeling**
- **Help check the sensitivity of proposed solutions to changes in scenarios**

Possible Scenarios

- Many, but …
  - Worst possible (Low demand, High costs)
  - Best possible (High demand, High Revenue, Low Costs)
  - Most likely (Typical or average values)

- The scenario sets the stage for the analysis

2.8 The Choice Phase

- Search, evaluation, and recommending an appropriate *solution* to the model
- Specific set of values for the decision variables in a selected alternative

  The problem is considered solved after the recommended solution to the model is *successfully implemented*

Search Approaches

- Analytical Techniques
- Algorithms (Optimization)
- Blind and Heuristic Search Techniques

TABLE 2.3 Examples of Heuristics

Sequence jobs through a machine	Do the jobs that require the least time first.
Purchase stocks	If a price-to-earnings ratio exceeds 10, then do not buy the stocks.
Travel	Do not use the freeway between 8 and 9 a.m.
Capital investment in high-tech projects	Consider only those projects whose estimated payback period is less than two years.
Purchase of a house	Buy only in a good neighborhood, but buy only in the lower price range.

2.9 Evaluation: Multiple Goals, Sensitivity Analysis, "What-If," and Goal Seeking

- Evaluation (coupled with the search process) leads to a recommended solution
- Multiple Goals
- Complex systems have multiple goals
  Some may conflict
- Typical quantitative models have a single goal
- Can transform a multiple-goal problem into a single-goal problem

Common Methods

- Utility theory
- Goal programming
- Expression of goals as constraints, using linear programming
- Point system

- Computerized models can support multiple goal decision making

Sensitivity Analysis

- **Change inputs or parameters, look at model results**

  Sensitivity analysis checks relationships

Types of Sensitivity Analyses

- **Automatic**
- **Trial and error**

Trial and Error

- **Change input data and re-solve the problem**
- **Better and better solutions can be discovered**
- **How to do? Easy in spreadsheets (Excel)**
  - **what-if**
  - **goal seeking**

What-If Analysis

- **Figure 2.8 - SSpreadsheet example of a what-if query for a cash flow problem**

Goal Seeking

- **Backward solution approach**
- **Example: Figure 2.9**
- **Example: What interest rate causes an the net present value of an investment to break even?**

- **In a DSS the what-if and the goal-seeking options *must* be easy to perform**

2.10 The Implementation Phase

There is nothing more difficult to carry out, nor more doubtful of success, nor more dangerous to handle, than to initiate a new order of things (Machiavelli [1500s])
***** The Introduction of a *Change* *****

Important Issues

- **Resistance to change**
- **Degree of top management support**
- **Users' roles and involvement in system development**
- **Users' training**

2.11 How Decisions Are Supported

Specific MSS technologies relationship to the decision making process (see Figure 2.10)

- **Intelligence: DSS, ES, ANN, MIS, Data Mining, OLAP, EIS, GDSS**
- **Design and Choice: DSS, ES, GDSS, Management Science, ANN**
- **Implementation: DSS, ES, GDSS**

2.12 Human Cognition and Decision Styles

Cognition Theory

- **Cognition: Activities by which an individual resolves differences between an internalized view of the environment and what actually exists in that same environment**
- **Ability to perceive and understand information**
- **Cognitive models are attempts to explain or understand various human cognitive processes**

Cognitive Style

- **The subjective process through which individuals perceive, organize, and change information during the decision-making process**
- **Often determines people's preference for human-machine interface**
- **Impacts on preferences for qualitative versus quantitative analysis and preferences for decision-making aids**

Cognitive style research impacts on the design of management information systems

- **Analytic decision maker**
- **Heuristic decision maker**

(See Table 2.4)

TABLE 2.4 Cognitive-style Decision Approaches.

Problem-solving Dimension	Heuristic	Analytic
Approach to learning	Learns more by acting than by analyzing the situation and places more emphasis on feedback.	Employs a planned sequential approach to problem solving; learns more by analyzing the situation than by acting and places less emphasis on feedback.
Search	Uses trial and error and spontaneous action.	Uses formal rational analysis.
Approach to analysis	Uses common sense, intuition, and feelings.	Develops explicit, often quantitative, models of the situation.
Scope of analysis	Views the totality of the situation as an organic whole rather than as a structure constructed from specific parts.	Reduces the problem situation to a set of underlying causal functions.
Basis for inferences	Looks for highly visible situational differences that vary with time.	Locates similarities or commonalities by comparing objects.

(*Source*: G. B. Davis. *Management Information Systems: Conceptual Foundations, Structure, and Development.* New York: McGraw-Hill, 1974, p. 150. Reproduced with permission of McGraw-Hill, Inc.)

