



Chapter 1 Introduction to Simulation

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Discrete-Event System Simulation

Outline



- When Simulation Is the Appropriate Tool
- When Simulation Is Not Appropriate
- Advantages and Disadvantages of Simulation
- Areas of Application
- Systems and System Environment
- Components of a System
- Discrete and Continuous Systems
- Model of a System
- Types of Models
- Discrete-Event System Simulation
- Steps in a Simulation Study

Definition

- A *simulation* is the imitation of the operation of real-world process or system over time.
 - Generation of artificial history and observation of that observation history
- A *model* construct a conceptual framework that describes a system
- The behavior of a system that evolves over time is studied by developing a simulation *model*.
- The model takes a set of expressed assumptions:
 - Mathematical, logical
 - Symbolic relationship between the *entities*

Goal of modeling and simulation

- A model can be used to investigate a wide verity of “what if” questions about real-world system.
 - Potential changes to the system can be simulated and predicate their impact on the system.
 - Find adequate parameters before implementation
- So simulation can be used as
 - Analysis tool for predicating the effect of changes
 - Design tool to predicate the performance of new system
- It is better to do simulation before Implementation.

How a model can be developed?




■ Mathematical Methods

- ☐ Probability theory, algebraic method ,...
- ☐ Their results are accurate
- ☐ They have a few Number of parameters
- ☐ It is impossible for complex systems


■ Numerical computer-based simulation

- ☐ It is simple
- ☐ It is useful for complex system

When Simulation Is the Appropriate Tool

- 
- Simulation enable the study of internal interaction of a subsystem with complex system
 - Informational, organizational and environmental changes can be simulated and find their effects
 - A simulation model help us to **gain knowledge** about improvement of system
 - Finding important input parameters with changing simulation inputs
 - Simulation can be used with new design and policies before implementation
 - Simulating different capabilities for a machine can help determine the requirement
 - Simulation models designed for training make learning possible without the cost disruption
 - A plan can be visualized with animated simulation
 - The modern system (factory, wafer fabrication plant, service organization) is too complex that its internal interaction can be treated only by simulation

When Simulation Is Not Appropriate

- 
- When the problem can be solved by common sense.
 - When the problem can be solved analytically.
 - If it is easier to perform direct experiments.
 - If cost exceed savings.
 - If resource or time are not available.
 - If system behavior is too complex.
 - Like human behavior

Advantages and disadvantages of simulation



- In contrast to optimization models, simulation models are “run” rather than solved.
 - Given as a set of inputs and model characteristics the model is run and the simulated behavior is observed

Advantages of simulation

- New policies, operating procedures, information flows and son on can be explored without disrupting ongoing operation of the real system.
- New hardware designs, physical layouts, transportation systems and ... can be tested without committing resources for their acquisition.
- Time can be compressed or expanded to allow for a speed-up or slow-down of the phenomenon(**clock is self-control**).
- Insight can be obtained about interaction of variables and important variables to the performance.
- Bottleneck analysis can be performed to discover where work in process, the system is delayed.
- A simulation study can help in understanding how the system operates.
- “What if” questions can be answered.

Disadvantages of simulation

- Model building requires special training.
 - Vendors of simulation software have been actively developing packages that contain models that only need input (templates).
- Simulation results can be difficult to interpret.
- Simulation modeling and analysis can be time consuming and expensive.
 - Many simulation software have output-analysis.

Areas of application

- Manufacturing Applications
- Semiconductor Manufacturing
- Construction Engineering and project management
- Military application
- Logistics, Supply chain and distribution application
- Transportation modes and Traffic
- Business Process Simulation
- Health Care
- Automated Material Handling System (AMHS)
 - Test beds for functional testing of control-system software
- Risk analysis
 - Insurance, portfolio,...
- Computer Simulation
 - CPU, Memory,...
- Network simulation
 - Internet backbone, LAN (Switch/Router), Wireless, PSTN (call center),...

