Program:	Software Engineering عثمان انسٹیٹیوٹ آف ٹیکنالوجی	Class:	VIII-A, and B
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This lecture aims to introduce students to the workings of simulation without computers. These examples would provide insight into the methodology of discrete system simulation and the output analysis techniques of a simulation model.

3-Steps Required For Manual Simulation

- Determine the characteristics of each of the inputs to the simulation. Quite often, these may be modeled as probability distributions, either continuous or discrete.
- Construction of simulation tables. Each simulation table is different; each is developed for the purpose.
- For each repetition *i*, generate a value for each p input and evaluate a function, calculating the response value y_i. This step is accomplished by sampling values from the distributions determined in Step 1.

Simulation is a powerful tool that can be used to analyze many complex problems; however, before a simulation is chosen as the solution method, every effort should be made to solve the problem mathematically. Perhaps with mathematical models developed for queuing problems, perhaps with inventory theory, and so on. Simulation modeling can be time-consuming, and if a closed-form solution exists, it can be much less expensive than simulation.

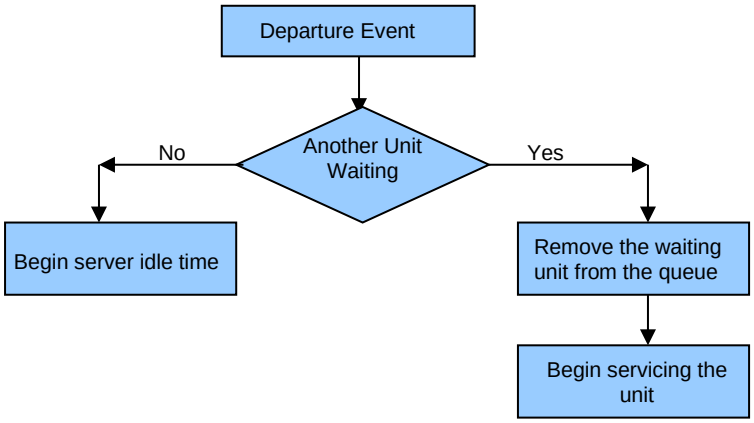
Simulation Of Queuing System

- Terminology
- Examples.

Terminology

- **Calling population:** the population of potential customers.
- **Arrival nature: usually characterized in terms of inter-arrival** times.
- **System capacity is the limit** of the number of customers in the waiting line or on the system.
- **Queuing discipline refers to customers'** actions while in a queue waiting for service to begin.
- Calling population is infinite.
- If a queue grows without bound, it is termed explosive or unstable.
- The **state of the system** can be defined from:
  - ✓ The number of customers in the queue or service.
  - ✓ The status of the server, busy or idle.
- In a single queuing system, only two possible events can affect the system's state.
  - ✓ The arrival event.
  - ✓ The departure event.
- **The clock system's clock time can be defined as the variable that lurches from the time of one event to the time of the following events**

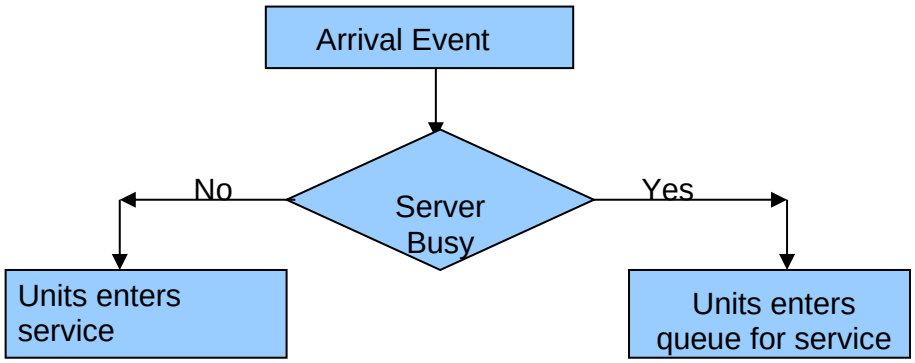
- **Event.**



		Not Empty	Empty
Server Status	**Busy**	Enter Queue	Enter Queue
	Idle	Impossible	Enter Service

