Program:	Software Engineering	Class:	VIII-A, and B
Course Name:	Modeling & Simulation	Date:	March 05, 2024
Instructor's Name:	M. