System

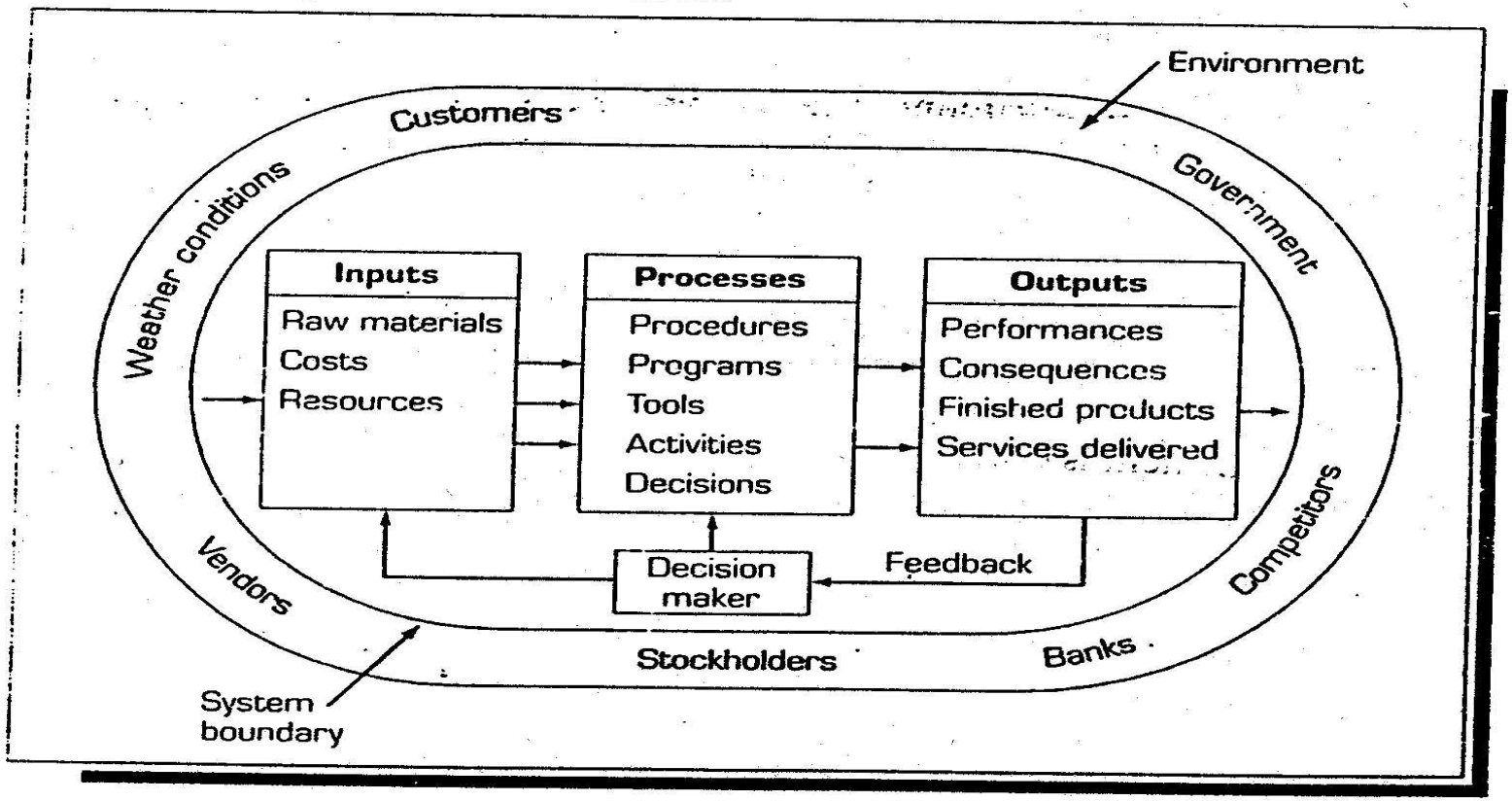
- **A system is a collection of objects such as people , resources , concepts and procedures intended to perform an identifiable function or to serve a goal(s) .**
  - ***Its clear that any system is a subsystem of the super-system***

The structure of a system

Systems are divided into three distinct parts: inputs, processes, and outputs. They are surrounded by an environment and often include a feedback mechanism . In addition a human decision maker is considered to be part of the system.

The structure of a system

FIGURE 2.1 The System and Its Environment.



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!***

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

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

Benefits of Models

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.

Computer graphics advances: more iconic and analog models (visual simulation)

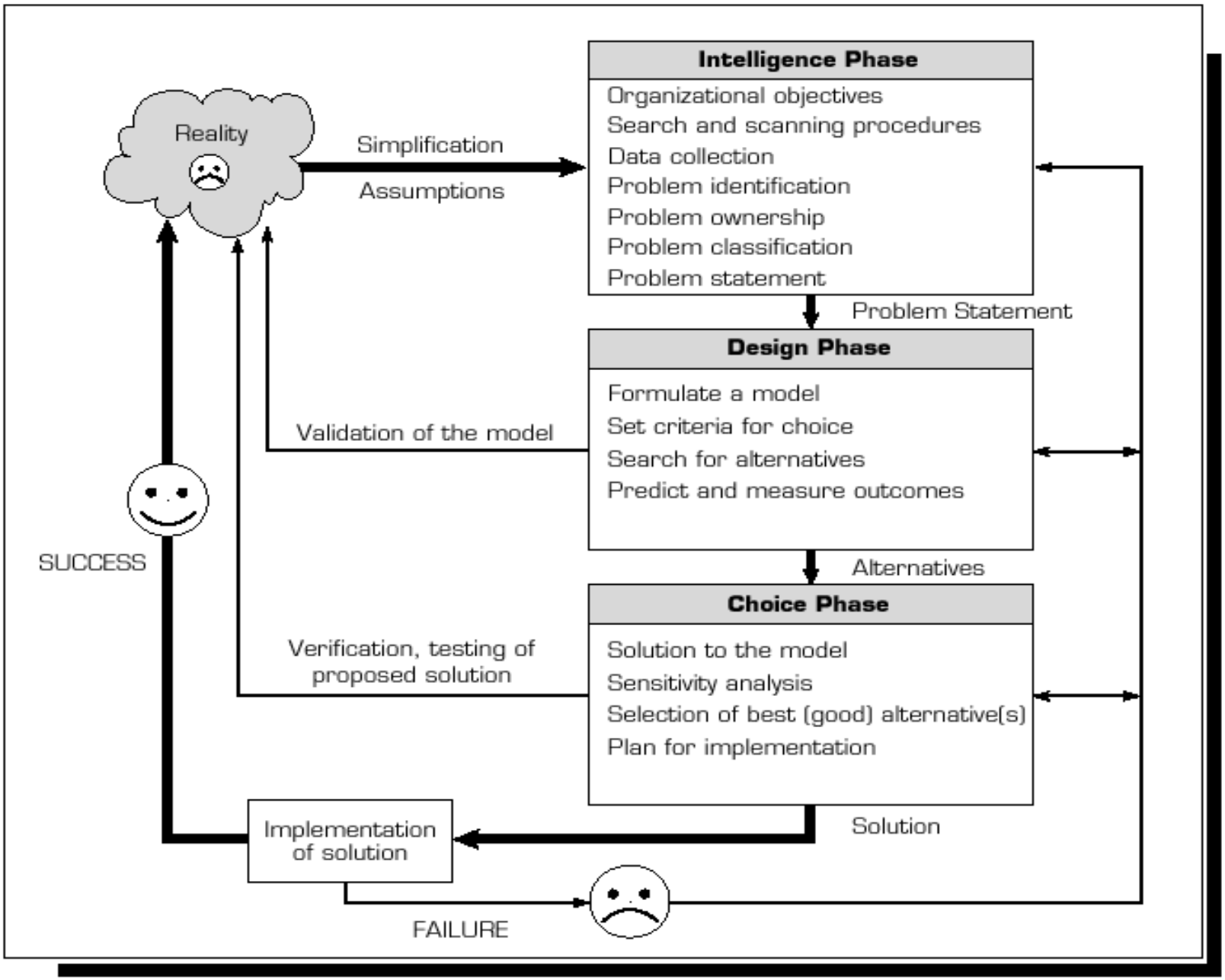
Decision Making:

is a process of choosing among alternative courses of action for the purpose of attaining a goal or goals .

The Decision-Making Process

- Intelligence
- Design
- Choice
- Implementation

Figure 2.2 The Decision-Making/Modeling Process



The Intelligence Phase

- Scan the environment to identify problem situations or opportunities

- Find the Problem
- Identify organizational goals and objectives
- Determine whether they are being met
- Explicitly define the problem

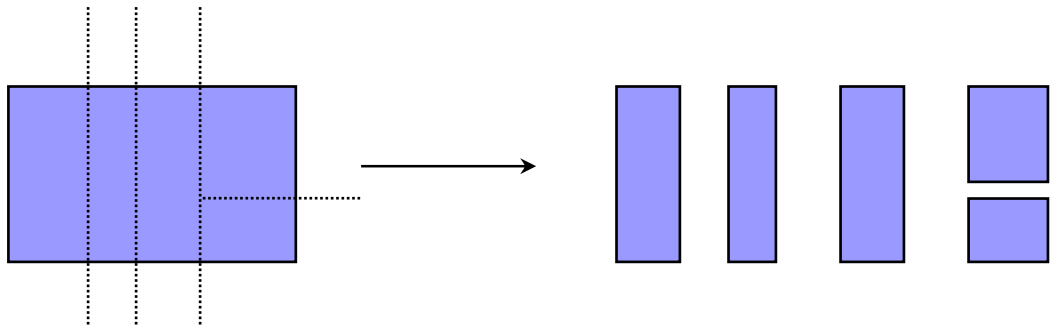
Problem Classification

Structured versus Unstructured

Programmed versus Nonprogrammed Problems
Simon (1977)

Nonprogrammed Problems ⟷ Programmed Problems

- Problem Decomposition:
  - Divide a complex problem into (easier to solve) subproblems
    Chunking (Salami)
- Some seemingly poorly structured problems may have some highly structured subproblems



- Problem Ownership

Outcome: Problem Statement

The Design Phase

- Generating, developing, and analyzing possible courses of action

Includes

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

Modeling

- 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

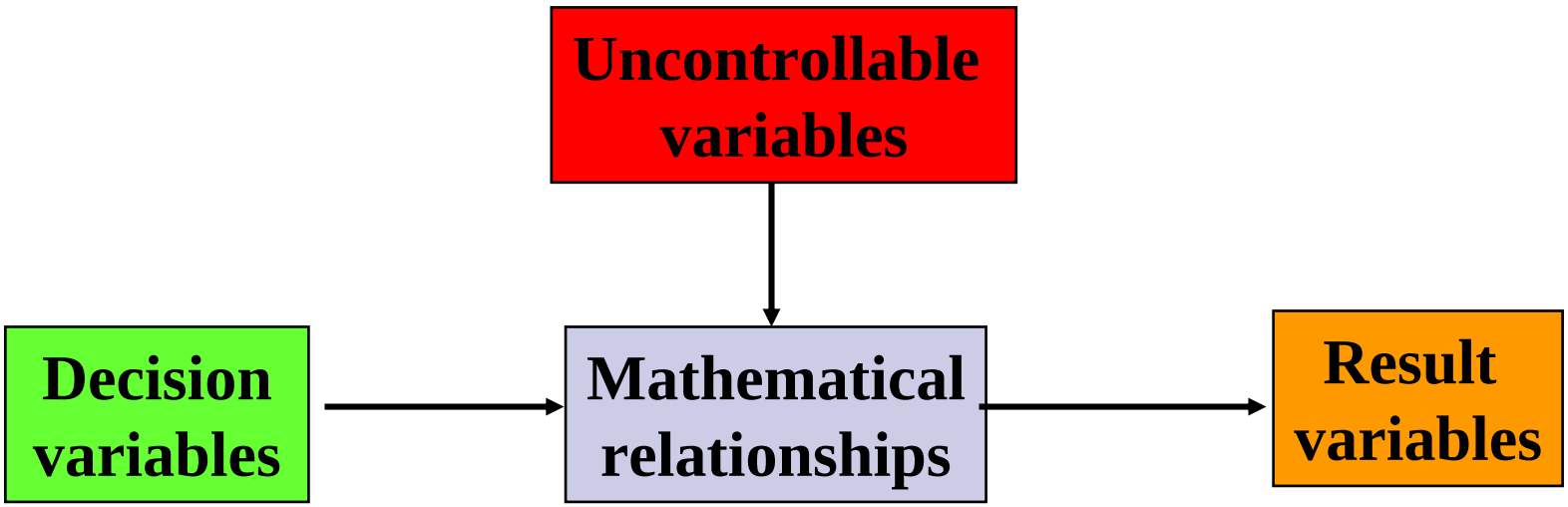
Quantitative Modeling Topics

- 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

- Decision Variables
- Uncontrollable Variables (and/or Parameters)
- Result (Outcome) Variables
- Mathematical Relationships or Symbolic or Qualitative Relationships (Figure 2.3)

