Faculty of Computers and Information
Mansoura University

Modeling and Simulation

Prof. Dr. Hazem El-Bakry
Information Systems Dept.
elbakry@mans.edu.eg

Components of system

Entity

- **An object of interest in the system. (Machines in factory)**

Attribute

– a property of an entity
– E.g., checking account balance

Activity

– Represents a time period of specified length.
– Collection of operations that transform the state of an entity
– E.g., making bank deposits

Event

- Change in the system state.
- A instantaneous occurrence that might change the state of the system.
- E.g., arrival; beginning of a new execution; departure, breakdown)

Endogenous

- **Activities and events occurring with the system**

Exogenous

Activities and events occurring with the environment

Note

- **A system is often affected by changes occurring outside the system: system environment**

Examples

- a. Factory : Arrival orders
- b. Effect of supply on demand : relationship between factory output and arrival (activity of system)
- c. Banks : arrival of customers

State

- The state of a system is a collection of variables and their values necessary to describe the system at that time
  - The state of the system might depend on desired objectives, output performance measures.
  - E.g.: Status of machine (busy, idle, down,…)
  - Bank model: Could include number of busy tellers, time of arrival of each customer, etc.

State Variables:

  - Define the state of the system
  - Can restart simulation from state variables
  - E.g., length of the job queue.
- 1. In practice, the system depends on objectives of study.
- 2. It might be limited by the boundaries (physical and logical).
- 3. The behavior of the system can be Judged in details.
- 4. It usually assume a time element – *dynamic* system

How to Study Systems

- 1. Experiment with the actual system if possible
- 2. Experiment with a model of the system
  - Physical Model
  - Mathematical Model
    - Analytical Solution
- 3. Simulation

To study the system

  - it is sometimes possible to experiments with system
- However,
  - This is not always possible (bank, factory,…)
  - A new system may not yet exist

When to Use Simulation for a system

- The system does not exist.
- Experimentation with real system is expensive
- There is a need to study the past, present and the future behavior of the system in real time.
- Mathematical Models are impossible.
- Mathematical Models exist but have no analytical solution.
- Results of Simulation are possible.
- Expected accuracy of simulation results is consistent with the given problem.

Applications

- Designing and analyzing manufacturing systems
- Evaluating H/W and S/W requirements for a computer system
- Evaluating a new military weapons system or tactics
- Determining ordering policies for an inventory system
- Designing communications systems and message protocols for them

EXAMPLES OF SYSTEMS AND COMPONENTS

System	Entities	Attributes	Activities	Events	State Variables
Banking	Customers	Checking account balance	Making deposits	Arrival; Departure	# of busy tellers; # of customers waiting

Note: **State Variables may change continuously (continuous sys.) over time or they may change only at a discrete set of points (discrete sys.) in time.**

Examples

- Bank tellers + customers waiting
- Supermarket cashiers + customers waiting
- Hospital emergency room + patients
- Machines + parts
- Cities + Highways
- Telephones + connection networks
- Materials + handling equipment

