K S Institute of Technology

Department of Computer Science and Engineering

Welcome to
2020-21 EVEN Semester
Online Class

System Modelling and Simulation

18CS645

Staff: Dr Rekha B Venkatapur

Vision and Mission of Institute

VISION

To impart quality technical education with ethical values, employable skills and research to achieve excellence.

MISSION

To attract and retain highly qualified, experienced and committed faculty.

To create relevant infrastructure

Network with industry and premier institutions to encourage emergence of new ideas by providing research and development facilities to strive for academic excellence

To inculcate the professional and ethical values among young students with employable skills and knowledge acquired to transform the society

Vision and Mission of Department

Vision:

“To create **competent professionals** in Computer Science and Engineering with adequate **skills** to drive the IT industry”

Mission:

M1: Impart sound **technical knowledge** and quest for **continuous learning**.

M2: To equip students to furnish Computer Applications for the society through **experiential learning** and research with **professional ethics**.

M3: Encourage **team work** through inter-disciplinary project and evolve as leaders with **social concerns**.

Program Educational Objectives

PEO1: Excel in professional career by acquiring knowledge in cutting edge technology and contribute to the society as an excellent employee or as an entrepreneur in the field of Computer Science Engineering.

PEO2: Continuously enhance their knowledge on par with the development in IT industry and pursue higher studies in Computer Science & Engineering.

PEO3: Exhibit professionalism, cultural awareness, team work, ethics, and effective communication skills with their knowledge in solving social and environmental problems by applying computer technology.

Program Specific Outcomes(PSOs)

PSO1: Ability to understand, Analyze and implement programs in programming languages, as well apply concepts in core areas of Computer Science.

PSO2: Ability to use Computational skills in Mathematics, Algorithms and apply software knowledge to develop projects based on architecture of the system, data analysis to solve Real world problems.

PSO3: Ability to participate in Teams and use computer knowledge in various domains to become successful Entrepreneur.

Course Learning Outcomes:

After completing the course, the students will be able to,

Bloom’s Level

18CS645.1	**Identify the System components and apply analytical modeling methods to simulate the activities of systems- Queuing, inventory & reliability.**	**Applying (K3)**
18CS645.2	**Make use of the characteristics of a Discrete system and Event scheduling time advance algorithm to model the Single Queuing Simulation in Java. Identify useful statistical models, discrete and continuous distributions.**	**Applying (K3)**
18CS645.3	**Model the behaviour of M/G/1 queue behaviour with measures of performance of queuing systems, Random number and variate generation, Tests for random numbers.**	**Applying (K3)**
18CS645.4	**Identify the steps in Input Modelling by choosing parameters, Solve Goodness of fit tests problems.**	**Applying (K3)**
18CS645.5	**Apply effective verification, calibration and validation of methods, Plan Optimization through Simulation.**	**Applying (K3)**

Chapter 1 **Introduction to Simulation**

Banks, Carson, Nelson & Nicol

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

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.

Applications of Simulation

Human-in-the-loop simulation of outer space

Motorcycle simulator *Automóvel* exhibition, Brazil.