Systems and System Environment

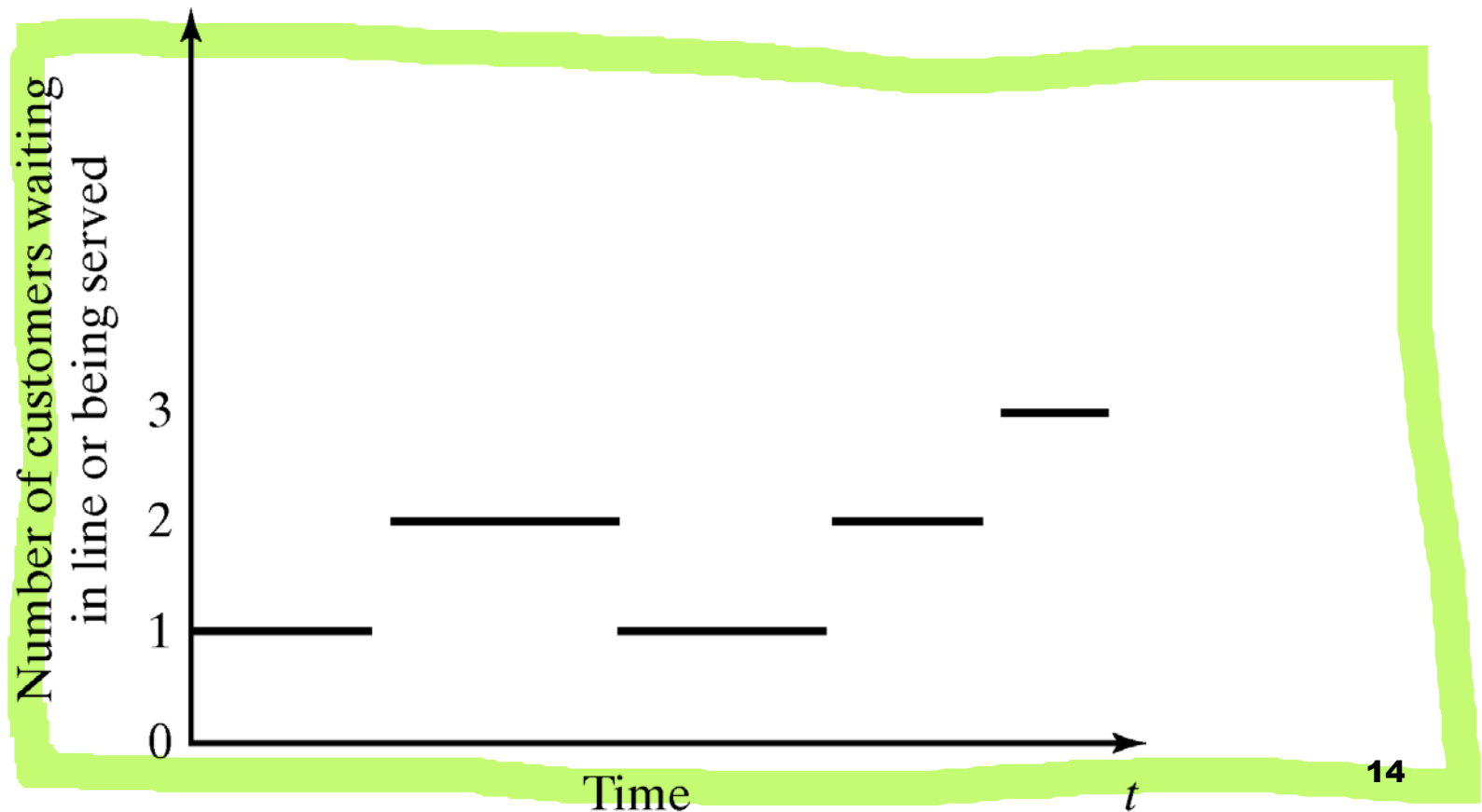
- A *system* is defined as a groups of objects that are joined together in some regular interaction toward the accomplishment of some purpose.
 - An automobile factory: Machines, components parts and workers operate jointly along assembly line
- A system is often affected by changes occurring outside the system: *system environment*.
 - Factory : Arrival orders
 - Effect of supply on demand : relationship between factory output and arrival (activity of system)
 - Banks : arrival of customers

Components of system

- Entity
 - An object of interest in the system : Machines in factory
- Attribute
 - The property of an entity : speed, capacity
- Activity
 - A time period of specified length :welding, stamping
- State
 - A collection of variables that describe the system in any time : status of machine (busy, idle, down,...)
- Event
 - A instantaneous occurrence that might change the state of the system: breakdown
- Endogenous
 - Activities and events occurring with the system
- Exogenous
 - Activities and events occurring with the environment

