COIS 4470H
Modeling and Simulation

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Course Description

This course provides an introduction to computational and mathematical techniques for modeling, simulation, and analyzing the performance of various systems by using simulation.

Stochastic, dynamic and discrete-event systems models are studied.

Goals

- We will study: how systems operate and respond to change by modeling, simulate, and analyze simple-but-representative systems.
- We will use: computer programs and mathematical analysis.

Simulation

- The process of mimicking of the operation of a real system in a computer:
  - day-to-day operation of a bank
  - the value of a stock portfolio over a time period
  - the running of an assembly line in a factory
  - the staff assignment of a hospital or a security company
  - transportation systems
- Simulation software has made it possible to model and analyze the operation of a real system by non-experts such as managers but not programmers

Model

- A simulation is the execution of a model represented by a computer program that gives information about the system being investigated
- In general, a model is an abstraction of a system (a collection of interacting elements or components that act together to achieve a common goal)
- The simulation approach of analyzing a model is opposed to the analytical approach, where the method of analyzing the system is purely theoretical

Why to Use Models

- The system may only be in planning stage
- System performance under new workload can be evaluated more efficiently
- System performance under new configuration can be evaluated more efficiently
- Can get result faster and cheaper
- Model is less risky to experiment

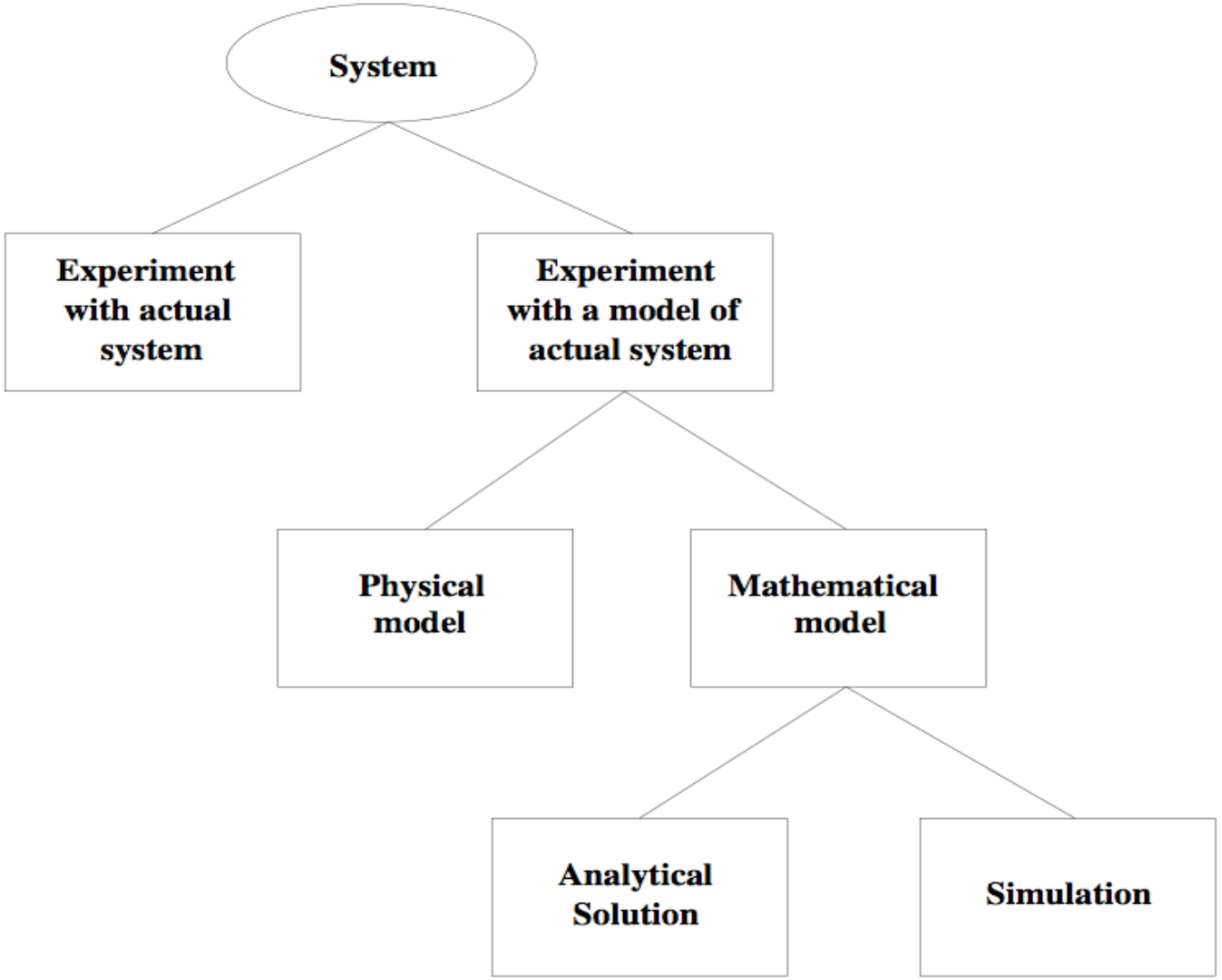
  - To fly a simulator is safer and cheaper than the real airplane

Analytic Modelling

Analytic Modelling: solve by mathematical methods

- Usually less costly to compute numerical results
- Easier to give interpretation to results
- Solutions to complex models are not available

Ways to Study a System



Advantages of Simulation

- Ability to compress time, expand time
- Ability to control sources of variation
- Avoids errors in measurement
- Ability to stop and review
- Ability to restore system state
- Facilitates replication
- Modeler can control level of detail

Disadvantages of Simulation

- Model building requires special training
- It is possible that two individuals arrive at different models for the same system
- Simulation results may be difficult to interpret (involve random numbers)
- Simulation modeling and analysis can be time consuming
- Simulation is some time used when an analytical model in not possible

Applications of Simulation

- Manufacturing systems: aircraft assembly, semiconductor manufacturing, assembly lines
- Heath Care: emergency rooms delays
- Military, combat modeling, nuclear testing, pilot training
- Natural resources: oil spills, waste management
- Transportation systems: traffic patterns
- Restaurant and entertainment services: quick service restaurant traffic, games
- Computer system performance: microchip design, computer networks, database system

Examples

- Queueing model simulator:
  http://www.raczynski.com/pn/qms.htm#download

- Bank simulators

- Road simulator

Characterizing a Model

- Deterministic or Stochastic
  - Does the model contain stochastic (random) components?
- Static or Dynamic
  - Is time a significant variable?
- Continuous or Discrete
  - Does the system state evolve continuously or only at discrete points in time?
  - Continuous: differential equations
  - Discrete: queuing, inventory, machine shop models

Definitions

- Discrete-Event Simulation Model
  - *Stochastic*: some state variables are random
  - *Dynamic*: time evolution is important
  - *Discrete-Event*: significant changes occur at discrete time instances
- Monte Carlo Simulation Model
  - *Stochastic*
  - *Static:* time evolution is not important

Model Taxonomy