# … Modeling and Analysis

1. Management support system modeling
2. Static and Dynamic Models
3. Certainty, Uncertainty, and Risk
4. Management Support Systems Modeling with Spreadsheets
5. Decision Tables
6. Decision Tree
7. The structure of Mathematical Models for Decision Support
8. Mathematical Programming Optimization
9. Multiple Goals, Sensitivity Analysis, What-If Analysis, and Goal Seeking
10. Problem-Solving Search Methods
11. **Simulation Applications**

*Decision Support and Business Intelligence Systems*
Efraim Turban, Jay E. Aronson, Ting-Peng Liang, Ramesh Sharda
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# 11. Simulation Applications

"**Simulation** is the appearance of reality. In MSS is a technique for conducting experiments with a computer on a model of a management system. Because DSS deals with semi.structured or unstructured situations, reality is complex, which may not be easily represented by optimization or other models but can often be handled by simulation. **Simulation** is one of the most commonly used DSS methods."

# Characteristics of **Simulation**

**Models** ***represent*** reality, **simulation** ***imitates*** it.

**Simulation** is a technique for ***conducting experiments***.

**Simulation** is a ***descriptive method*** – there is no automatic search for an optimal solution.

**A simulation model** ***describes or predicts the characteristics*** of a given system under different conditions.

**The simulation process** usually repeats an experiment many times to obtain an estimate (and a variance) of the overall effect of certain action.

**Simulation is used** when the problem is too complex to be treated using numerical optimization techniques.

# Advantages of Simulation

**Simulation** is used in MSS for:

- The theory is fairly straightforward.
- A great amount of ***time compression*** can be attained.
- **Simulation is descriptive** – allows the manager to pose *what-if* questions → *trial-and-error* approach to problem solving and can do so faster, at less expense, more accurately, and with less risk.
- The model is built from the manager's perspective.
- The simulation model is built for one particular problem and typically cannot solve any other problem – every component in the model corresponds to part of the real system.
- Simulation is often the only DSS modeling method that can readily handle relatively unstructured problems.

# Disadvantages of Simulation

**Disadvantages of simulation** are:

- **The optimal solution cannot be guaranteed**, but relatively good ones are generally found.
- **Simulation model construction** can be a slow and costly process, although never modeling system are easier to use than ever.
- **Solutions and inferences** from a simulation study are usually not transferable to other problems because the model incorporates unique problem factors.
- **Simulation is** sometimes so **easy to explain** to managers that analytic methods are often overlooked.
- **Simulation software** sometimes requires special skills because of the complexity of the formal solution method.

# The Methodology of **Simulation**

**Simulation** involves setting up a model of a real system and conducting repetitive experiments on it.

The methodology consists of the following steps:

1. ***Define the problem.*** We examine and classify the real-world problem – we specify why a simulation approach is appropriate. .
2. ***Construct the simulation model.*** This step involves determination of the variables and their relationships, as well as data gathering.
3. ***Test and validate the model.*** The simulation model must represent the system being studied.
4. ***Design the simulation experiments.*** When the model has been proven valid, an experiment is designed – how long to run the simulation (accuracy and cost?).
5. ***Conduct the experiments:*** involves issues ranging from random-number generation to result presentation.
6. ***Evaluate the results.*** The results must be interpreted – sensitivity analysis.
7. ***Implement the results.*** The chances of success are better because the manager is usually more involved with the simulation process then other models.

# The Process of Simulation


Define the problem

Construct the simulation model

Test and validate the model

Design the simulation experiments

Conduct the experiments

Evaluate the results

Implement the results

# Simulation Types

The types of **Simulation** are:

1. ***Probabilistic Simulation.*** The independent variables are probabilistic:
   - ***Discrete distributions*** – a situation with a limited number of events (variables) that can take on only a finite number of values.
   - ***Continuous distributions*** – unlimited number of possible events that follow density functions, such as the *normal distribution*.
2. ***Time-Dependent Simulation*** – is important to know the precise time of arrival.
3. ***Time-Independent Simulation*** - is not important to know exactly when the event occurred.
4. ***Object-oriented Simulation.*** SIMPROCESS: object-oriented process modeling tool that lets the user create a simulation model by using screen-based objects. UML could be used in practice for modeling complex, real-time systems.
5. ***Visual Simulation.*** The graphical display of computerized results, which may include animation, is one of the most successful developments in computer-human interaction and problem solving.

# Visual Interactive Simulation

We examine methods that show a decision maker a representation of the decision-making situation in action as it runs through scenarios of the decision maker's choices of alternatives.

"These powerful methods overcome some of the inadequacies of conventional methods and help build trust in the solution attained because they can be visualized directly."