The General Structure of a Quantitative Model



Quantitative Model
The General Structure

- Result Variables
  - Reflect the level of effectiveness of the system
  - *Dependent variables*
- Decision Variables
  - Describe alternative courses of action
  - The decision maker *controls* them
- Uncontrollable Variables
  - 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*
- Intermediate Result Variables
  - Reflect intermediate outcomes

Examples of the Components of Models

Area	Decision Variables	Result Variables	Uncontrollable Variable
Financial investment	■Investment alternatives & amounts ■How long to invest ■When to invest	■Total profit ■Risk ■ROI ■Earning/share ■Liquidity level	■Inflation rate ■Prime rate ■Competition
Marketing	■Advertising budget ■Where to advertise	■Market share ■Customer satisfaction	■Customer's income ■Competitor's actions

The Structure of Quantitative Models

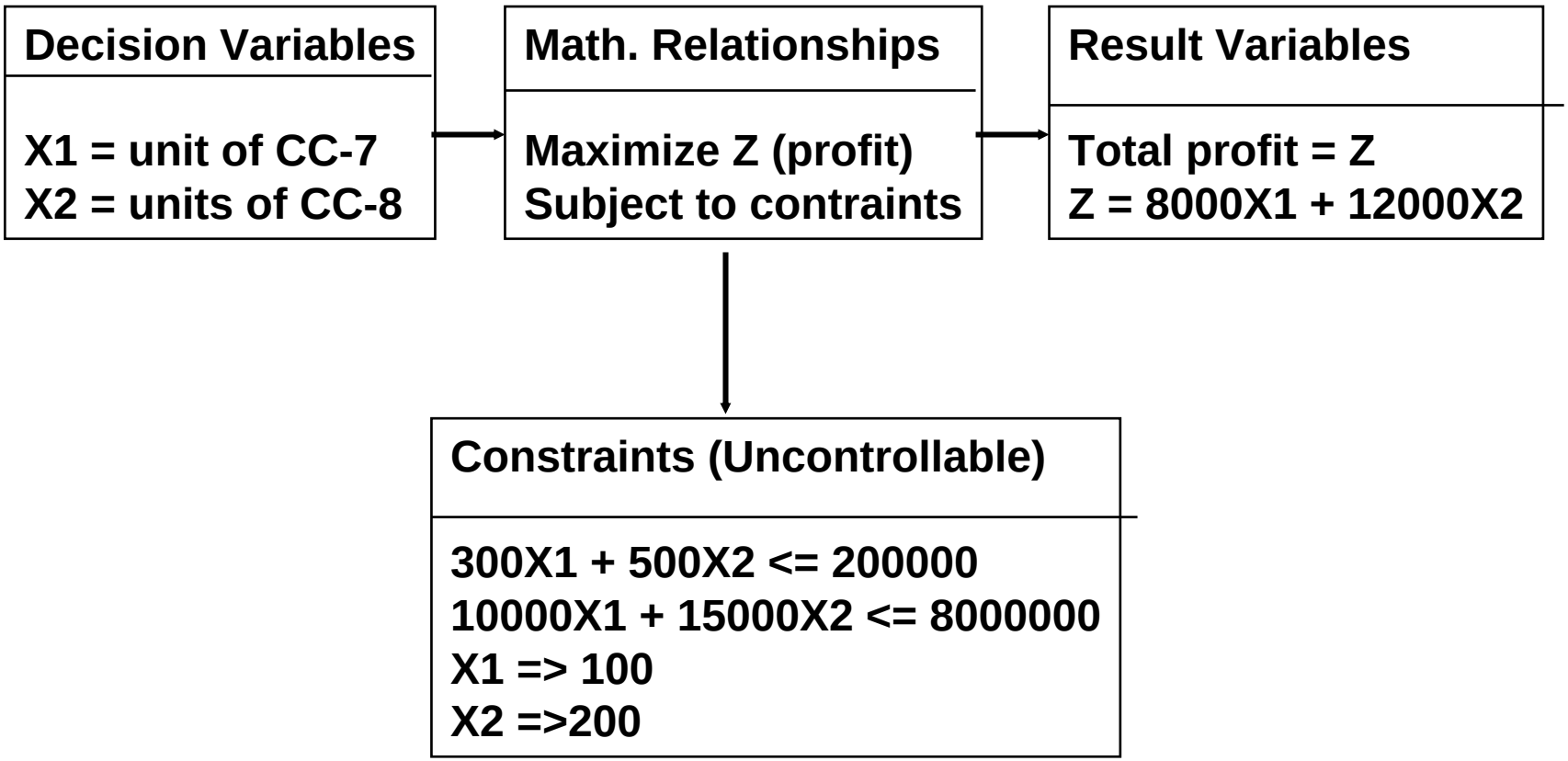
- Mathematical expressions (e.g., equations or inequalities) connect the components

- Simple financial model
  $P = R - C$

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

Mathematical Model

Product Mix Example



Selection of a Principle of Choice

- Not part of the choice phase but How we establish our decision making objectives

- Normative
- Descriptive

Normative Models

- The chosen alternative is demonstrably the best of all (normally a good idea)
- *Optimization* process
- Normative decision theory based on *rational* decision makers

Rationality Assumptions

- 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*: Descriptive modeling technique

Descriptive Models

- Information flow
- Scenario analysis
- Financial planning
- Complex inventory decisions
- Markov analysis (predictions)
- Environmental impact analysis
- Simulation
- Waiting line (queue) management

Satisficing (Good Enough)

- Most human decision makers will settle for a good enough solution

- Tradeoff: time and cost of searching for an optimum versus the value of obtaining one

- Good enough or *satisficing* solution may meet a certain goal level is attained

(Simon, 1977)

Why Satisfice?
Bounded Rationality (Simon)

- Humans have a limited capacity for rational thinking
- Generally construct and analyze a simplified model
- Behavior to the simplified model may be rational
- But, the rational solution to the simplified model may NOT BE rational in the real-world situation
- Rationality is bounded by
  - limitations on human processing capacities
  - individual differences
- Bounded rationality: why many models are descriptive, not normative

Developing (Generating) Alternatives

- Searching and Creativity
- Requires
  - Expertise
  - Availability of information
  - Cost of information
- Methods for Generating Alternatives:
  - Heuristics
  - Brainstroming

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

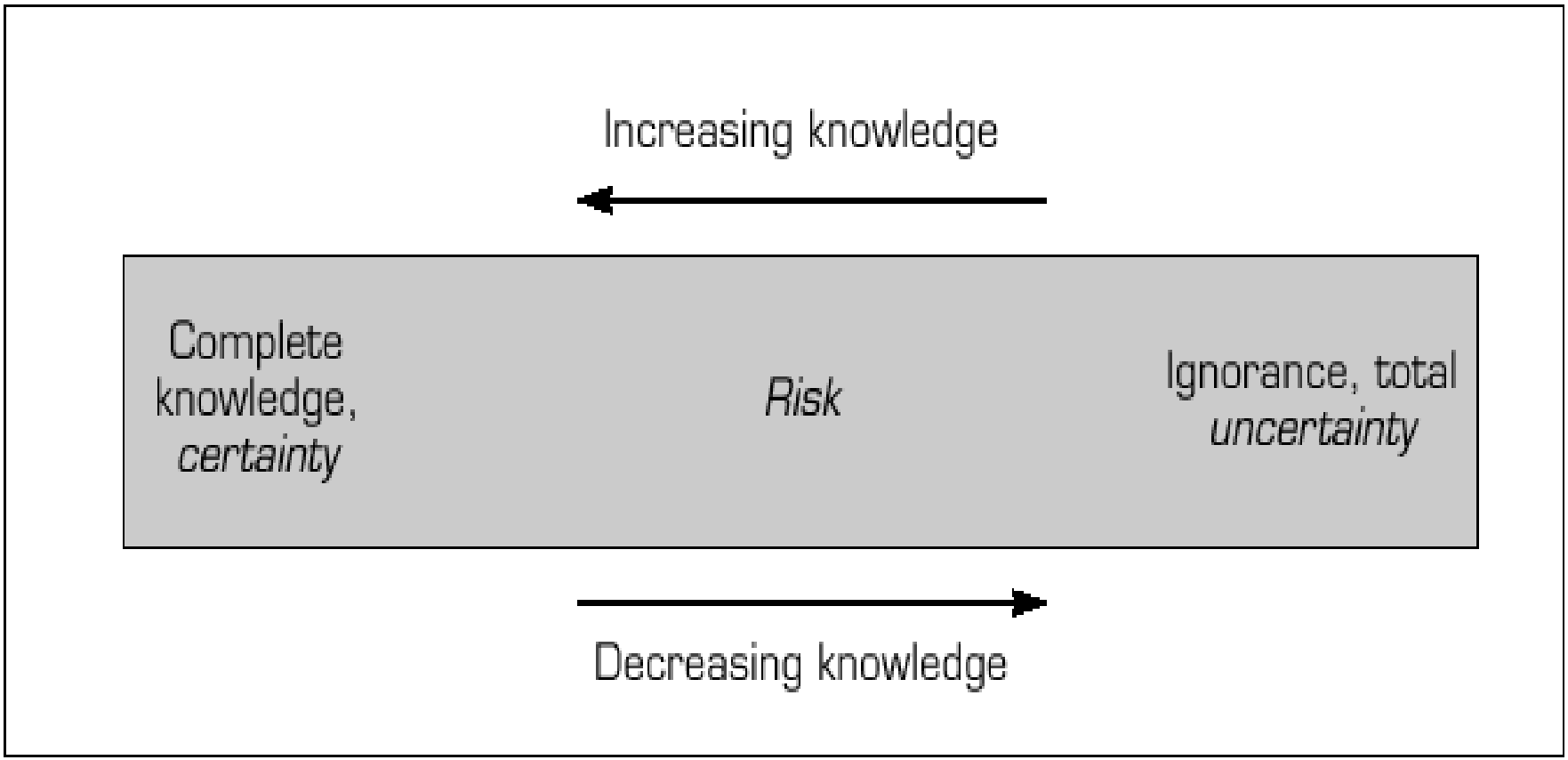
- Classify Each Situation as Under
  - Certainty
  - Risk
  - Uncertainty

