Simulation, Modeling ; and Types of Models

Simulation refers to the process of creating a computer-based model of a system, process, or phenomenon and analyzing its behavior under different conditions or scenarios. The goal of simulation is to provide insights into the behavior of the system and to predict how it may behave in the future. Simulation can be used for various purposes, such as testing new designs, optimizing processes, and understanding complex systems.

Modeling, on the other hand, refers to the process of creating a simplified representation of a system or process that captures its essential features. Models can be mathematical, conceptual, or physical, and they are used to gain insights into the behavior of the system and to make predictions about its future behavior. Modeling can be used to understand complex phenomena, test theories, and make predictions.

There are several types of models used in simulation and modeling. Some of the common types include:

Mathematical models: These models use mathematical equations to represent the behavior of a system or process. They can be used to simulate physical systems, such as mechanical or electrical systems.

Statistical models: These models use statistical methods to analyze data and make predictions. They are commonly used in fields such as economics, finance, and social sciences.

Agent-based models: These models represent a system as a collection of individual agents that interact with each other. They are commonly used in social and economic simulations.

System dynamics models: These models represent a system as a collection of feedback loops and stocks and flows. They are commonly used to simulate complex systems, such as environmental or social systems.

Discrete event models: These models represent a system as a sequence of discrete events, such as arrivals, departures, and delays. They are commonly used to simulate complex systems, such as computer networks or transportation systems.

Rule-based models: These models represent a system as a set of rules that govern the behavior of the different components of the system. They are commonly used to simulate complex systems, such as biological systems or traffic flow.

The choice of model depends on the nature of the system being simulated and the desired outcome of the simulation. A combination of different models may be used to simulate complex systems with multiple interacting components.

Distributed Lag Model

A distributed lag model is a type of simulation model used in econometrics and other fields to analyze the relationship between a dependent variable and a set of lagged independent variables. In this model, the dependent variable is assumed to be influenced by a set of independent variables over time, with each independent variable having a different lag effect on the dependent variable.

In a simulation context, a distributed lag model can be useful for predicting future trends and making policy decisions based on the expected impact of different interventions.

These models consist of linear algebraic equations. They represent a continuous system but data is available at a fixed point in time.

E.g:

C = Consumption
I = Investment.
T = Tax
G = Government expenditure.
Y = National Income.

$$C = 20 + 0.7(Y - T)$$
$$I = 2 + 0.1Y$$
$$T = 0.2Y$$
$$Y = C + I + G.$$

This is static model but can be made dynamic by picking fixed interval and expressing the current values of the variables in terms of value at previous interval. Variables that appears in form of its current value and one or more previous intervals is said to be lag variable. Its value is denoted by suffix $-n$; where n indicates the interval. Above set of equation can be made dynamic by lagging all the variables as follows :

$$I = 2 + 0.1Y_{-1}$$
$$T = 0.2Y_{-1}$$
$$Y = C_{-1} + I_{-1} + G_{-1}$$
$$C = 20 + 0.7(Y_{-1} - T_{-1})$$

It is not necessary to lag all the variables. Suppose there is one equation that express a single current variable in terms of lag variables only. When these equations is solved, values for second equation can be derived and from these two eqn, 3rd eqn can be solved. Taking this under consideration, substituting T and C in original eqn, then:

$$Y = 45.45 + 2.27(I + G)$$

The set of eqn's can be written as:

