Experiment No. : 3
Title:
Single Server system
(The Grocery Store problem)

Batch: B2 **Roll No.: 160104210859** **Experiment No.:3**

Aim: To simulate Single Channel Queuing System

Resources needed: Microsoft Excel / Open Office

Problem Statement:

A small grocery store has only one checkout counter. Customer arrives at this check out counter at random.

In order to evaluate the system performance

a) Let the arrival distribution be uniformly distributed between 1 to 10 minutes.

b) Let service time distribution be as:

Service Time(minutes)	1	2	3	4	5	6
Probability	0.05	0.1	0.2	0.3	0.25	0.1

c) Perform simulation for 20 customers and compute the performance measures.

Concepts:

The key elements of queuing system are customers & servers. The term customer can refer to people, machines, and trucks. The server might refer to receptionist, person etc.

A queing system is described by its calling population, the nature of the arrivals, the service mechanism, the system capacity and the queing discipline.

1. Calling population: The population of potential customer is referred to as calling population. In systems with large population the calling population is usually assumed to be infinity. E.g. population of potential customer of a bank. The actual population may be finite. The main difference between finite & infinite population is based on the definition of the arrival rate.

2. System Capacity: The system capacity has no limit meaning that any no. of units comes and waits in the queue. In many queuing system there is a limit to the no. of customers that may be waiting.

3. Nature of Arrivals: Arrivals for service occur at a time in random fashion and once they join the waiting line, they are served.

4. Service Mechanism: The units are served in order of their arrival by a single server or a channel.

5. Queuing Discipline: It refers to the logical ordering of customers that will be chosen for service when a server becomes busy.

6. State Of System: It is the no. of units in the system & status of server (busy / idle).

7. Events: It is a set of circumstances that causes an instantaneous change in the state of system

Possible events in a single server system:

- The Entry of a unit in the system.
- Departure of unit from system on completion of service.

8. Simulation Clock: It is used to track simulation time.

Conceptual Model:

The grocery store with one checkout counter is simulated by using a Semi – automatic approach by using simulation table to record successive system snapshots as time advances. The simulation requires mainly a service time distribution and an interarrival time distribution of customers.

Characteristics of Grocery Store checkout counter System:

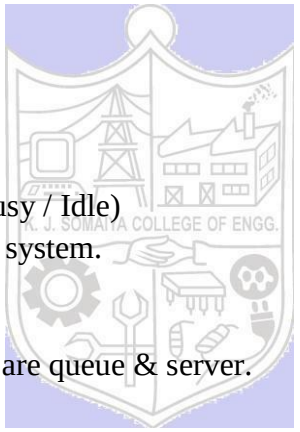
I) Calling Population: Infinite.

II) System capacity: Infinite.

III) Nature of Arrival: Random arrival uniformly distributed.

IV) Service Mechanism: At a time only one customer is served; service time is random, probability distribution is given.

V) Queuing Discipline: FIFO.



System State:

I) Waiting time in queue.

II) Status of Able and Baker (Busy / Idle)

III) Time customer spends in the system.

Entities:

The entities in single channel queue are queue & server.

Events:

a) Arrival Event

b) Departure Event

Activities:

a) Interarrival time.

b) Service time.

Delay:

Waiting time in the queue.

Use of Random Nos.:

- For generating interarrival time
- For generating service time
- RAND () or RANDBETWEEN() function of Excel can be used to generate random nos. in simulation.

Real life Examples:

1. Customers queuing in the Telephone Bill Payment System

Customers form single channel queue. Customer is chosen in FIFO manner.