Decision Making Under Certainty

- *Assumes* complete knowledge 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

The Zone of Decision Making



Decision Making Under Risk
Risk Analysis

- Probabilistic or stochastic decision situation
- Must consider several possible outcomes for each alternative, each with a probability
- Long-run probabilities of the occurrences of the given outcomes are assumed known or estimated

- Assess the (*calculated*) degree of risk associated with each alternative

Risk Analysis

- Calculate the expected value of each alternative
- Select the alternative with the best expected value

Decision Making Under Uncertainty

- Several outcomes possible for each course of action
- *BUT* the decision maker does not know, or cannot estimate the probability of occurrence

- More difficult - insufficient information
- 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)

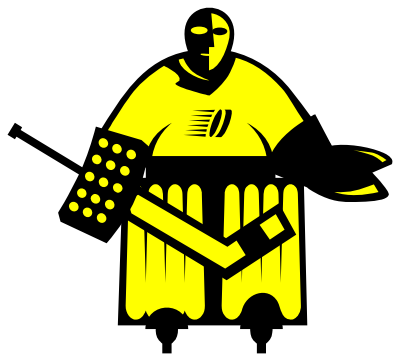
Measuring Outcomes

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

Scenarios

- Scenario is a statement of assumptions about the operating environment of a particular system at a given time.

- 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

Error in Decision Making

- Believing that you already have all the answers
- Asking the wrong questions
- The old demon ego
- Flying-by-the-seat-of-your-pants saves money doesn’t it?
- All aboard the bandwagon
- Hear no evil
- Hurry up and wait: making no decision can be the same as making a bad decision.

The Choice Phase

- The CRITICAL act - decision made here!
- 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 only after the recommended solution to the model is *successfully implemented*

Search Approaches

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

Analytical Techniques

- Mathematical formulas to derive an optimal solution directly or to predict a certain result.
- Step-by-step search
- Solve structure problems

Blind Search

- Arbitrary search approaches that are not guided.
  - Complete enumeration: all the alternatives are considered and therefore an optimal solution is discovered
  - Incomplete, partial search: continues until a good enough solution is found

Heuristic Search

- Heuristics are decision rules governing how a problem should be solved.
- Guidelines are usually developed as a result of a trial-and-error experience.
- Heuristic searches are step-by-step procedures which are repeated until a satisfactory solution is found.