3DiTeams learner is percussing the patient's chest in virtual field hospital

Car racing simulator

Simulation of airflow over an engine

An architectural model promoting a highrise condominium

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

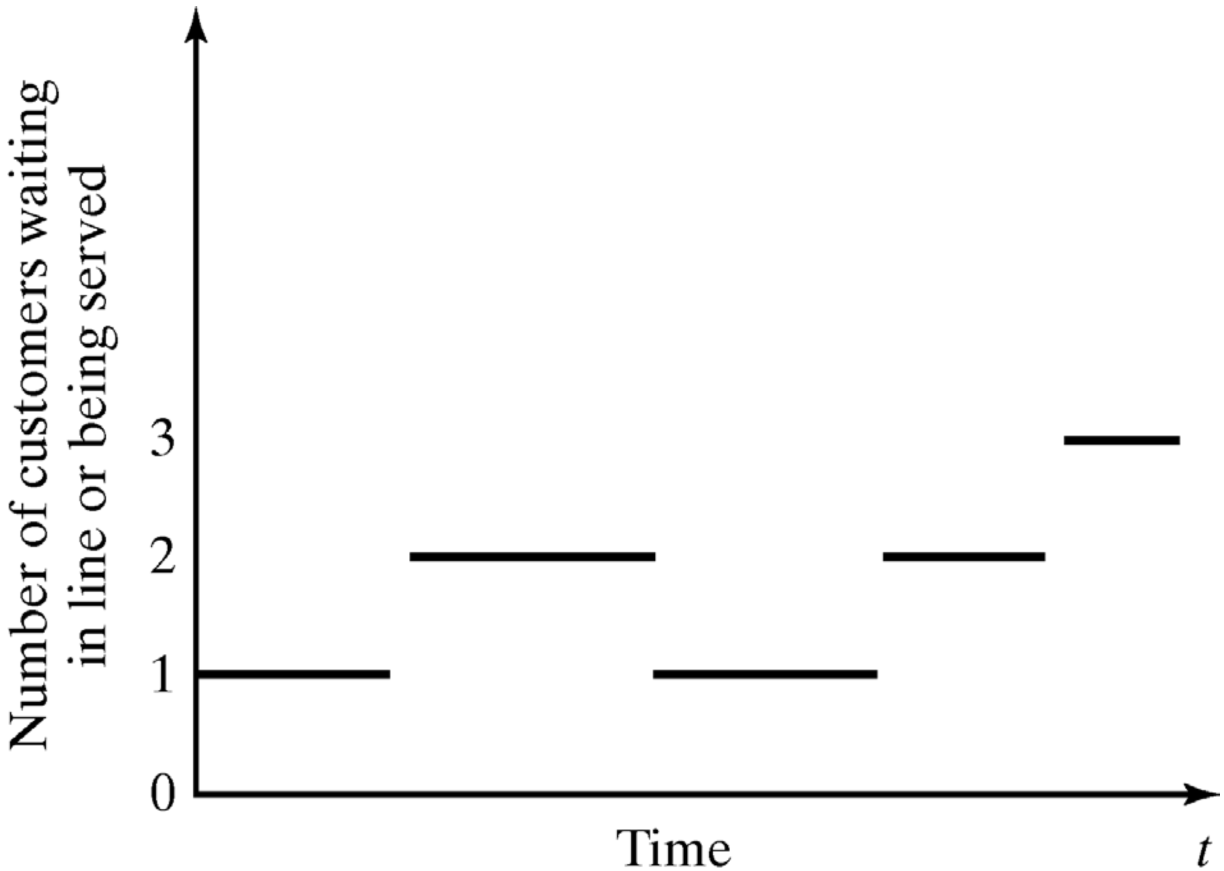
- A *system* is defined as a groups of objects that are joined together in some regular interaction toward the accomplishment of some purpose.
  - An automobile factory: Machines, components parts and workers operate jointly along assembly line
- A system is often affected by changes occurring outside 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