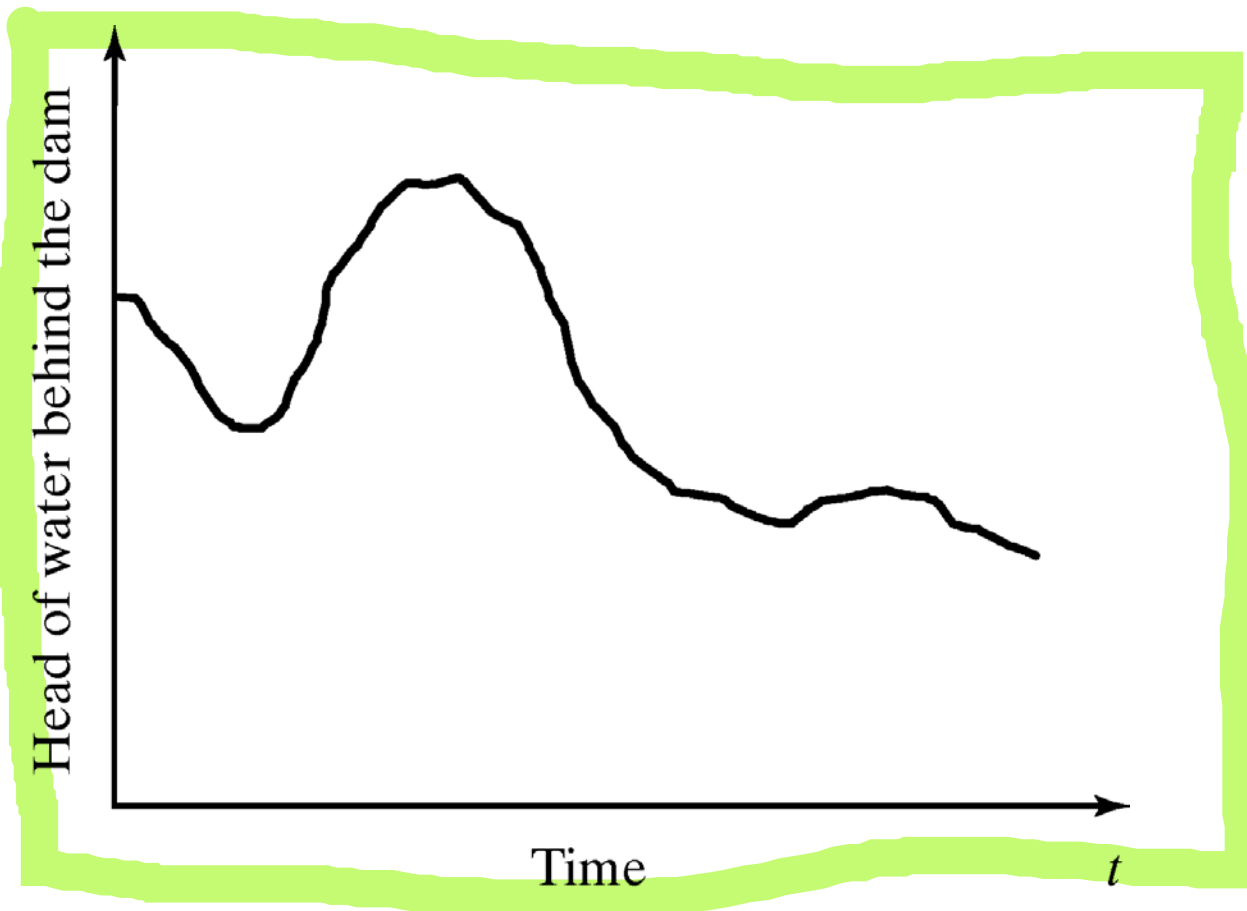
Discrete and Continues Systems

- A **discrete system** is one in which the state variables change only at a discrete set of points in time : Bank example



Discrete and Continues Systems (cont.)