Performance measures:

1. **Average Waiting Time** = (Total time customers wait in queue) / (Total no. of Customers)

2. **Probability. Of Customers waiting** =(No. of Customers who waits) / (Total no. of Customers)

3.Probability. Of Idle Server = (Total Idle Time Of Server) / (Total runtime of simulation)

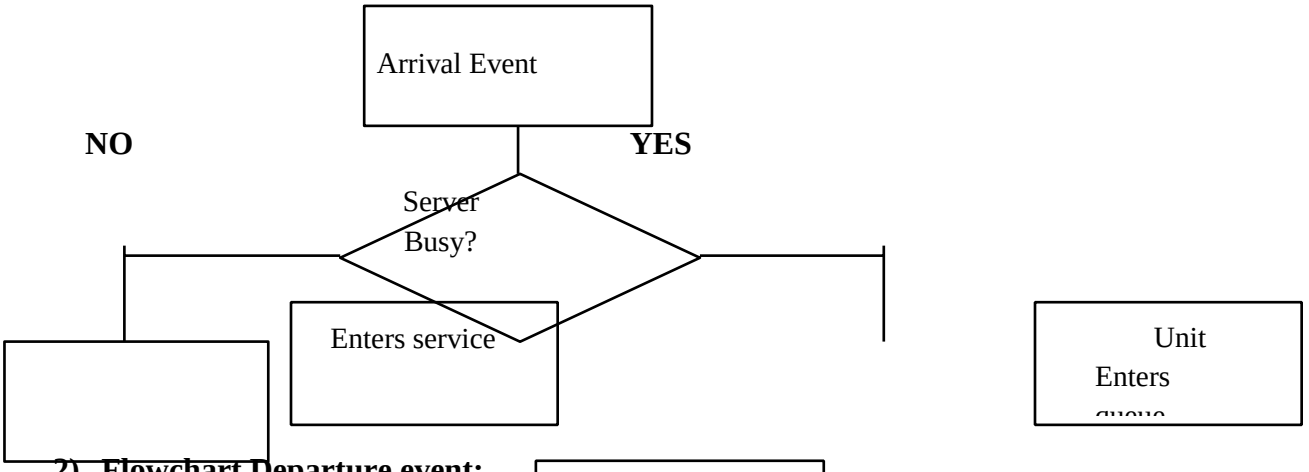
4.Average Time between Arrival = (Total Time between arrivals) / (No. of arrivals)-1

5.Average Waiting Time of Those Who Wait = (Total Time Customer waits in queue) / (Total no. of Customers who wait)

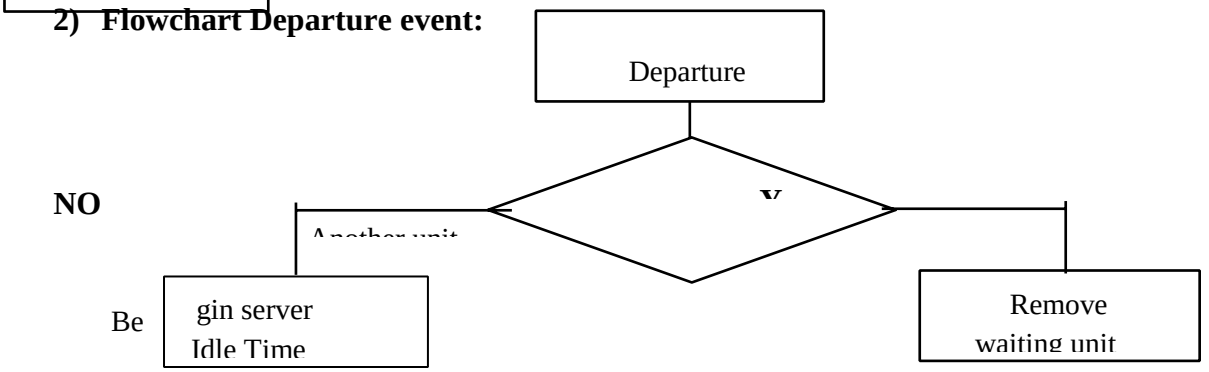
6.Average Time Customers Spends In System = (Total Time Customer spends in system) / (Total no. of Customers).

Activity Diagram:

1) Flowchart Arrival event:



2) Flowchart Departure event:



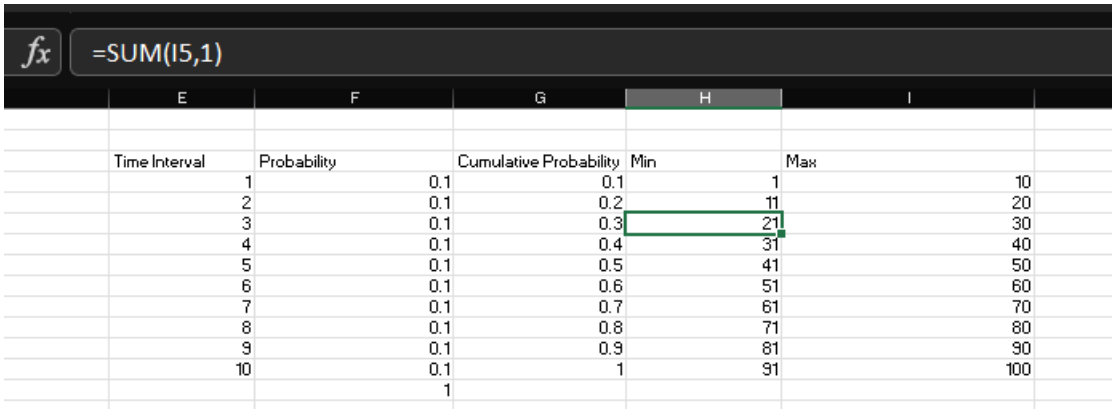
Results: (Program printout as per the format) Program:

(Problem solved using simulation table and the given inputs with MS-Excel.)

Time Interval	Probability	Cumulative Probability	Min	Max
1	0.1	0.1	1	10
2	0.1	0.2	11	20
3	0.1	0.3	21	30
4	0.1	0.4	31	40
5	0.1	0.5	41	50
6	0.1	0.6	51	60
7	0.1	0.7	61	70
8	0.1	0.8	71	80
9	0.1	0.9	81	90
10	0.1	1	91	100
	1			

Service Time	Probability	Cumulative Probability	Min	Max
1	0.05	0.05	1	5
2	0.1	0.15	6	15
3	0.2	0.35	16	35
4	0.3	0.65	36	65
5	0.25	0.9	66	90
6	0.1	1	91	100

Functions used :



=PRODUCT(G7,100)

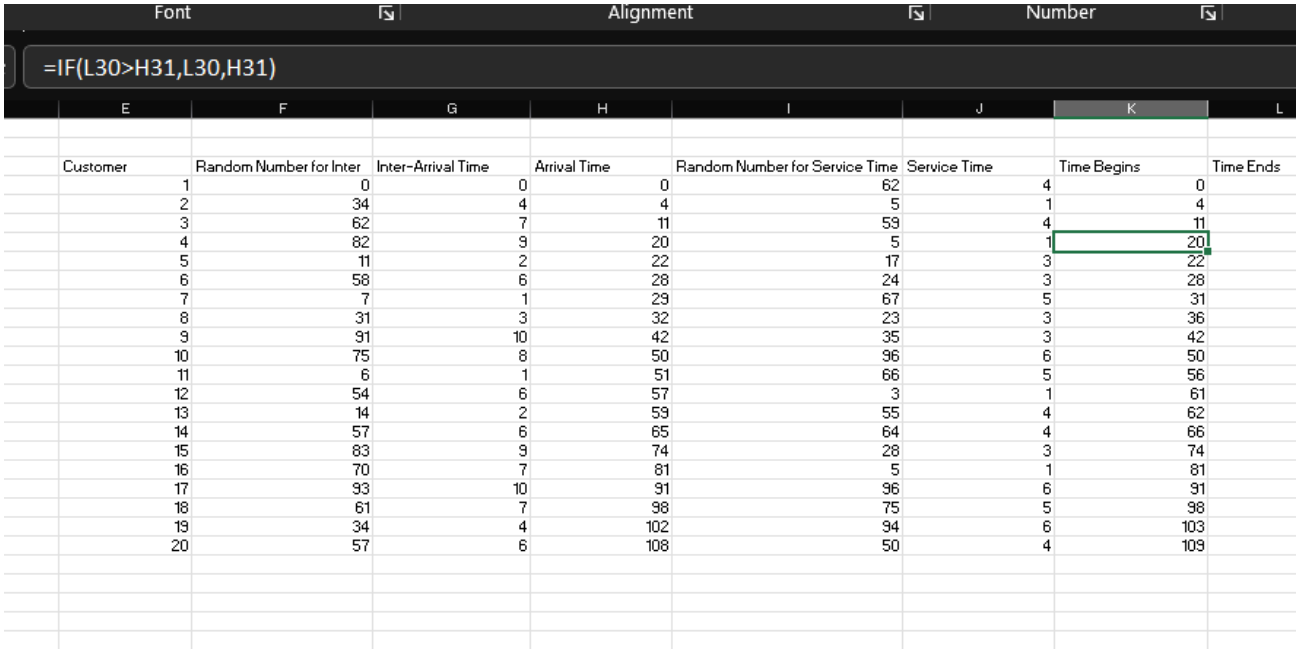
Time Interval	Probability	Cumulative Probability	Min	Max
1	0.1	0.1	1	10
2	0.1	0.2	11	20
3	0.1	0.3	21	30
4	0.1	0.4	31	40
5	0.1	0.5	41	50
6	0.1	0.6	51	60
7	0.1	0.7	61	70
8	0.1	0.8	71	80
9	0.1	0.9	81	90
10	0.1	1	91	100
	1			

