Experiment No. : 4

Title: Simulation of an Order-Up-To-Level Inventory System

Batch: B2 **Roll No.:16010421059** **Experiment No.:4**

Aim: Simulation of an Order-Up-To-Level (M, N) Inventory System

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Resources needed: Excel Spreadsheet

Theory

Problem Statement:

Consider a situation in which a company sells refrigerators. The system they use for maintaining inventory is to review the situation after a fixed number of days (say N) and make a decision about what is to be done.
The policy is to order up to a level (the order up to level-say, M), using the following relationship:

Order quantity = (Order-up-to level) - (Ending inventory) + (Shortage quantity)

Generate a simulation table for 25 days (5 cycles)

Table 4.1 Distribution of Daily Demand

Distribution of Daily Demand		
Demand	Probability	Cumulative Probability
0	0.10	0.10
1	0.25	0.35
2	0.35	0.70
3	0.21	0.91
4	0.09	1.00

Table 4.1 Distribution of Lead Time

Distribution of Lead Time		
Lead Time	Probability	Cumulative Probability
1	0.60	0.60
2	0.30	0.90
3	0.10	1.00

The Excel spreadsheet allows for numerous changes in the input. The policy can be changed (i.e., the values of M and N). The distribution of daily demand and lead time can be changed within the limits of the demand and lead time that is, demand can be 0, l, 2, 3, or 4 refrigerators per day and lead times can be 1, 2,. or 3 days.

Characteristics of Inventory System:

An important class of simulation problems involves inventory systems. The inventory system has a periodic review of length N, at which time the inventory level is checked. An order is made to bring the inventory up to the level M. At the end of the first review period, an order quantity, Q is placed. In this inventory system, the lead time (i.e., the length of time between the placement and receipt of an order) is zero. Demands are not usually known with certainty, so the order quantities are probabilistic.

Carrying stock in inventory has an associated cost attributed to the interest paid on the funds borrowed to buy the items (this also could be considered as the loss from not having the funds available for other investment purposes). Other costs can be placed in the carrying or holding cost column renting of storage space, hiring of guards, and so on. An alternative to carrying high inventory is to make more frequent reviews and, consequently, more frequent purchases or replenishments. This has an associated cost: the ordering cost. Also, there is a cost in being short. Customers could get angry, with a subsequent loss of good will. Larger inventories decrease the possibilities of shortages. These costs must be traded off in order to minimize the total cost of an inventory system. The total cost (or total profit) of an inventory system is the measure of performance. This can be affected by the policy alternatives. For example, the decision maker can control the maximum inventory level, M; and the length of the cycle, N. What effect does changing N have on the various costs? In an (M, N) inventory system, the events that may occur are the demand for items in the inventory, the review of the inventory position, and the receipt of an order at the end of each review period. When the lead time is zero, the last two events occur simultaneously.

Conceptual Model of an Order-Up-To-Level (M, N) Inventory System:

System State:

1. Ending Inventory
2. Shortage

Entities:

The entities in inventory system are the goods

Events:

1. Demand
2. Receipt of reordered goods

Activities:

1. Lead time

Stopping event:

5 cycles or 25 days

Use of Random Nos.:

- For generating Demand
- For generating Lead time

Performance measures:

1. **Average ending inventory**
2. **Average Shortage**
3. **Average Demand**

Procedure / Approach /Algorithm / Activity Diagram:

Simulate using simulation table

Let's say that the order-up-to level (M) is 11 and the ending inventory is three. Further, let's say that the review period (N) is five days. Thus, on the fifth day of the cycle, 8 refrigerators will be ordered from the supplier. If there is a shortage of two refrigerators on the fifth day, then 13 refrigerators will be ordered.
(There can't be both ending inventory and shortages at the same time.) If there were a shortage of three refrigerators, the first three received would be provided to the customers when the order arrived. That's called "making up backorders." The lost sales case occurs when customer demand is lost if the inventory is not available.

The number of refrigerators ordered each day is randomly distributed as shown in Table 4.1. Another source of randomness is the number of days after the order is placed with the supplier before arrival, or lead time. The distribution of lead time is shown in Table 4.2. Assume that the orders are placed at the end of the day. If the lead time is zero, the order from the supplier will arrive the next morning, and the refrigerators will be available for distribution that next day. If the lead time is one day, the order from the supplier arrives the second morning after, and will be available for distribution that day. The simulation starts with the inventory level at 3 refrigerators and an order for 8 refrigerators to arrive in 2 days' time.