$$I = 2 + 0.1Y_{-1}$$
$$Y = 45.45 + 2.27(I + G)$$
$$T = 0.2Y$$
$$C = 20 + 0.7(Y - T).$$

Time Advance Mechanism

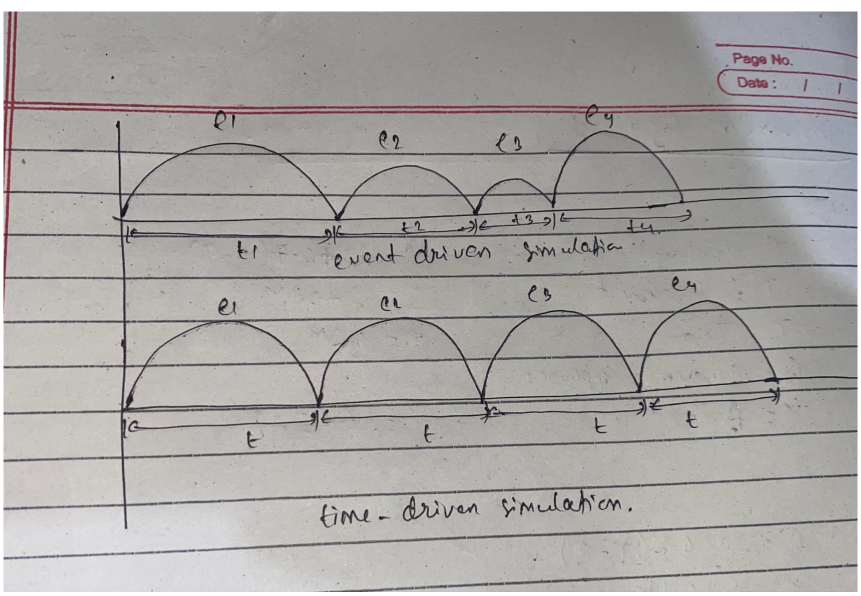
Time advance mechanism is a key concept in simulation that determines how the simulation progresses over time. The mechanism defines how time is modeled and how changes are propagated throughout the system. The two main types of time advance mechanism in simulation are:

Event-driven simulation: In this mechanism, time advances as a result of discrete events that occur in the system. These events trigger changes in the system, and the simulation progresses from one event to the next. Event-driven simulation is particularly useful for modeling systems with discrete changes, such as a queue of customers or a manufacturing process.

Time-driven simulation: In this mechanism, time advances continuously, and changes occur in the system at a certain rate over time. The simulation progresses in small time increments, and the system is updated at each time step. Time-driven simulation is particularly useful for modeling systems with continuous changes, such as a weather model or a traffic flow model.

There are also hybrid approaches that combine event-driven and time-driven simulation mechanisms, known as "hybrid simulation". These approaches can be particularly useful for modeling complex systems with both discrete and continuous changes, such as a manufacturing plant with both assembly lines and continuous processes.

In general, the choice of time advance mechanism will depend on the specific characteristics of the system being modeled and the level of detail required in the simulation.



Queuing System :

Characteristics:

- Arrival Pattern
- Service process.
- Queue Discipline (First-in-First-Out(FIFO), SIRO(Service In Random Order), Priority, SPTF(Shortest Processing Time First)).

Performance measures of queue :

- Average delay of customers in queue.
- Average no.of customer in queue at time t.
- Server utilization.

System environment

The system environment in simulation refers to the external factors that can influence the behavior of the simulated system. These factors can include physical conditions, such as temperature, humidity, and lighting, as well as human factors, such as user behavior, decision-making, and interactions.

For example : In a simulation of a traffic flow system, the system environment could include factors such as the number and type of vehicles on the road, weather conditions, and road conditions.

Understanding the system environment is important for developing accurate and reliable simulations, as it helps to identify the key factors that can influence the behavior of the system being simulated.

(dx^2)^3
Order : 2 , degree :3
Non-linear if degree > 1
Linear if degree = 1.

Analog Simulation:

Advantage :

- Analog computer have higher speed of solution than that of digital simulation.
- Analog computer have direct access to an immediate display of computer result.

Disadvantage:

- Limited accuracy
- Hardware setup required
- Output of analog simulation is not easily understood by general people.

Random Number Properties:

1. Non-deterministic: Random numbers are non-deterministic, meaning that their values cannot be predicted in advance
2. Uniform distribution: Random numbers should be uniformly distributed over a given range. This means that each number in the range is equally likely to be selected.
3. Independence: Random numbers should be independent of each other. That is, the selection of one number should not affect the probability of selecting another number.
4. Seed value: The seed value is the initial value used to generate the sequence of random numbers. By changing the seed value, it is possible to generate different sequences of random numbers.

Random Number Generating Algorithm

... generating random number. ... A number of recursive procedure
One of the method for generating PRN is Mid square method. It starts with a fixed initial value, say 4-digit integer, called seed. The number is squared and the middle four digit of this square

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become the second number. The middle digit of this second number are then squared again to generate third random number and so on. We may also have to add zero to make the digit's length eight if necessary. Finally, we get realization from the uniform (0,1) distribution after placement of decimal points i.e. after division by 10000.

Example: if we take seed $Z_0 = 1234$, then we will get the sequence of numbers as 0.1234, 0.5227, 0.3215, 0.3362, 0.3030, 0.1809……………………

5. # Generate the random number sequence of number for $Z_0 = 2100$ using mid square method.