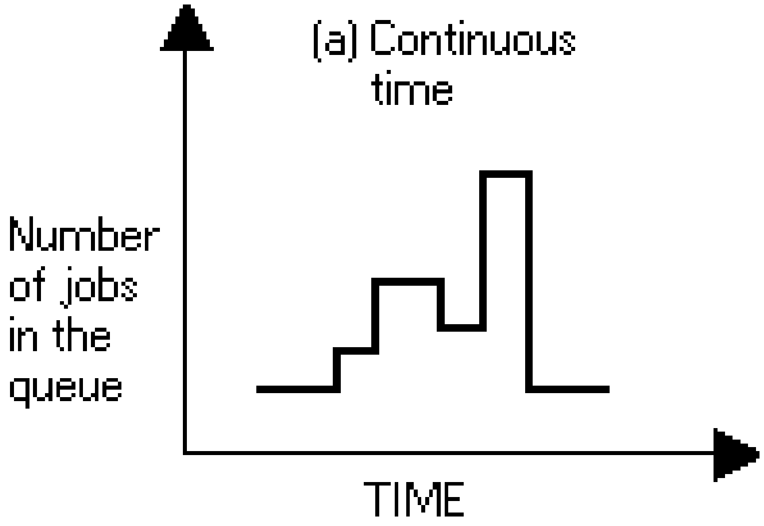
Types of System Simulation

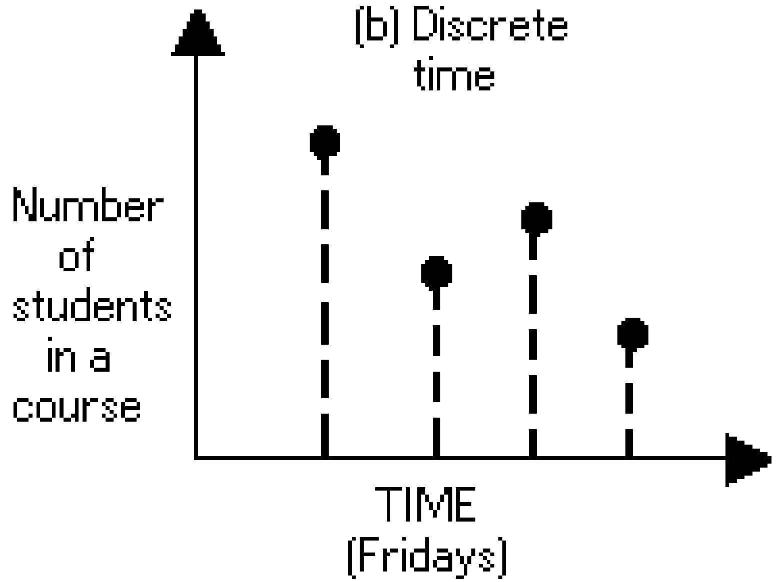
- **Pure Continuous Simulation**
- **Pure Discrete Simulation**
  - **Event-oriented**
  - **Activity-oriented**
  - **Process-oriented**
- **Combined Discrete / Continuous Simulation**

Types of Models from the point of continuity

– **Static or Dynamic**
– **Deterministic or Probabilistic**
– **Continuous Time or Discrete Time Models:**

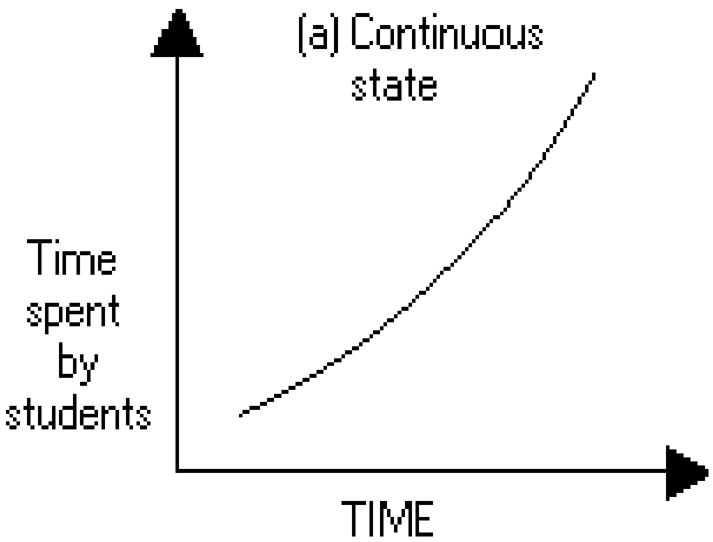
CPU scheduling model vs. number of students attending the class.

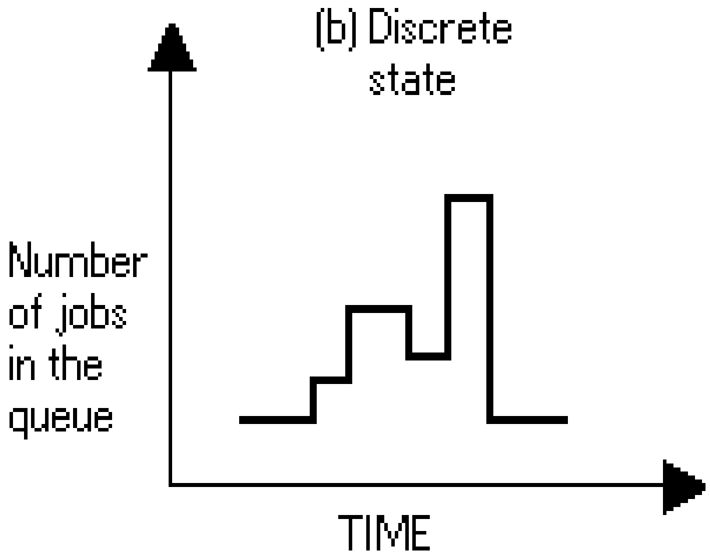




Continuous State and Discrete State Models:

- **Example: Time spent by students in a weekly class vs. Number of jobs in Queue.**
-





Types of systems from the point of continuity.