In this example, there cannot be more than one order outstanding from the supplier at any time, but there are situations where lead times are so long that the relationship shown so far needs to be modified to the following:

Order quantity = (Order-up-to level) - (Ending inventory) - (On order) + (Shortage quantity)

This relationship makes sure that extra ordering doesn't occur. To make an estimate of the mean refrigerators in ending inventory by using simulation, many trials would have to be simulated.

Results: (Program printout with output / Document printout as per the format)

1. Distribution of daily demand

Distribution of demand				
Service Time (minutes)	Probability	Cumulative Probability	Range Min (Random)	Range Max(Random)
0	0.1	0.1	1	10
1	0.25	0.35	11	35
2	0.35	0.7	36	70
3	0.21	0.91	71	91
4	0.09	1	92	0

2. Distribution on lead time

Distribution of Lead Time				
Service Time (minutes)	Probability	Cumulative Probability	Range Min (Random)	Range Max(Random)
1	0.6	0.6	1	6
2	0.3	0.9	7	9
3	0.1	1	0	0

3. Simulation table

Simulation for 5 Cycles									
cycle	Day in cycle	RD Demand	Demand	Start	End	Shortage	Order	RD Lead	Lead
1	1	99	4	3	0	1	12	3	1
	2	66	2	0	0	2			
	3	86	3	8	5	0			
	4	96	4	5	1	0			
	5	37	2	1	0	1			
2	1	56	2	0	0	3	9	9	3
	2	46	2	9	7	0			
	3	76	3	7	4	0			
	4	17	1	4	3	0			
	5	13	1	3	2	0			
3	1	34	1	2	1	0	7	7	3
	2	27	1	1	0	0			
	3	89	3	0	0	3			
	4	19	1	6	5	0			
	5	33	1	5	4	0			
4	1	58	2	4	2	0	8	5	1
	2	23	1	2	1	0			
	3	31	1	1	0	0			
	4	16	1	7	6	0			
	5	90	3	6	3	0			
5	1	58	2	3	1	0	10	9	3

	2	66	2	9	7	0			
	3	41	2	7	5	0			
	4	55	2	5	3	0			
	5	54	2	3	1	0			

CALCULATIONS:

Average Ending Inventory	2.44
Average Shortage	0.4
Average Demand	1.96

Questions:

1. **Give real world examples which can be modelled as inventory systems?**

Ans: Inventory systems are used to manage and track the flow of goods and materials within a business or organization. Here are some real-world examples of situations that can be modeled as inventory systems:

1. Retail Stores:
   - Example: A clothing store needs to keep track of the quantity and types of clothing items in stock, reorder products as needed, and manage seasonal changes in inventory.

2. Manufacturing Companies:
   - Example: An automobile manufacturer needs to monitor the levels of raw materials, work-in-progress (WIP), and finished goods to ensure efficient production and timely deliveries.

3. Grocery Stores:
   - Example: A grocery store manages the inventory of perishable and non-perishable goods, monitors expiration dates, and restocks shelves to meet customer demand.

4. E-commerce Businesses:
   - Example: An online retailer needs to track the availability of products in warehouses, update stock levels in real-time, and manage orders to prevent stockouts or overstock situations.

5. Pharmacies:
   - Example: A pharmacy must monitor the inventory of prescription and over-the-counter medications, manage expiration dates, and ensure compliance with regulatory requirements.

6. Supply Chain Management:
   - Example: Companies involved in supply chain management need to track the movement of goods from suppliers to manufacturers to distributors and retailers, optimizing the entire process.

7. Restaurants:
   - Example: A restaurant needs to manage its food inventory, ensuring that ingredients are available for menu items, minimizing waste, and preventing shortages during peak hours.

8. Electronics Retailers:
   - Example: A store selling electronic gadgets needs to keep track of various models, update inventory as new products are introduced, and manage obsolete or discontinued items.

9. Hospitals and Healthcare Institutions:
- Example: Hospitals need to manage the inventory of medical supplies, medications, and equipment to ensure they have what is needed for patient care while avoiding excess stock that can lead to waste.