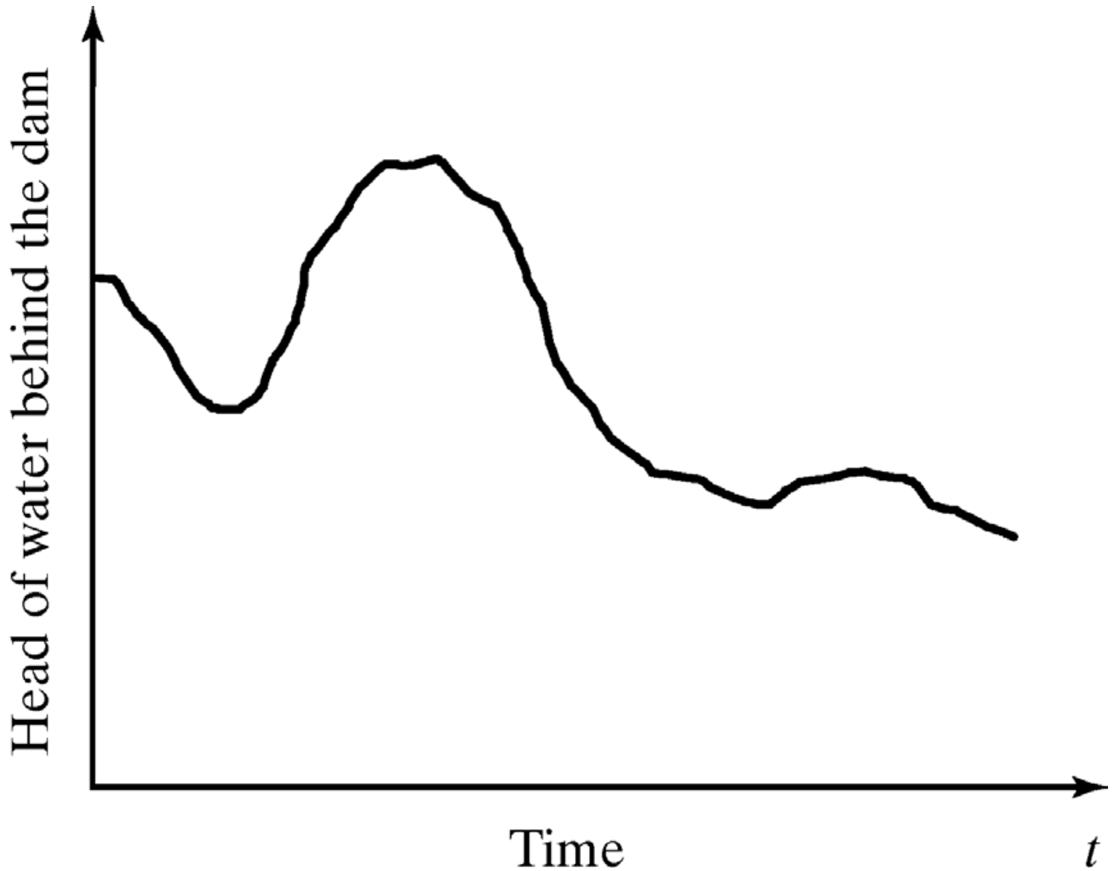
Discrete and Continues Systems

- 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.)

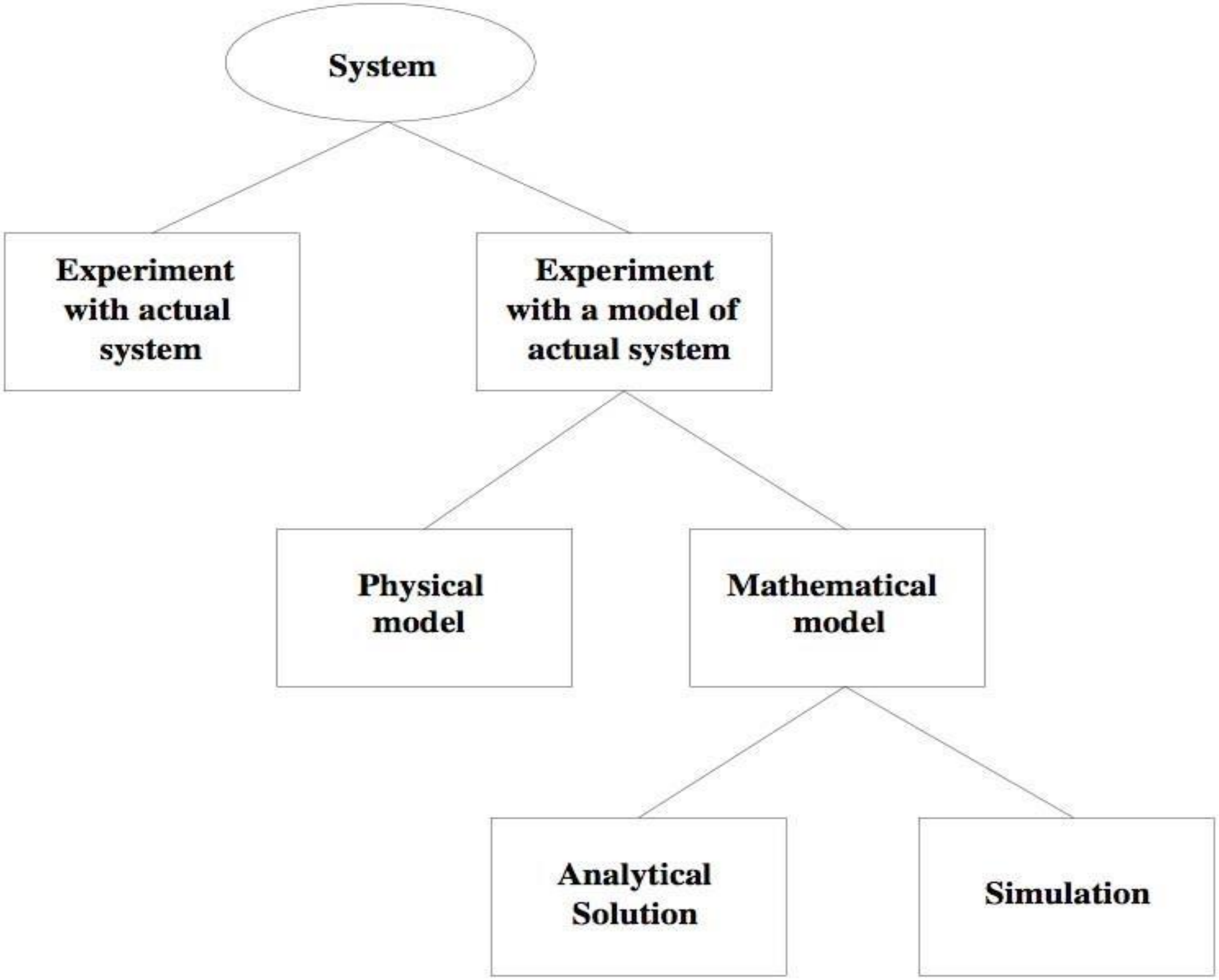
- A continues system is one in which the state variables change continuously over time: Head of water behind the dam



