Simulation Model

- Can be in the form of:
  - mathematical
  - logical
- Representing system behavior.
- The part of the system being modeled is tailored to the purpose of the system modeling and simulation.
- It is important to understand the objective(s) of carrying out system modeling and simulation so that a system model can be created that meets the objective(s).

Types of Simulation

- Monte-Carlo Simulation
- Discrete-Event Simulation
- Continuous Simulation

JaamSim

- JaamSim (Java Animation Modelling and Simulation) is a discrete-event simulation software package first developed in 2002 as the foundation for simulation applications. JaamSim includes a drag-and-drop graphical user interface, 3D animation, and a full set of built-in objects for model building. It is object oriented, extremely fast, and scalable to the largest of applications. Windows, Linux, and OSX are all supported.
- JaamSim represents the lessons learned from simulation projects we have performed around the world for more than 35 years.
- Background information on JaamSim can be found in the JaamSim blog: www.jaamsim.com/blog.
- JaamSim is free open source software, licensed under Apache 2.0. The latest version of the software and manuals can be downloaded from the JaamSim website: www.jaamsim.com.
- The source code is published on GitHub: www.github.com/jaamsim/jaamsim.
- Presentations and tutorials for JaamSim can be found at: www.youtube.com/user/javasimulation.

- (from www.jaamsim.com)

Bank Teller Problem

- Information:
  - Customers of a bank arrive every 5 minutes (deterministic arrivals).
  - One Bank teller is assigned to serve customers.
  - After entering the door, a customer needs 30 seconds to arrive at the Teller's desk.
  - A customer needs to queue if the teller is busy servicing another customer.
  - The service time for each customer is 3 minutes.
  - After being serviced by the teller, a customer walks out of the bank, requiring 45 seconds.
  - The simulation should run for 6 hours.

→The system has a single queue and one server.

Bank Teller Problem (Exponential Arrival Pattern)

- Information:
  - Customers of a bank arrive at an average of 30 customers per hour (Exponential distribution).
  - One Bank teller is assigned to serve customers.
  - After entering the door, a customer needs 30 seconds to arrive at the Teller's desk.
  - A customer needs to queue if the teller is busy servicing another customer.
  - The service time for each customer is 3 minutes.
  - After being serviced by the teller, a customer walks out of the bank, requiring 45 seconds.
  - The simulation should run for 6 hours.

→The system has a single queue and one server.

Bank Teller Problem

- Objective: Report the following:

  (a) Average queue length

  (b) Average waiting time in queue

  (c) Average teller utilization.

  Average waiting time in queue = Total waiting time of all customers / Total number of customers

Average Queue Length

$$L_q = \frac{\sum_{i=1}^{n} (\text{Queue Length}_i \times \text{Time Interval}_i)}{\text{Total Observation Time}}$$

where:

Queue Length $_i$ = observed queue length at duration i.

Time Interval $_i$ = the duration the queue persisted before changing.

Average Waiting Time in Queue

$$\text{Average Waiting Time} = \frac{\text{Total Waiting Time of All Customers}}{\text{Total Number of Customers}} = \frac{\sum WQ_i}{N}$$

where:

WQ_i is the waiting time in the queue for the i-th customer.

N is the total number of customers that arrived and were served during the observation period.

Teller Utilization

$$\text{Resource Utilization Rate} = \frac{\text{Total Time Used (or Worked)}}{\text{Total Time Available (Capacity)}} \times 100\%$$

where:

Total Time Used (or Worked) = Aggregated discrete time intervals when the resource was actively working or engaged in a task during that same period.