Decision Styles

The manner in which decision makers

- **Think and react to problems**
- **Perceive**
  - **Their cognitive response**
  - **Their values and beliefs**

- **Varies from individual to individual and from situation to situation**
- **Decision making is a nonlinear process**

The manner in which managers make decisions (and the way they interact with other people) describes their decision style

- **There are dozens**

Some Decision Styles

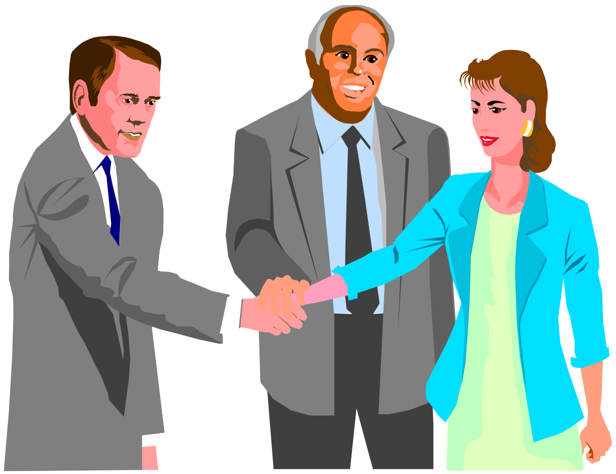
- Heuristic
- Analytic
- Autocratic
- Democratic
- Consultative (with individuals or groups)
- Combinations and variations

- For successful decision making support, an MSS must fit the
  - Decision situation
  - Decision style

- **The system**
  - should be flexible and adaptable to different users
  - have what-if and goal-seeking
  - have graphics
  - have process flexibility
- **An MSS should help decision makers use and develop their own styles, skills, and knowledge**
- **Different decision styles require different types of support**
- **Major factor: individual or group decision maker**

2.13 The Decision Makers

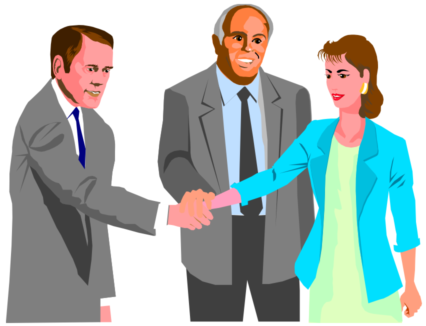
- **Individuals**
- **Groups**



Individuals

- May still have conflicting objectives
- Decisions may be fully automated

Groups



- Most major decisions in medium and large organizations are made by groups
- Conflicting objectives are common
- Variable size
- People from different departments
- People from different organizations
- The group decision making process can be very complicated
- Consider Group Support Systems (GSS)

- Organizational DSS can help in enterprise-wide decision making situations

Summary

- Managerial decision making is <u>synonymous</u> with the whole process of management
- Problem solving also refers to opportunity's evaluation
- A system is a collection of objects such as people, resources, concepts, and procedures intended to perform an identifiable function or to serve a goal
- DSS deals primarily with open systems
- A model is a simplified representation or abstraction of reality
- Models enable fast and inexpensive experimentation with systems

Summary (cont.)

- **Modeling can employ optimization, heuristic, or simulation techniques**
- **Decision making involves four major phases: intelligence, design, choice, and implementation**
- **What-if and goal seeking are the two most common sensitivity analysis approaches**
- **Computers can support all phases of decision making by automating many of the required tasks**
- **Human cognitive styles may influence human-machine interaction**
- **Human decision styles need to be recognized in designing MSS**

Questions for the Opening Vignette

1. Identify the conflicting objectives
2. Identify the uncertainties
3. Identify the alternative courses of action (can they be combined?)
4. What are the possible results of the decision?

   Why may the results be difficult to predict?
5. What kind of risk is associated with the decision?
6. What were the decision-makers different "attitudes" toward risk? How could this influence the decision?
7. What would you do and why?

Group Project

- **Interview an individual who was recently involved in making a business decision. Try to identify:**

  1. The scope of the problem being solved
  2. The individuals involved in the decision (explicitly identify the problem owner(s))
  3. Simon's phases (you may have to ask the individual specific questions such as how he or she identified the problem, etc.)
  4. The alternatives (choices) and the decision chosen
  5. How the decision was implemented
  6. How computers were used or why they were not used

Produce a detailed report describing an analysis of the above and clearly state how closely the real-world decision making process compares to Simon's suggested process. Also, clearly identify how computers were used or why they were not used.