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



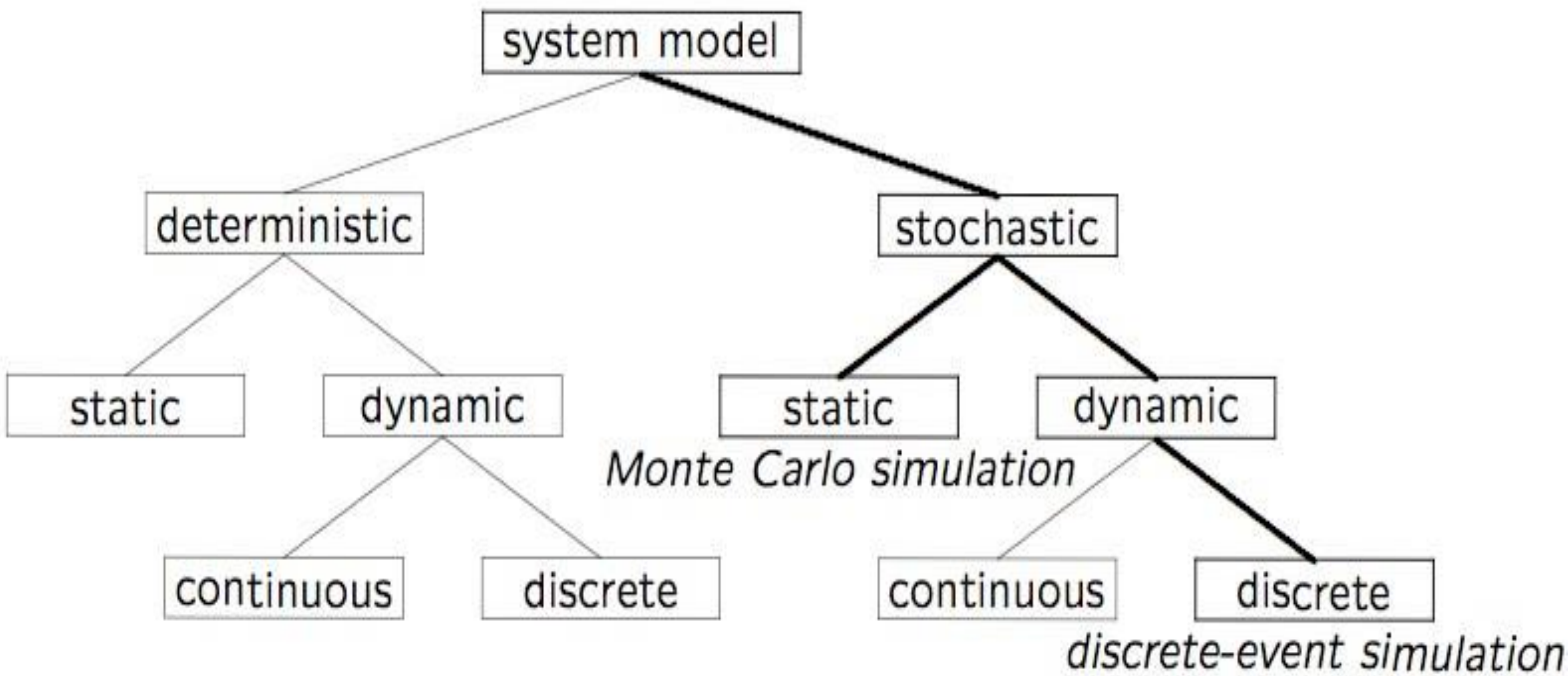
Characterizing a Simulation Model

- 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 <u>model right</u>?
- *Validation*
  - Computational model should be consistent with the system being analyzed
  - Did we build the <u>right model</u>?
  - Can an expert distinguish simulation output from system output?
- Interactive graphics can prove valuable