=RANDBETWEEN(1,100)

Customer	Random Number for Inter	Inter-Arrival Time
1	0	
2	34	
3	62	
4	82	
5	11	
6	58	
7	7	
8	31	
9	91	
10	75	
11	6	
12	54	
13	14	
14	57	
15	83	
16	70	
17	93	
18	61	
19	34	
20	57	

=LOOKUP(F30,$H$4:$I$13,$E$4:$E$13)

Customer	Random Number for Inter	Inter-Arrival Time	Arrival
1	0	0	
2	34	4	
3	62	7	
4	82	9	
5	11	2	
6	58	6	
7	7	1	
8	31	3	
9	91	10	
10	75	8	
11	6	1	
12	54	6	
13	14	2	
14	57	6	
15	83	9	
16	70	7	
17	93	10	
18	61	7	
19	34	4	
20	57	6	



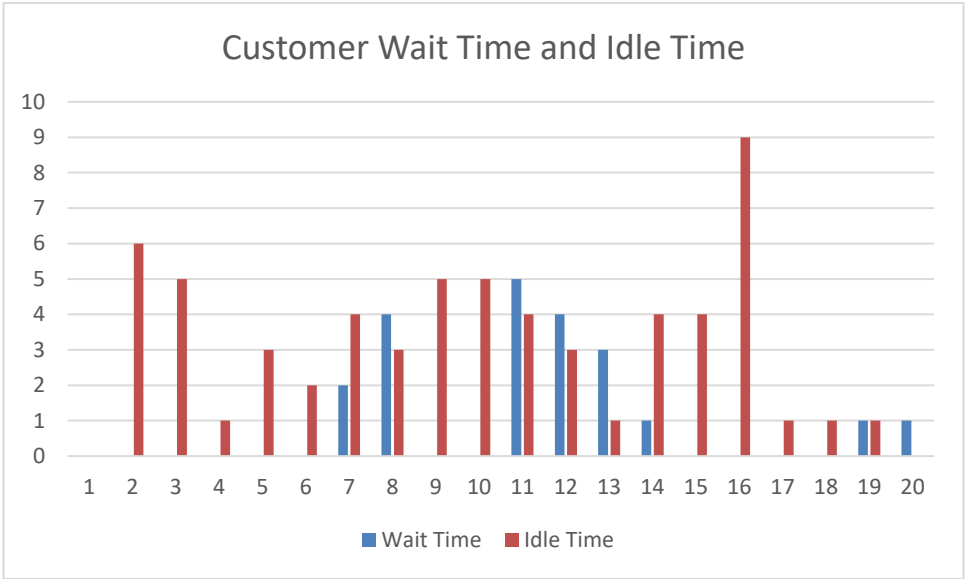
Customer	Random Number for Inter	Inter-Arrival Time	Arrival Time	Random Number for Service Time	Service Time	Time Begins	Time Ends
1	0	0	0	62	4	0	
2	34	4	4	5	1	4	
3	62	7	11	59	4	11	
4	82	9	20	5	1	20	
5	11	2	22	17	3	22	
6	58	6	28	24	3	28	
7	7	1	29	67	5	31	
8	31	3	32	23	3	36	
9	91	10	42	35	3	42	
10	75	8	50	96	6	50	
11	6	1	51	66	5	56	
12	54	6	57	3	1	61	
13	14	2	59	55	4	62	
14	57	6	65	64	4	66	
15	83	9	74	28	3	74	
16	70	7	81	5	1	81	
17	93	10	91	96	6	91	
18	61	7	98	75	5	98	
19	34	4	102	94	6	103	
20	57	6	108	50	4	109	

