Lecture 1:
Introduction to simulation

Dr. Hatem Noaman

About This Course

- Time: Lecture Sunday (11-1)
- Office Hours: Sunday (1-2)
- Text Book: Discrete Event System Simulation (Fifth Edition) , Jerry Banks , John S. Carson , Barry L. Nelson and David M. Nicol

Overview

- What is simulation ?
- When simulation is appropriate tool
- When simulation is not appropriate
- Advantages of simulation
- Areas of application
- Systems and Systems environment
- Components of a system
- Discrete and continuous systems
- Model of a system
- Types of models
- Discrete-event systems simulation
- Steps in simulation study

What is simulation ?

- **Simulation** is the imitation of the operation of a real world process or system over time.
- **Simulation models** help us to study the behavior of system as it evolves
- **Simulation models** keeps the set of assumption concerning the operation of the system in terms of **mathematical, logical and symbolic** relationship between the entities or object of interest of the system.

Cont.

- Simulation modeling can be used both as an **analysis tools** to predict the performance of the new system and also **predict the effect of changes to existing system**.
- Simulation can be done by hand or computer its keeps the history of system
- Simulation produce the set of data is used to estimate the measures of performance of system.

When simulation is appropriate tool

- Simulation enables the study of **internal reactions** of a complex system
- Informational, organizational, and environmental **changes** can be simulated.
- To **improve** the system performance
- **Important variables** that affect the system can be identified
- To reinforce **analytic** solution methodologies.
- To experiment with **new designs or policies** prior to implementation, so as to prepare for what may happen.
- **The modern system is so complex** that the interactions can be treated only through simulation.

When simulation is not appropriate

- If the problem can be solved with common sense.
  - Average arrival rate 100/hour and service rate is 12/hour, then the number of servers 100/12=8.33. Which means 9 or more servers are needed.
- If the problem can be solved analytically.
- If it is easier to perform experiments
- If costs exceed savings
- If the resources or time is not available.
- If data or estimates are not available
- Ability to verify the model
- If managers have unreasonable expectations
- If the system is too complex.

Advantages

- New policies, operating procedures, decision rules, information flows, or organizational procedures, and so on can be explored **without disrupting ongoing operations of the real system**
- New hardware designs, physical layouts, transportation systems, and so on, **without committing resources for their acquisition.**
- Hypotheses about **how or why** certain phenomena occur can be tested for feasibility.
- Insight can be obtained about the **interaction of variables**

Advantages

- Insight can be obtained about the **importance of variables** to the performance of the system
- **Bottleneck analysis** can be performed where work in progress , information, materials and so on are being delayed.
- A simulation study can help **understanding** how the system operates rather than how individuals think the system operates.
- **What-if questions** can be asked. This is useful in the design of new systems.

Areas of applications

- Manufacturing applications
- Construction Engineering
- Military applications
- Logistics, transportation, and distributed applications
- Business process simulation
- Human Systems

Manufacturing applications

- Analysis of **electronics assembly** operations
- Determining **optimal lot size** for a semiconductor back-end factory
- Analysis of **storage and retrieval strategies** in a warehouse
- Model for an Army **chemical munitions disposal** facility

Construction engineering

- Construction of a **dam embankment**
- Trenchless renewal of **underground** urban infrastructures
- Investigation of the structural **steel erection process**
- Special-purpose template for utility **tunnel construction**

Military applications

- Modeling leadership effects and recruit type in an **army recruiting station**
- Design and test of an intelligent controller for **autonomous underwater vehicles**
- Modeling military requirements for **non-war-fighting operations.**

Logistics, Transportation, and Distribution

- Evaluating the potential benefits of **a real-traffic planning algorithm**
- Evaluating strategies to **improve railroad performance**
- Parametric modeling in **rail-capacity planning**
- Analysis of **passenger flows** in an airport terminal
- Proactive **flight-schedule** evaluation

Business process simulation

- Impact of connection **bank redesign** on airport gate assignment
- Product development program **planning**
- **Reconciliation** of business and systems modeling
- Personnel forecasting and **strategic workforce planning**

Human Systems

- Modeling **human performance** in complex systems
- Studying **the human element** in air traffic control.

