# Simulation

**Simulation:**

Simulation is an experiment conducted on a model of some system to collect necessary information on the behavior of that system.

The representation of reality in some physical form or in some form of Mathematical equations are called Simulations. Simulations are imitation of reality.

For example:

1, Children cycling park with various signals and crossing is a simulation of a read model traffic system

2. Planetarium

3. Testing an air craft model in a wind tunnel.

**Need for simulation:**

- Consider an example of the queuing system, namely the reservation system of a transport corporation.
- The elements of the system are booking counters (servers) and waiting customers (queue).
- Generally the arrival rate of customers follow a Poisson distribution and the service time follows exponential distribution.
- Then the queuing model (M/M/1) : (GD/∞ /∞ ) can be used to find the standard results.

But in reality, the following combinations of distributions may exist.

1. Arrived rate does not follow Poisson distribution, but the service rate follows an exponential distribution.

2. Arrival rate follows a Poisson distribution and the service rate does not follow exponential distribution.

3. Arrival rate does not follows Poisson distribution and the service time also does not follow exponential distribution.

In each of the above cases, the standard model (M/M/1) : (G/D/∞ /∞ ) cannot be used. The last resort to find the

solution for such a queuing problem is to use simulation.

**Advantage of simulation :**

1. Simulation is Mathematically less complicated
2. Simulation is flexible
3. It can be modified to suit the changing environments.
4. It can be used for training purpose
5. It may be less expensive and less time consuming in a quite a few real world situations.

**Limitations of Simulation:**

1. Quantification or Enlarging of the variables maybe difficult.
2. Large number of variables make simulations unwieldy and more difficult.
3. Simulation may not. Yield optimum or accurate results.

4. Simulation are most expensive and time consuming model.
5. We cannot relay too much on the results obtained from simulation models.

**Steps in simulation:**

1. Identify the measure of effectiveness.
2. Decide the variables which influence the measure of effectiveness and choose those variables, which affects the measure of effectiveness significantly.
3. Determine the probability distribution for each variable in step 2 and construct the cumulative probability distribution.
4. Choose an appropriate set of random numbers.
5. Consider each random number as decimal value of the cumulative probability distribution.
6. Use the simulated values so generated into the formula derived from the measure of effectiveness.
7. Repeat steps 5 and 6 until the sample is large enough to arrive at a satisfactory and reliable decision.

**Uses of Simulation:**
Simulation is used for solving
1. Inventory Problem
2. Queuing Problem
3. Training Programs etc

**General Purpose Languages used for Simulation:**

**FORTRAN:** Probably more models than any other language

**PASCAL;** Not an universal as FORTRAN

**MODULA:** Many improvements over PASCAL

**ADA:** Department of Defense attempt at standardization

**C, C++:** Object-Oriented Programming Language

**PSPICE:** Simulation Software

**MAT LAB:** MATrix LABoratory : High Level Languages (Mathematical and Graphical Subroutines)

**SIMULINK:** Used to Model, Analyze and Simulate Dynamic Systems using block diagrams

**Problem** :

Customers arrive at a milk booth for the required service. Assume that inter – arrival and service time are constants and given by 1.5 and 4 minutes respectively. Simulate the system by hand computations for 14 minutes.
(i) What is the waiting time per customer?
(ii) What is the percentage idle time for the facility?
(Assume that the system starts at t = 0)

**Solution :**

First customer arrives at the service center at t = 0
His departure time after getting service = 0 + 4 = 4 minutes.
Second customer arrives at time t = 1.5 minutes
he has to wait = 4 – 1.5 = 2.5 minutes.
Third customer arrives at time t = 3 minutes
he has to wait for = 8-3 = 5 minutes
Fourth customer arrives at time t = 4.5 minutes and he has to wait for 12 – 4.5 = 7.5 minutes.
During this 4.5 minutes, the first customer leaves in 4 minutes after getting service and the second customer is getting service.
Fifth customer arrives at t = 6 minutes
he has to wait 14 – 6 = 8 minutes
Sixth customer arrives at t = 7.5 minutes
he has to wait 14 – 7.5 = 6.5 minutes
Seventh customer arrives at t = 9 minutes
he has to wait 14 – 9 = 5 minutes
During this 9 minutes the second customer leaves the service in 8th minute and third person is to get service in 9th minute.
Eighth customer arrives at t = 10.5 minutes
he has to wait 14 – 10.5 = 3.5 minutes
Nineth customer arrives at t = 12 minutes
he has to wait 14 – 12 = 2 minutes
But by 12th minute the third customer leaves the Service
**10th Customer** arrives at t = 13.5 minutes
he has to wait 14-13.5 = 0.5 minute
From this simulation table it is clear that
(i) Average waiting time for 10 customers = $\frac{2.5+5+7.5+8+6.5+5.0+3.5+2+0.5}{10}$

= $\frac{40.5}{10}$ = 4.05

(ii) Average waiting time for 9 customers who are in waiting for service $\frac{40.5}{9}$ = 4.5 minutes.

But the average service time is 4 minutes which is less that the average waiting time, the percentage of idle time for service = 0%

# Tutorial Questions

1. Solve the following sequence problem given optimal solution when passing is not allowed

| | Jobs | | | | |
|---|---|---|---|---|---|
| Operator | 1 | 2 | 3 | 4 | 5 |
| 1 | 6 | 2 | 5 | 2 | 6 |
| 2 | 2 | 5 | 8 | 7 | 7 |
| 3 | 7 | 8 | 6 | 9 | 8 |
| 4 | 6 | 2 | 3 | 4 | 5 |
| 5 | 9 | 3 | 8 | 9 | 7 |
| 6 | 4 | 7 | 4 | 6 | 8 |

2. Six jobs are to be processed on three machines A, B, C with the order of processing jobs as BCA

| Job | U | V | W | X | Y | Z |
|---|---|---|---|---|---|---|
| Proc,time on machine A | 12 | 10 | 9 | 14 | 7 | 9 |
| Proc,time on machine B | 7 | 6 | 6 | 5 | 4 | 4 |
| Proc,time on machine C | 6 | 5 | 6 | 4 | 2 | 4 |

The suggested sequence is Y-W-Z-V-U-X. Find out the elapsed time for the sequence suggested. Is it optimal? If it is not optimal, then find out the optimal sequence and the minimum total elapsed time associated with it.

3. A book binder has one printing press, one binding machine and manuscripts of 7 different books The time required for performing printing and binding operations for different books are shown below

| Book | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Printing time (hr) | 20 | 90 | 80 | 20 | 120 | 15 | 65 |
| Binding time(hrs) | 25 | 60 | 75 | 30 | 90 | 35 | 50 |

Decide the optimum sequence of processing of books binder to minimize the total time required to bring out all the books

# Assignment Questions

1. A bakery keeps stock of a popular brand of cake. Previous experience show the daily demand pattern for the item with associated probabilities as given,Use the following sequence of random numbers to simulate the demand for next 10 days Random numbers: 25,39,65,76,12,05,73,89,19,49 Also estimate the daily average demand for the cakes on the basis of the

| Daily damand (number) | 0 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|
| Probability | 0.01 | 0.20 | 0.15 | 0.50 | 0.12 | 0.02 |

2. Define simulation why simulation uses. Give one application area when thistechnique is used in practice