Customer	Random Number for Inter	Inter-Arrival Time	Arrival Time	Random Number for Service Time	Service Time	Time Begins	Time Ends	Time Spent	Wait Tim
1	0	0	0	62	4	0	4	4	
2	34	4	4	5	1	4	5	1	
3	62	7	11	59	4	11	15	4	
4	82	9	20	5	1	20	21	1	
5	11	2	22	17	3	22	25	3	
6	58	6	28	24	3	28	31	3	
7	7	1	29	67	5	31	36	7	
8	31	3	32	23	3	36	39	7	
9	91	10	42	35	3	42	45	3	
10	75	8	50	96	6	50	56	6	
11	6	1	51	66	5	56	61	10	
12	54	6	57	3	1	61	62	5	
13	14	2	59	55	4	62	66	7	
14	57	6	65	64	4	66	70	5	
15	83	9	74	28	3	74	77	3	
16	70	7	81	5	1	81	82	1	
17	93	10	91	96	6	91	97	6	
18	61	7	98	75	5	98	103	5	
19	34	4	102	94	6	103	109	7	
20	57	6	108	50	4	109	113	5	

Output:

(In printed form i.e. Simulation table along with the performance measures and histogram showing number of customers against waiting time)

Customer	Random Number for Inter	Inter-Arrival Time	Arrival Time	Random Number for Service Time	Service Time	Time Begins	Time Ends	Time Spent	Wait Time	Idle Time
1	0	0	0	62	4	0	4	4	0	0
2	34	4	4	5	1	4	5	1	0	6
3	62	7	11	59	4	11	15	4	0	5
4	82	9	20	5	1	20	21	1	0	1
5	11	2	22	17	3	22	25	3	0	3
6	58	6	28	24	3	28	31	3	0	2
7	7	1	29	67	5	31	36	7	2	4
8	31	3	32	23	3	36	39	7	4	3
9	91	10	42	35	3	42	45	3	0	5
10	75	8	50	96	6	50	56	6	0	5
11	6	1	51	66	5	56	61	10	5	4
12	54	6	57	3	1	61	62	5	4	3
13	14	2	59	55	4	62	66	7	3	1
14	57	6	65	64	4	66	70	5	1	4
15	83	9	74	28	3	74	77	3	0	4
16	70	7	81	5	1	81	82	1	0	9
17	93	10	91	96	6	91	97	6	0	1
18	61	7	98	75	5	98	103	5	0	1
19	34	4	102	94	6	103	109	7	1	1
20	57	6	108	50	4	109	113	5	1	



Questions:

1) What is simulation? List the different types of simulation.

Simulation is a technique used to model and analyze the behavior of a system over time. It involves creating a simplified representation of a real-world process or system to gain insights into its behavior, performance, or characteristics. Simulations can be used for various purposes, such as testing hypotheses, predicting outcomes, optimizing processes, and training.