Systems and System environment

- **A system** is defined as a group of objects that are joined together in some regular interaction or interdependence toward the accomplishment of common purpose
  - Example: Production system manufacturing automobiles. The machines, component parts and workers operate jointly along an assembly line to produce a high-quality vehicle.
- **Environment**: A system effected by changes occurring outside the system. Such changes are said to occur in the system environment.
- There is a boundary between the system and environment.

Components of a System

- **Entity**: object of interests in the system
- **Attribute:** property of an entity
- **Activity:** time period of specified length
  - Example: bank: Customers might be one of the **entities,** balance might be an **attributes**, and making deposit is an **activity.**
- **State:** Collation of variables necessary to describe the system at any time relative to the objectives of the study.
  - Bank: # of busy tellers, # of customers waiting in the queue, arrival time of the next customer
- **Event:** It is defined as an instantaneous occurrence that may change the state of the system.
- Depending on purpose, the number of components (entities, attributes, activities, states, events) varies.

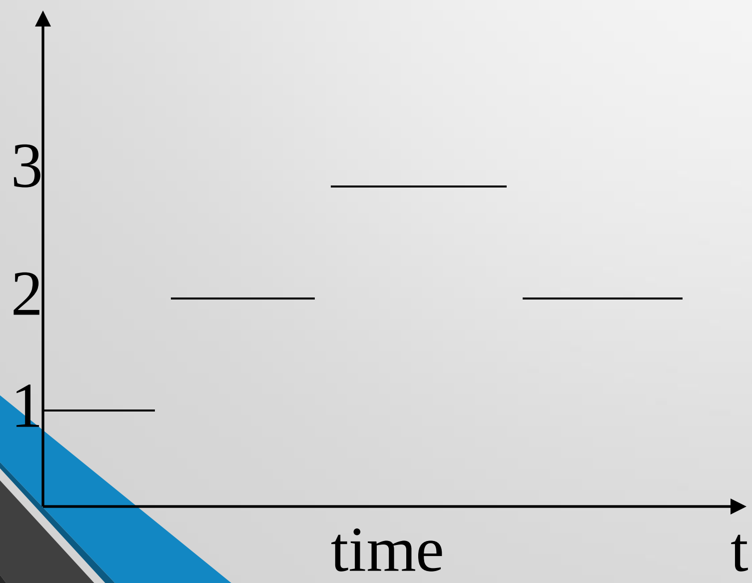
Examples of Systems

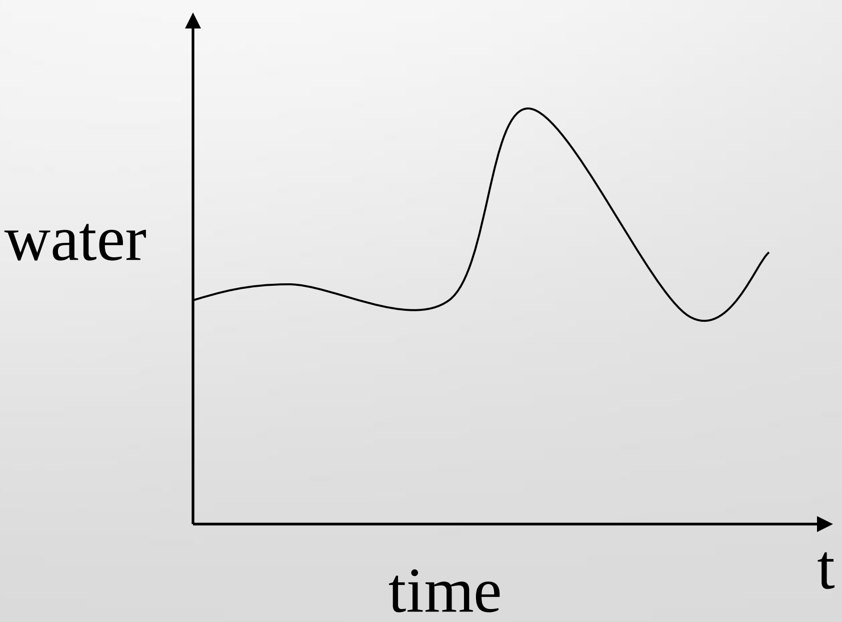
System	*Entities*	*Attributes*	*Activities*	*Events*	*State Variables*
Banking	Customers	Checking-account balance	Making deposits	Arrival; departure	Number of busy tellers; number of customers waiting
Rapid rail	Riders	Origin; destination	Traveling	Arrival at station; arrival at destination	Number of riders waiting at each station; number of riders in transit
Production	Machines	Speed; capacity; breakdown rate	Welding; stamping	Breakdown	Status of machines (busy, idle, or down)
Communications	Messages	Length; destination	Transmitting	Arrival at destination	Number waiting to be transmitted
Inventory	Warehouse	Capacity	Withdrawing	Demand	Levels of inventory; backlogged demands

Discrete and Continuous Systems

- Discrete systems: State variables change only at a discrete set of points in time.
  - Example : bank: the number of customers change when a customer enters or leaves the system

- Continuous system: State variables change continuously over time.
  - Example: water in the dam





Model of a System

- A model is defined as a representation of a system for the purpose of studying the system.
- Types of models : Mathematical or physical.
- A mathematical model uses symbolic notation and mathematical equations to represent a system. A simulation model is a particular type of mathematical model of a system.

Simulation models

- Simulation models: Static or dynamic, Deterministic or stochastic, Discrete or continuous.
- **Static or Monte Carlo simulation**" represents a system at a particular point in time.
- **Dynamic models:** represent systems as they change over time.
- **Deterministic simulation**: Known sets of inputs and a unique sets of outputs.
  - If all patients arrive at an appointed time
- **Stochastic simulation**: has one or more random variables as inputs. Random inputs lead to random outputs.
  - Bank: random inter-arrival times and random service times.
  - Output: average number of people waiting, average waiting time of a customer.

Discrete-event simulation: Modeling of systems in which the state variables changes at a discrete set of points in time .

Steps in Simulation study

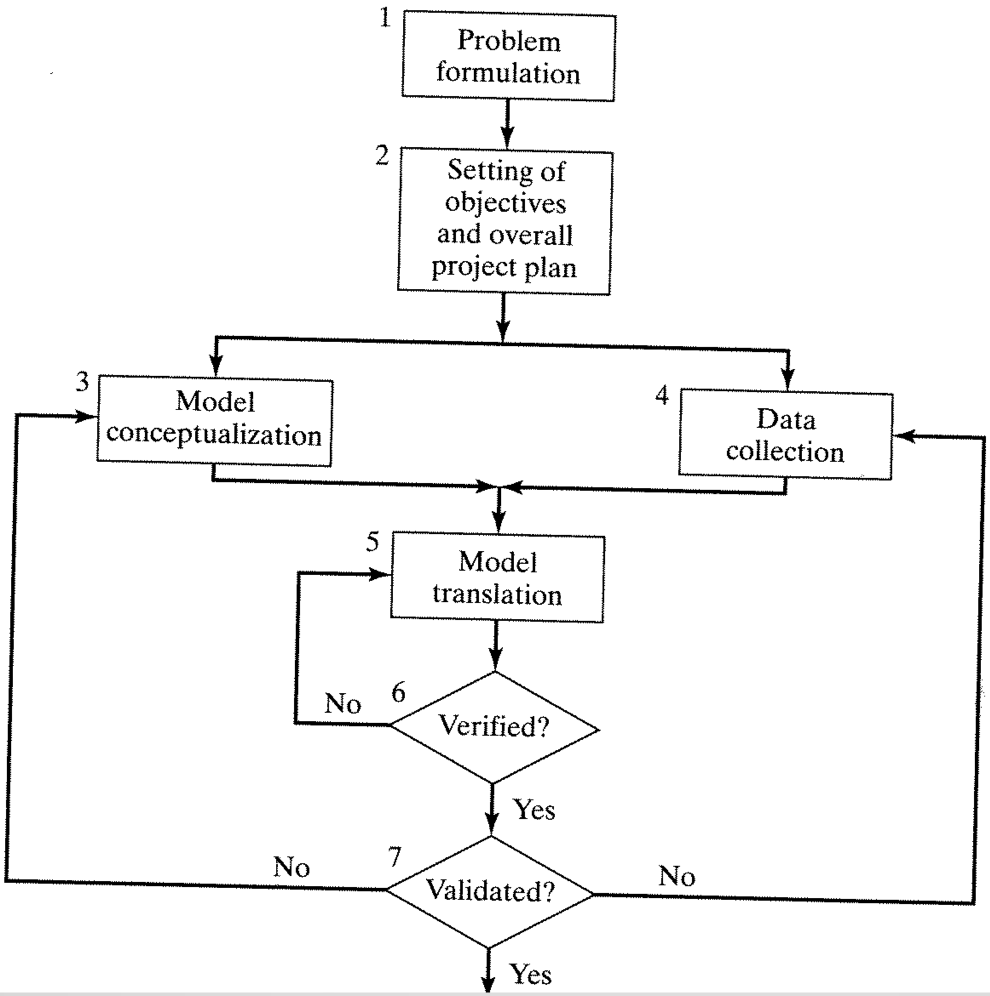
- **Problem formulation:**
  - Statement of the problem.
  - The problem should be clearly understood.
- **Setting of objectives and overall project plan:**
  - The objectives indicate the questions to be answered by the simulation.
  - Determination should be made whether the simulation is appropriate methodology or not.
- **Model conceptualization:**
  - It is an art.
  - Abstract the essential features of the problem
  - Select and modify basic assumptions that characterize the system
  - Enrich and elaborate the model until a useful approximation results.
  - It is best to start a simple model and build toward greater complexity.
  - Not necessary to have one-one mapping with real system.
  - Only the essence of the real system is needed.
  - Advisable to involve model user
  - However, only experience can teach the model building.