- A continues **system** is one in which the state variables change continuously over time: Head of water behind the dam



Model of a System

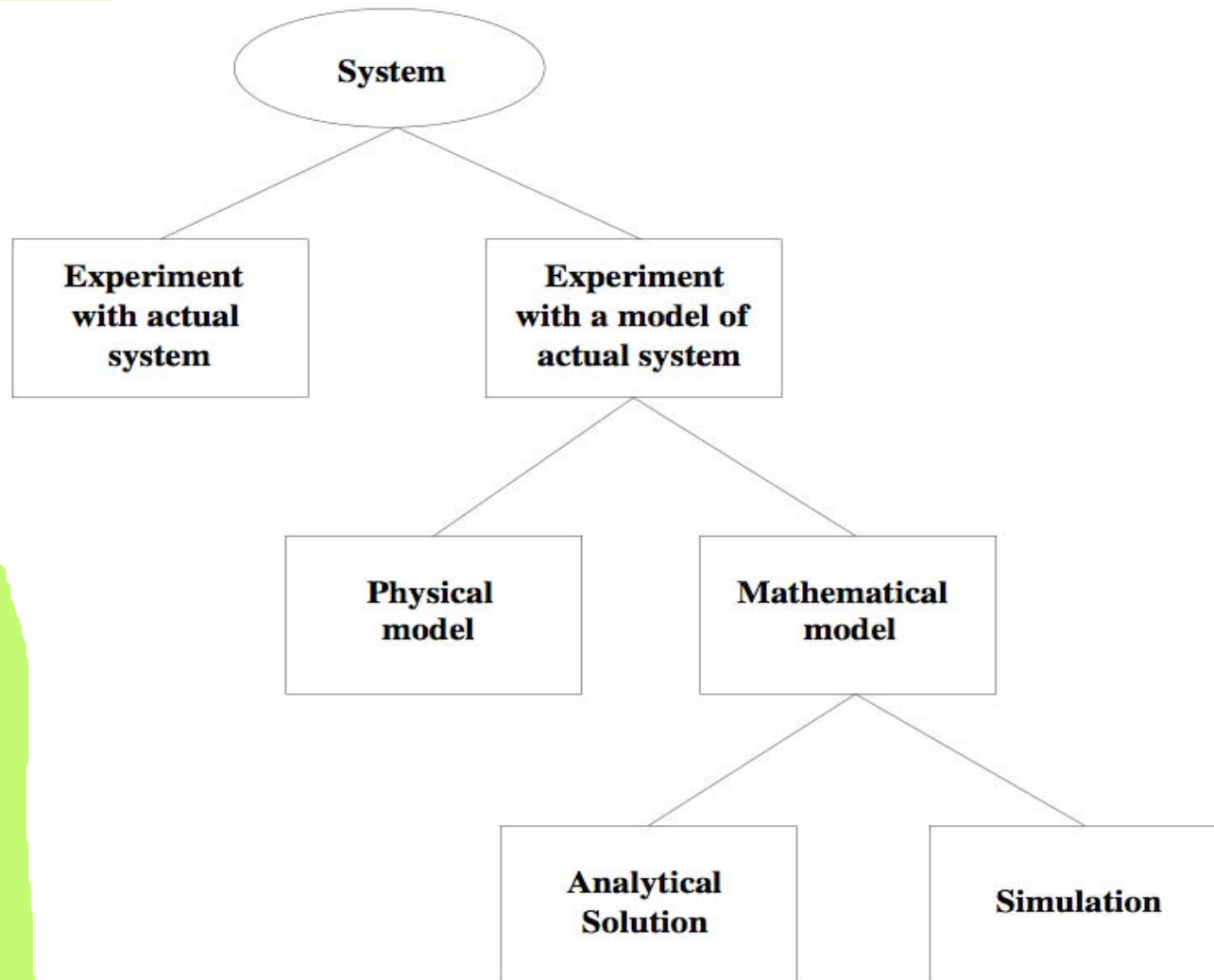
- To study the system

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

- **Model:** construct a conceptual framework that describes a system

- ☐ It is necessary to consider those accepts of systems that affect the problem under investigation (unnecessary details must remove)

Types of Models



Characterizing a Simulation Model

■ Deterministic or Stochastic

- ☐ Does the model contain stochastic components?
- ☐ Randomness is easy to add to a DES

■ Static or Dynamic

- ☐ Is time a significant variable?