Different types of simulations are:

1. **Monte Carlo Simulation:**
   Involves using random sampling and statistical techniques to model the probability of different outcomes in a process.

2. **Discrete Event Simulation:**
   Models the system as a sequence of discrete events, where the state of the system changes at specific points in time.

3. **Agent-Based Simulation:**
   Represents individuals or entities (agents) and their interactions within a system to observe emergent behaviors and patterns.

4. **Continuous Simulation:**
   Deals with systems where state variables change continuously over time, often modeled using differential equations.

5. **System Dynamics:**
   Focuses on modeling the feedback loops and interdependencies between different components of a system to understand dynamic behavior.

2) List the queue disciplines used in simulation?

Ans:

The queue disciplines used in simulation are:

1. **First-In-First-Out (FIFO):** Think of FIFO like waiting in line at a grocery store. The first person who gets in line is the first to be served.

2. **Last-In-First-Out (LIFO):** In LIFO, it's like a stack of plates. The plate that's placed on top last is the first one you pick up.

3. **Priority Queuing:** Imagine if there are two lines at a ticket counter, one for regular customers and one for VIPs. VIPs get served before regular customers because they have higher priority.

4. **Shortest Job Next (SJN) or Shortest Job First (SJF):** Picture a to-do list where you prioritize tasks based on how quick they are to finish. You'd start with the shortest task first.

5. **Round Robin (RR):** This is like taking turns. Everyone gets a set amount of time, and you cycle through them, making sure no one waits too long before their turn comes up again.

6. **Processor Sharing:** Imagine you're sharing a pizza equally with friends. Each person gets an equal slice, regardless of how hungry they are.

7. **Weighted Fair Queuing (WFQ):** Similar to sharing pizza, but some friends might get more pizza based on how hungry they are or how much they contributed to buying the pizza.

8. **Processor Affinity:** Think of it like assigning specific tasks to certain workers in a factory. Each worker specializes in certain tasks, so they handle only those tasks they're good at.

Outcomes:

CO1: Apply the experimental process of simulation for model building using simulation languages and tool.

CO3: Analyze simulation results to reach an appropriate conclusion.

Conclusion:

Thus with the help of this experiment we successfully implemented To simulate Single Channel Queuing System

Grade: AA / AB / BB / BC / CC / CD /DD

Signature of faculty in-charge with date

References:

Books/ Journals/ Websites:

1. Jerry Banks, John Carson, Barry Nelson, and David M. Nicol; "Discrete Event System Simulation", Fifth Edition, Pearson Education.
2. Jerry Banks, John Carson, Barry Nelson, and David M. Nicol; "Discrete Event System Simulation", Third Edition, Pearson Education.
3. Real Queuing Examples:http://www2.uwindsor.ca/hlynka/qreal.html This site contains excerpts from news articlesthat deal with aspects of waiting lines.
4. ClearQ :http://clearq.com/ This company produces "take-a-number" systems for servicefacilities (e.g., delis), but also providesperformance information about the waiting line.
5. Qmatic:http://us.q-matic.com/index.htmlThiscompany produces informational displays andother products to keep customers informedabout waiting times.
6. "Queuing Presentation" by Richard Larson, givenat the Institute for Operations Research and the Management.
7. ciences:http://caes.mit.edu/people/larson/MontrealINFORMS1/sld001.htm.
8. Queuing Tutor :http://www.dcs.ed.ac.uk/home/jeh/Simjava/queueing/mm1_q/mm1_q.html This site has twoanimated displays of waiting lines. The user canchange arrival and service rates to see howperformance is affected.
9. Myron Hlynka"s Queuing Page:http:www2.uwindsor.ca/hlynka/queue.html This web site contains information about waiting linesas well as links to other interesting sites.
10. Queuing ToolPak:http://www.bus.ualberta.ca/aingolfsson/qtp/
11. The Queuing ToolPak is an Excel add-in that allowsyou to easily compute performance measures fora number of different waiting line models