Evaluation

Multiple Goals, Sensitivity Analysis, What-If, and Goal Seeking

- Evaluation (with the search process) leads to a recommended solution
- Multiple goals
- Complex systems have multiple goals
  Some may conflict

- Typically, 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

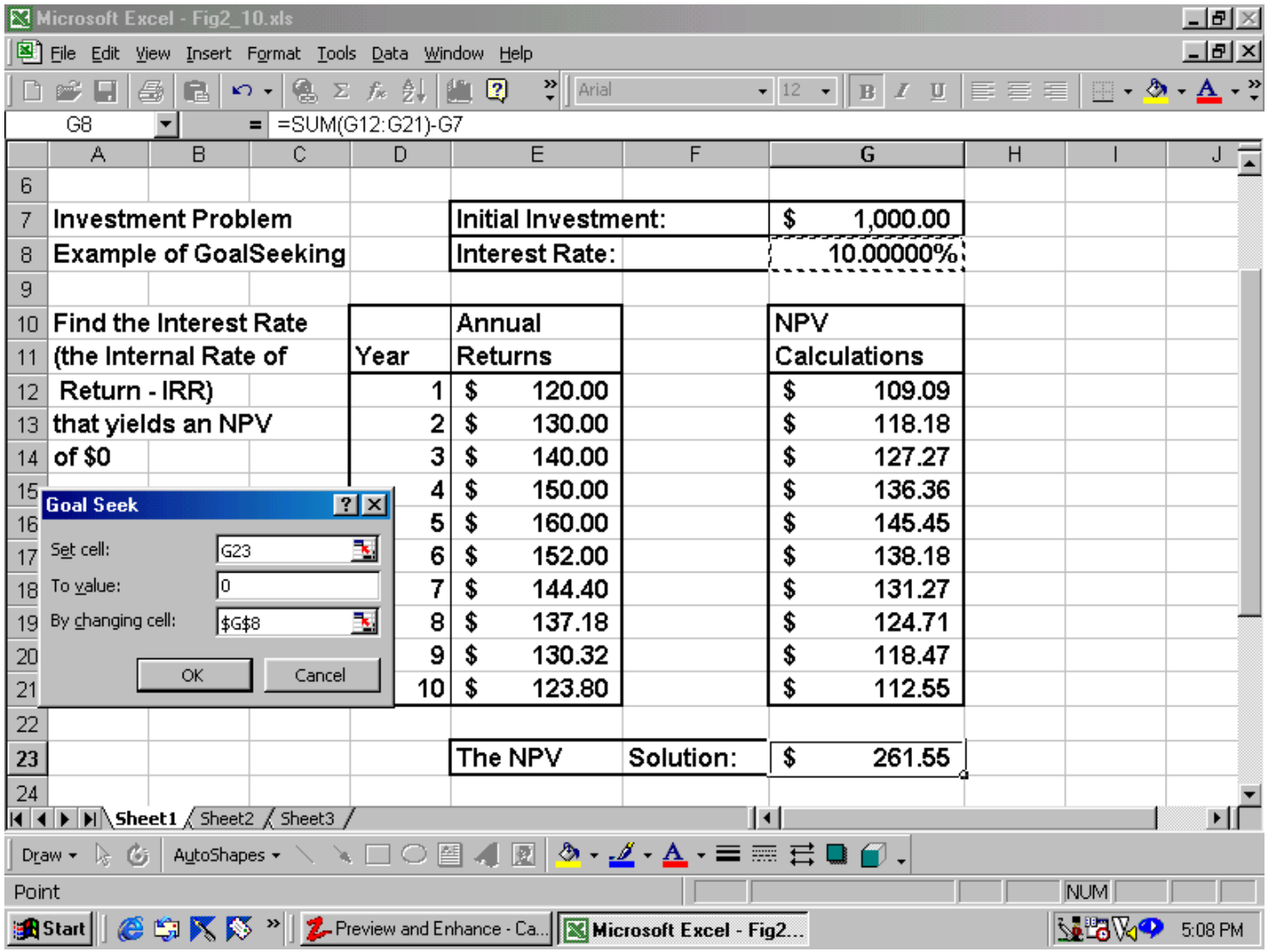
What-If Analysis

- What will happen to the solution if an input variable, or a parameter value is changed?

