# *CS-470*
# *Modeling & Simulation*

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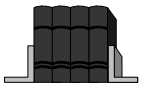
## *Course Logistics*



- Syllabus Review
  - Questions?!
- Course Web Page
  - www.msoe.edu/~blessing/cs470
  - Notes & Handouts from Class
  - Assignments and other useful links
- Weekly Quizzes
  - Held in Lab session

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## *What do the following have in common?*

- Voters at a polling place
- Patients in a hospital X-ray dept.
- Office workers waiting for an elevator in the World Trade Center or the Sears Tower
- Airport passengers traveling during the peak holiday traveling times
- Military personnel stationed around the world

Ans: Their activities are modeled and simulated.

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## *What is a Model?*

- *"A representation of an object, system, or idea in some form other than the entity itself"*
  - Shannon, *System Simulation: The Art and Science*
- Model Types:
  - Physical
    - Scale models, prototypes, etc.
  - Mathematical (*Analytical*)
    - Formulas, Markov Chains, Linear Programs
  - Computer
    - Queueing Networks, Simulation "objects"

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## *What is Simulation?*

- *"to assume or have the appearance or characteristic of"* - Random House English Dictionary
- The simulation of a system is the operation of a *model* which represents the system
- Usually takes the form of a computer program (but not always)
- The model and the simulation are inextricably linked

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## *What is Simulation?*

- *"Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of either understanding the behavior of the system or of evaluating various strategies for the operation of the system"*
  - Shannon, *System Simulation: The Art and Science*

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## *Reasons for Modeling & Sim.*

- The actual system may be costly to build
  - Factories, Computer Centers, Comm. Networks
  - Simulation provides insight to the proposed project before it has taken shape
- The running system may be too important
  - Online banking, Airline scheduling
  - Tinkering with the actual system is undesirable
- Training on a simulator is preferred
  - Flight simulators, Maritime navigation

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## *Classification of Models*

Five Dimensions

- Prescriptive or Descriptive
- Discrete or Continuous
- Probabilistic or Deterministic
- Static or Dynamic
- Open Loop or Closed Loop

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## *Prescriptive vs. Descriptive*

- Prescriptive models are often called *optimization* models
  - Finding the single best solution is desired
- Descriptive models (a.t.n.i.) describe salient features of the system
  - Tinkering or optimizing is left entirely to the analyst using the system

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## *Discrete vs. Continuous*

- This dichotomy refers to the model variables
  - Continuous variables take on any real value
  - Discrete variables can assume only a limited, specified number of values
- Time, as a variable, is particularly important
  - If values change continuously over time, the model is classified as continuous
  - If values change only at discrete points in time, the model is classified as discrete

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## *Probabilistic vs. Deterministic*

- The distinction is with the model variables
  - If *random variables* are present, the model is a probabilistic one
    - An appropriate *density function* must be specified for each random variable
    - Arrival times and Service times are examples
  - If variable values are always known with 100% certainty, classify the model as deterministic

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## *Static vs. Dynamic*

- Do model variables change over time?
  - If so, the model is dynamic in nature
  - If not, the model is said to be static
- Static models tend to set values for variables before the simulation is run (these values are referred to as the *parameters* of the simulation).
- Static systems are typically simpler to model

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## *Open Loop vs. Closed Loop*

- This notion is determined by the structure of the model rather than the variables
  - Closed Loop systems *feed back* some of the output as input to the system
    - Presumably, to modify subsequent output!
  - Open Loop systems lack any provision for feedback
    - The vast majority of models are Open Loop
    - Control systems tend to be Closed Loop and Continuous

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## *Which Model Do We Use?*

- With the five dichotomies mentioned, there are $2^5 = 32$ model types (too many!)
- For our purposes we'll concentrate on models that are:
  - Discrete
  - Probabilistic
  - Dynamic
  - Open Loop

Later on in the course, We'll get to do some Continuous models!

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