10. Library Systems:
- Example: Libraries manage book inventories, keeping track of the available copies, loaned books, and returned items. They also handle requests for new acquisitions.

11. Automobile Dealerships:
- Example: Car dealerships manage the inventory of vehicles, spare parts, and accessories. They need to balance the variety of models in stock to meet customer preferences.

12. Agricultural Supply Chains:
- Example: Agricultural businesses need to manage the inventory of seeds, fertilizers, pesticides, and equipment to ensure successful and timely crop production.

These examples demonstrate the diversity of inventory systems across different industries, all aimed at efficiently managing resources and meeting customer demand.

2. Name simulation language or package which can be used for modeling inventory systems?

Ans: There are several simulation languages and packages commonly used for modeling inventory systems. These tools help simulate the behavior of inventory systems under various conditions, allowing businesses to analyze and optimize their inventory management strategies. Here are some popular simulation languages and packages:

1. SimPy:
- SimPy is a process-based discrete-event simulation framework for Python. It is open-source and widely used for modeling complex systems, including inventory systems.

2. Arena:
- Arena is a simulation software developed by Rockwell Automation. It provides a graphical interface for building and analyzing simulation models, making it suitable for inventory modeling in manufacturing and logistics.

3. AnyLogic:
- AnyLogic is a multi-method simulation software that supports both discrete event and agent-based modeling. It is used for a wide range of applications, including supply chain and inventory management.

4. ExtendSim:
- ExtendSim is a discrete event simulation software that allows users to model and analyze complex systems, such as inventory and manufacturing processes. It provides a visual environment for model development.

5. GPSS (General Purpose Simulation System):
- GPSS is a simulation language specifically designed for modeling and analyzing systems with discrete events. It has been widely used in academia and industry for inventory and logistics simulations.

6. Witness:
- Witness is a simulation software package that enables users to model and optimize complex systems. It is often used in manufacturing and logistics for inventory and supply

chain simulation.

7. ProModel:
- ProModel is a simulation software solution that supports discrete event modeling. It is utilized for various applications, including inventory optimization and supply chain analysis.

8. MATLAB Simulink:
- MATLAB Simulink is a simulation and modeling environment that supports both continuous and discrete event simulation. It is versatile and can be used for modeling inventory systems among other applications.

9. NetLogo:
- NetLogo is an agent-based modeling environment that is used for simulating natural and social phenomena. It is suitable for modeling complex systems, including inventory and supply chain dynamics.

10. Python (with other libraries):
- While not a dedicated simulation language, Python is a popular programming language often used for simulation modeling. Libraries like SimPy and PySP can be utilized for discrete event simulation and stochastic programming, respectively, in inventory modeling.

These tools offer different features and capabilities, so the choice often depends on the specific requirements of the inventory system being modeled and the preferences of the modeler.

Outcomes:
CO1
Apply the experimental process of a simulation using spreadsheets as well as Simulation language/package.

Conclusion: (Conclusion to be based on outcomes)
Understood Simulation of an Order-Up-To-Level (M, N) Inventory System.

<u>Grade: AA / AB / BB / BC / CC / CD /DD</u>

Signature of faculty in-charge with date

References:

Books/ Journals/ Websites:

Text Book:

Banks J., Carson J. S., Nelson B. L., and Nicol D. M., “Discrete Event System Simulation”, 3rd edition, Pearson Education, 2001.

Additional Web Resources:

• Real Queuing Examples:http://www2.uwindsor.ca/hlynka/qreal.html
This site contains excerpts from news articlesthat deal with aspects of waiting lines.
• ClearQ :http://clearq.com/ This company produces “take-a-number” systems for servicefacilities (e.g., delis), but also providesperformance information about the waiting line.
• Qmatic:http://us.q-matic.com/index.htmlThiscompany produces informational displays andother products to keep customers informedabout waiting times.

• “Queuing Presentation” by Richard Larson, givenat the Institute for Operations Research and theManagement Sciences:http://caes.mit.edu/people/larson/MontrealINFORMS1/sld001.htm.
•The Queuing Theory 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.
• 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.
• Queuing ToolPak:http://www.bus.ualberta.ca/aingolfsson/qtp/
The Queuing ToolPak is an Excel add-in that allowsyou to easily compute performance measures fora number of different waiting line models

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