Goal Seeking

- Calculates the values of inputs necessary to achieve a desired level of an output (goal).
- Backward solution approach
- In a DSS the what-if and the goal-seeking options *must* be easy to perform

Goal Seeking



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

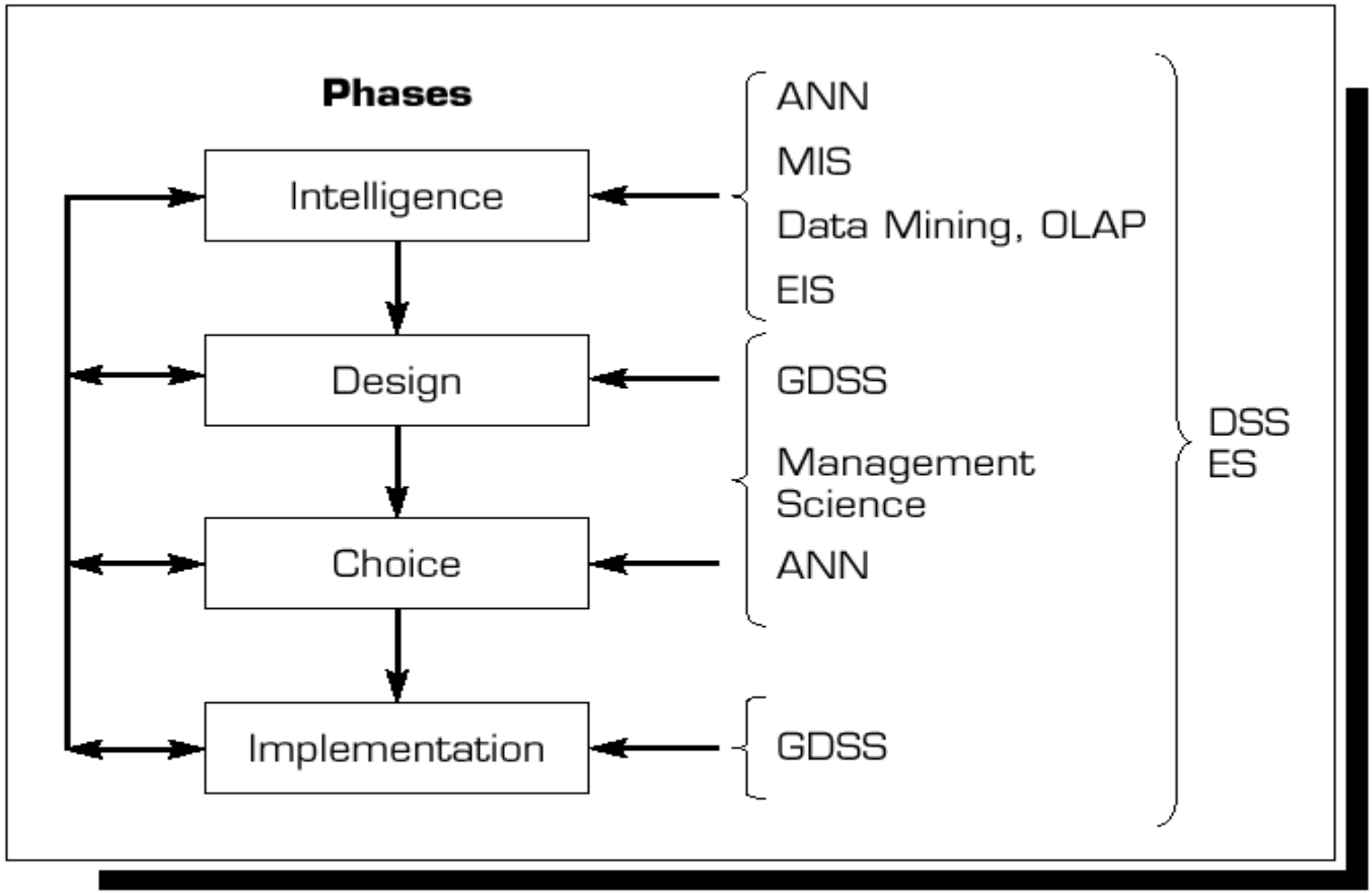
  (Machiavelli, 1500s)

  *** The Introduction of a *Change* ***

  Important Issues

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

DSS Support



Source: Based on R.H.Sprague, Jr. [1980, Dec.]. "A Framework for the Development of DSS." *MIS Quarterly*, Figure 5, p.13.