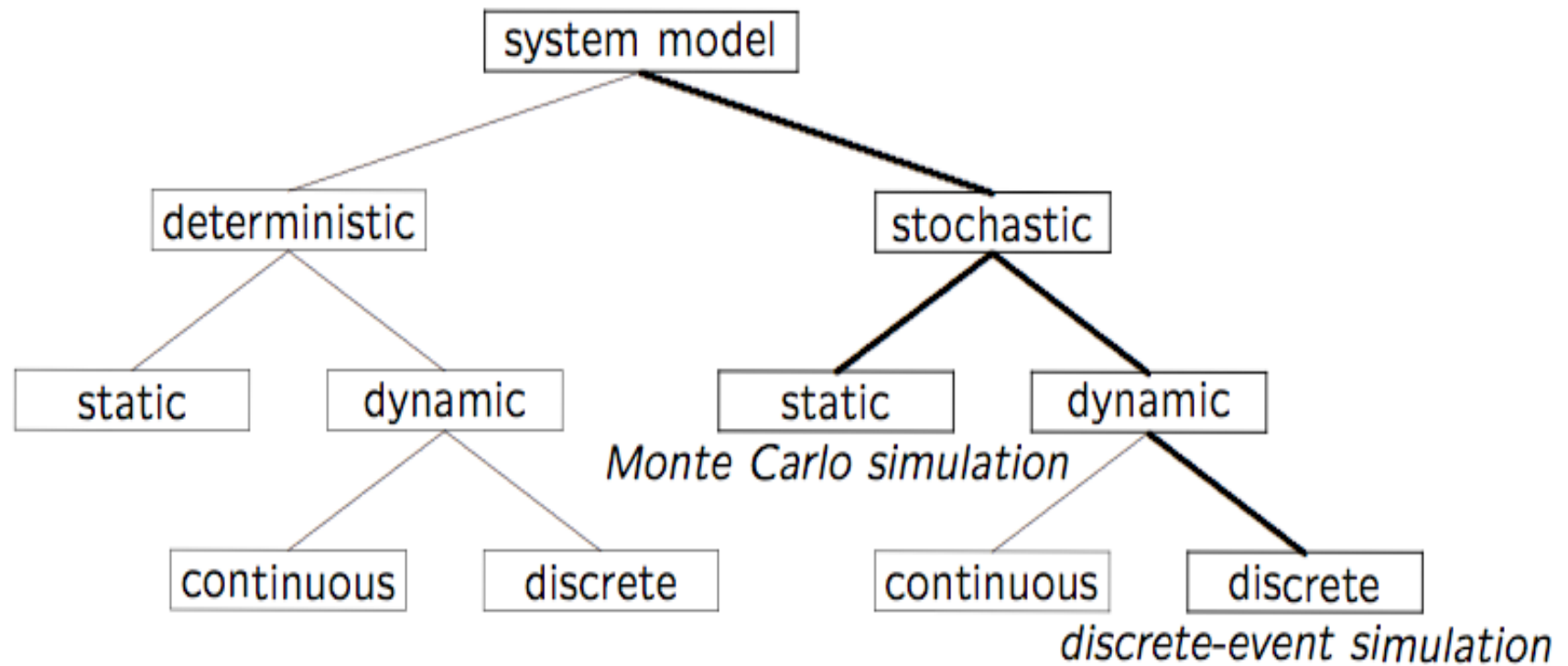
■ Continuous or Discrete

- ☐ Does the system state evolve continuously or only at discrete points in time?
- ☐ Continuous: classical mechanics
- ☐ Discrete: queuing, inventory, machine shop models

Discrete-Event Simulation Model

- Stochastic: some state variables are random
- *Dynamic*: time evolution is important
- *Discrete-Event*: significant changes occur at discrete time instances

Model Taxonomy



DES Model Development



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

Three Model Levels

■ Conceptual

- ☐ Very high level
- ☐ How comprehensive should the model be?
- ☐ What are the *state variables*, which are dynamic, and which are important?

■ Specification

- ☐ On paper
- ☐ May involve equations, pseudocode, etc.
- ☐ How will the model receive input?

■ Computational

- ☐ A computer program
- ☐ General-purpose PL or simulation language?

Verification vs. Validation

■ *Verification*

- ☐ Computational model should be consistent with specification model
- ☐ Did we build the model right?

■ *Validation*

- ☐ Computational model should be consistent with the system being analyzed
- ☐ Did we build the right model?
- ☐ Can an expert distinguish simulation output from system output?

■ Interactive graphics can prove valuable

Steps in Simulation Study