Cont.

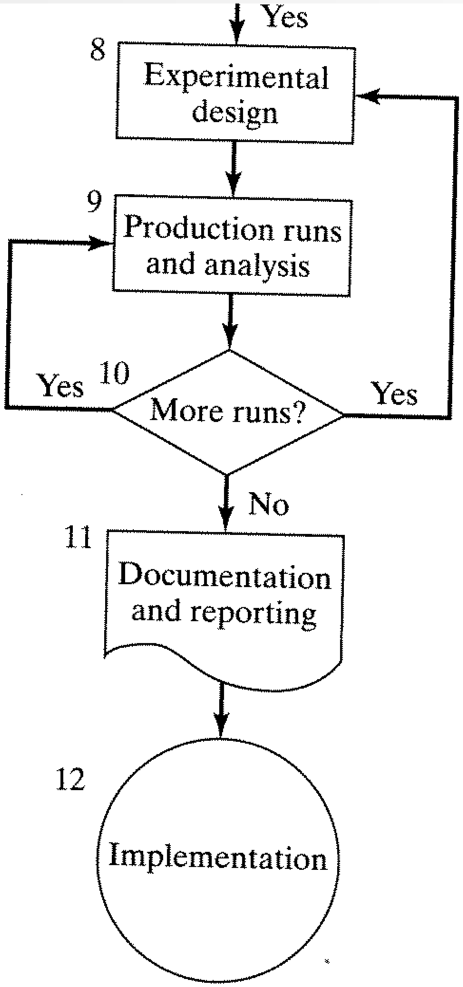
- **Data collection:**
  - Different kinds of data should be identified and collected while building a model.
- **Model translation**: The model can be translated into program.
- **Verified:**
  - Is the computer program performing correctly ?
  - With complex models it is difficult.
- **Validation:** determination that a model is an accurate representation of the real system
- **Experimental design:**
  - Length of the initialization period
  - The length of simulation runs
  - The number of replications to be made for each run

Cont.

- **Documentation and reporting**
  - Two types of documentation: program and progress.
  - Reporting frequent deliverables.
- **Implementation:** Completion of previous steps



1
Problem formulation
2
Setting of objectives and overall project plan
3
Model conceptualization
4
Data collection
5
Model translation
6
Verified?
No
Yes
7
Validated?
No
No
Yes



Yes
8
Experimental design
9
Production runs and analysis
Yes
10
More runs?
Yes
No
11
Documentation and reporting
12
Implementation