- *Discrete*
  - State variables change instantaneously at separated points in time
  - Bank model: State changes occur only when a customer arrives or departs
- *Continuous*
  - State variables change continuously as a function of time
  - Airplane flight: State variables like position, velocity change continuously

- **Many systems are partly discrete, partly continuous**
- **Most operational models are dynamic, stochastic, and discrete they are called discrete-event simulation models**

Modeling strategy

- Start with simple models and evolve to complex ones
- Focus on important issues and screen out unimportant issues

Three Model Levels

- **Three Model Levels**
- **a. Conceptual**
- **1. Very high level**
- **2. How comprehensive should the model be?**
- **3. What are the *state variables,* which are dynamic, and which are important?**

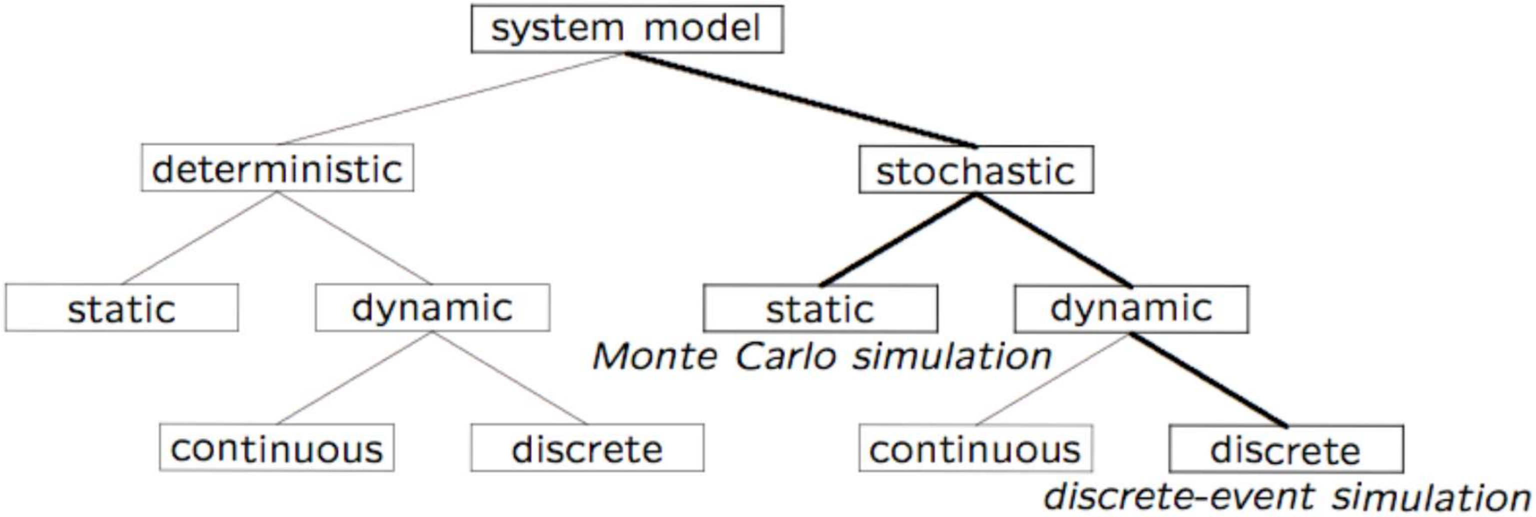
Three Model Levels

- **b. Specification**
- **1. On paper**
- **2. May involve equations, pseudo code, etc.**
- **3. How will the model receive input?**
- **c. Computational**
- **1. A computer program**
- **2. General-purpose PL or simulation language?**

Verification vs. Validation

- *Verification*
- - Computational model should be consistent with specification model
- *Validation*
- - Computational model should be consistent with the system being analyzed
- - Can an expert distinguish simulation output from actual system output?
- - Interactive graphics can prove the difference (if exists)

Model Taxonomy



How to develop a model:

- 1) Determine the goals and objectives
- 2) Build a *conceptual* model
- 3) Convert into a *specification* model
- 4) Convert into a *computational* model
- 5) Verify
- 6) Validate
- Typically an iterative process