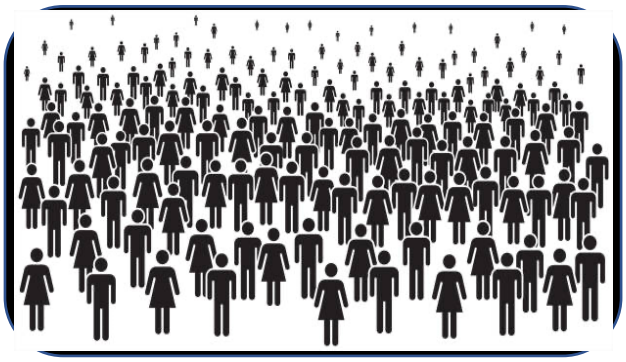
**Simulation**

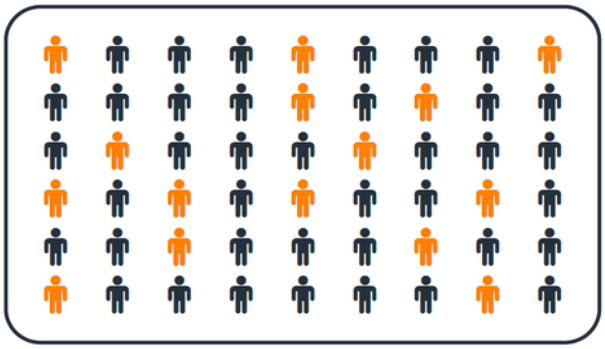
Simulation is a process of designing a model of a real system and conducting experiments with the model for the purpose of understanding the behaviour for the operation of the system.

- A duplication of the original system
- to understand the implementation of the system.

**Monte Carlo Simulation**

The technique was first used by scientists working on the atom bomb; it was named for Monte Carlo, the Monaco resort town renowned for its casinos. Since its introduction in World War II Monte Carlo simulation has been used to model a variety of physical and conceptual systems.





Monte Carlo simulations a computerized mathematical technique that allows people to account for risk in quantitative analysis and decision making. The technique is used by professionals in such widely disparate fields as finance, project management, energy, manufacturing, engineering, research and development, insurance, oil & gas, transportation, and the environment. Monte Carlo simulation furnishes the decision-maker with a range of possible outcomes and the probabilities they will occur for any choice of action. It shows the extreme possibilities the outcomes of going for broke and for the most conservative decision along with all possible consequences for middle-of-the-road decisions.

**Steps to perform**

1- Establishing probability distribution

2- Cumulative probability distribution

3- Setting random number intervals

4- Generating Random numbers

5- To find the answer of question asked using the above four steps

***Example :*** Dr. Ravi, a dentist schedules all his patients for 30 minute appointments. Some of the patients take more or less than 30 minutes depending on the type of dental work to be done. The following table shows the summary of the various categories of work, their probabilities and the time actually needed to complete the work.

***Simulation Problem***

| Category | Time Required(minutes) | No. of Patients |
|---|---|---|
| Filling | 45 | 40 |
| Crown | 60 | 15 |
| Cleaning | 15 | 15 |
| Extraction | 45 | 10 |
| Check-up | 15 | 20 |

Simulate the dentist's clinic for four hours and determine the average waiting time for the patients as well as the idleness of the doctor. Assume that all the patients show up at the clinic exactly at their scheduled arrival time, starting at 8.00 am. Use the following random numbers for handling the above problem: 40, 82, 11, 34, 25, 66, 17, 79

***Solution:*** Assign the random number intervals to the various categories of work as shown in table.

***Random Number Intervals Assigned to the Various Categories***

| Category of work | Probability | Cumulative probability | Random Number Interval |
|---|---|---|---|
| Filling | 0.40 | 0.40 | 00-39 |
| Crown | 0.15 | 0.55 | 40-54 |
| Cleaning | 0.15 | 0.70 | 55-69 |
| Extraction | 0.10 | 0.80 | 70-79 |
| Check-up | 0.20 | 1.00 | 80-99 |

*Assuming the dentist clinic starts at 8.00 am, the arrival pattern and the service category are shown in table.*

***Arrival Pattern of the Patients***

| Patient Number | Scheduled Arrival | Random Number | Service category | Service Time |
|---|---|---|---|---|
| 1 | 8.00 | 40 | Crown | 60 |
| 2 | 8.30 | 82 | Check-up | 15 |
| 3 | 9.00 | 11 | Filling | 45 |
| 4 | 9.30 | 34 | Filling | 45 |
| 5 | 10.00 | 25 | Filling | 45 |
| 6 | 10.30 | 66 | Cleaning | 15 |
| 7 | 11.00 | 17 | Filling | 45 |
| 8 | 11.30 | 79 | Extraction | 45 |

***Final Table to find waiting time and idle time***

| Patient | Arrival | Service Start | Service duration | Service Ends | Waiting Time | Idle Time |
|---|---|---|---|---|---|---|
| 1 | 8:00 am | 8:00 am | 60 min | 9:00 am | 0 min | 0 |
| 2 | 8:30 am | 9:00 am | 15 min | 9:15 am | 30 min | 0 |
| 3 | 9:00 am | 9:15 am | 45 min | 10:00 am | 15 min | 0 |
| 4 | 9:30 am | 10:00 am | 45 min | 10:45 am | 30 min | 0 |
| 5 | 10:00 am | 10:45 am | 45 min | 11:30 am | 45 min | 0 |
| 6 | 10:30 am | 11:30 am | 15 min | 11:45 am | 60 min | 0 |
| 7 | 11:00 am | 11:45 am | 45 min | 12:30 am | 45 min | 0 |
| 8 | 11:30 am | 12:30 am | 45 min | 1:45 am | 60 min | 0 |

The dentist was idle during the simulation period

The average waiting time of patients = 285/8 = **35.625 minutes.**

Formula Hint:

```
=IF( AND(D15>=G5,D15<=H5),"Filling" ,IF(AND(D15>=G6,D15<=H6),"Crown"
,IF(AND(D15>=G7,D15<=H7),"Cleaning" ,IF(AND(D15>=G8,D15<=H8),"Extracting"
,IF(AND(D15>=G9,D15<=H9),"Checkup" )))))
```