# Conventional Simulation Inadequacies

**Simulation** is a descriptive and mathematics-based method for gaining insight into complex decision-making situations. Simulation does not usually allow decision makers to see how a solution to a complex problem evolves over time, nor can decision makers interact with the simulation.

**Simulation** generally reports statistical results at the end of experiments. If the simulation results do not match the intuition or judgment of the decision maker, a *confidence gap* in the results can occur.

# Visual Interactive Simulation

***Visual Interactive Simulation*** **(VIS)** also know as ***Visual Interactive Modeling*** **(VIM)** and **Visual Interactive Problem Solving**, is a simulation method that lets decision makers see what the model is doing and how it interacts with the decisions made, as they are made.

The user can employ his knowledge to determine and try different decision strategies while interacting with the model. Decision maker also contribute to model validation, and support and trust their results.

VIS uses animated computer graphics display to present the impact of different decisions. It differs from regular graphics in that the user can adjust the decision-making process and see the results of the intervention. A visual model is a graphic used as an integral part of decision making or problem solving. VIS displays the effects of different decisions in graphic form on a computer screen. The simulation system identified the most important input factors that significantly affected performance.

# Visual Interactive Models

***Visual Interactive Simulation*** can represent static or dynamic systems:

- ***Static models*** display a visual image of the result of one decision alternative at a time.
- ***Dynamic models*** display systems that evolve over time, and the evolution is represented by animation.

The latest visual simulation technology has been coupled with the concept of virtual reality, where an artificial world is created for a number of purposes, from training to entertainment to viewing data in an artificial landscape.

***VIM*** in **DSS** has been used in several operations management decision. The method consists of priming a visual interactive model of a plant (or company) with its current status. The model then runs rapidly on a computer, allowing managers to observe how a plant is likely to operate in the future.

The ***VIM*** approach can also be used in conjunction with artificial intelligence. Integration of the two techniques adds several capabilities that range from the ability to build systems graphically to learning about the dynamics of the system.

# Quantitative Software Packages and Model Base Management

***Quantitative software packages*** are programmed (*ready-made*) models and optimization systems that serve as building blocks for other quantitative models.

A variety of these are readily available for inclusion in DSS as major and minor modeling components – there are complete packages that can be considered ready-made DSS. The latter tend to be developed and sold for a very specific application, whereas the former may be used as vehicles in which to develop model.

The **Excel** spreadsheet system has hundreds of models, ranging from functions to add-in packages (e.g. Solver). For data that can be dropped into a spreadsheet, generally Excel has many of the capabilities needed to produce usable results for many decision-making situations.

**OLAP** systems are essentially collections of optimization, simulation, statistical, and artificial intelligence packages that access large amounts of data for analysis. Data mining software, such as that from *MicroStrategy* and *Megaputer PolyAnalyst* contain models and solution methods that can be activated either automatically or directly by the user.

# Resources and Links

We recommend the following resources and links:

- The **INFORMS** Web site : informs.org.
- **OR/MS Today** : orms-today.com.
- **COIN-OR** : coin-or.org.
- **COIN-OR** : coin-or.org.
- **NEOS Server for Optimization** : neos.mcs.anl.gov/neos/index.html.
- **H.Arsham's Modeling & Simulation Resources** page: home.ubalt.edu/ntsbarsh/Business-stat/RefSim.htm.
- **Decision Science Resources** page : home.ubalt.edu/ntsbarsh/Business-stat/Refop.htm.
- **Jay Aronson's DSS Sofware Web** page: terry.uga.edu/people/jaronson/dss/DSS-Software.htm.
- **Decision Analysis Society** : faculty.fuqua.duke.edu/daweb/dasw6.htm.
- **Interactive Linear Programming** group: faqs.org/faqs/linear-programming-faq/.

- The Society for Modeling & Simulation International ~ JDMS: The Journal of Defense Modeling & Simulation ~ http://www.scs.org/jdms
- Ali M. Niknejad, Analysis, Simulation, and Applications of Passive Devices on Conductive Substrates
- Prof. Stephen G. Powell, Applications of Simulation ~ stephen.g.powell@dartmouth.edu, Tuck 210
- EXPLORING MONTE CARLO SIMULATION APPLICATIONS FOR PROJECT MANAGEMENT, Young Hoon Kawak and Lisa Ingall, Department of Decision Sciences, School of Business, The George Washington University , Washington , DC , USA, IBM Systems Technology Group , Silver Spring , MD
- Application of simulation techniques for accident management training in nuclear power plants, IAEA-TECDOC-1352, International Atomic Energy Agency, May 2003.