(Table-1)

Endogenous Event:



		Queue Status	
		Not Empty	Empty
Server Status	**Busy**		Impossible
	Idle	Impossible	

(Table-2)

EXAMPLES

Problem Statements:

1. A small grocery store has only one checkout counter. The customer randomly arrives at this checkout counter from 1 to 8 minutes apart. Each possible value of inter-arrival time has the same probability of occurrence. As shown in Table. The service time varies

from 1 to 6 minutes, with the possibilities in Table 2. Perform a simulation for 20 customers to analyze the system.

Solution:

Input Tables:

(Table-I) Distribution of time between inter-arrival

Time Between Arrivals (M)	Probability	Commutative Probability	Random Digit Assign
1	0.125	0.125	001-125
2	0.125	0.250	126-250
3	0.125	0.375	251-375
4	0.125	0.500	376-500
5	0.125	0.625	501-625
6	0.125	0.750	626-750
7	0.125	0.875	751-875
8	0.125	1.000	876-000

(Table-2) Service Time Distribution

Service Time (M)	Probability	Commutative Probability	Random Digit Assign
1	0.10	0.10	01-10
2	0.20	0.30	11-30
3	0.30	0.60	31-60
4	0.25	0.85	61-85
5	0.10	0.95	86-95
6	0.05	1.00	96-00

(Table-3) Time Between Arrival Determination

Customer	Random Digits	Time b/w Arrivals	Customer	Random Digits	Time b/w Arrivals
1			11		
2			12		
3			13		
4			14		
5			15		
6			16		
7			17		
8			18		
9			19		
10			20		

(Table-4) Service time generated

Customer	Random Digits	Service Time (m)	Customer	Random Digits	Service Time (m)
1			11		
2			12		
3			13		
4			14		

5					
6			16		
7			17		
8			18		
9			19		
10			20		

Simulation Table for Grocery Store

Customer	Time since last arrival (min)	Arrival time	Service time	Time service begin	Time customer waits in queue	Time service ends	Time customer spends in the sys	Idle time for server
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Find…

- The average waiting time for a customer.
- The prob. that a customer has to wait.
- The proportion for the idle time of the server.
- The average service time.
- Any other question you have in your mind.
- Give your suggestions regarding the system's working.

2. Double channel Queuing System

Consider a drive-in restaurant where carhops take orders and bring food to the car. Cars arrive in the manner shown in Table. There are two carhops –Able and Baker. Able is better

able to do the job and works somewhat faster than Baker. The distribution of service times is shown in tTables2 & 3, respectively. Find out how well the current arrangement is working.

Solution:

Input Tables:

(Table-1) interracial distribution of cars

Time Between Arrivals (M)	Probability	Commutative Probability	Random Digit Assign
1	0.25	0.25	01-25
2	0.40	0.65	26-65
3	0.20	0.85	66-85
4	0.15	1.00	86-00

(Table-2) Service distribution of Able

Service Time (M)	Probability	Commutative Probability	Random Digit Assign
2	0.30	0.30	01-30
3	0.28	0.58	31-58
4	0.25	0.83	59-83
5	0.17	1.00	84-00

(Table-3) Service distribution of Baker

Service Time (M)	**Probability**	**Commutative Probability**	**Random Digit Assign**
3	0.35	0.35	01-35
4	0.25	0.60	36-60
5	0.20	0.80	61-80
6	0.20	1.00	81-00

Simulation For
Restaurant
Multiple Channel Queuing System

					Able			**Baker**			
Customer No	**Random Digit for Arrival**	**Time b/w Arrivals**	**Clock Time of Arrival**	**Random Digits for Service**	**Time Service begins**	**Service Time**	**Time Service Ends**	**Time Service begins**	**Service Time**	**Time Service Ends**	**Time Customer waits in Queue**

Find…

- For what period/ proportion of time was Able busy?
- For what period/ proportion of time was Baker busy?
- Waiting time?
- Service time?
- Your suggestions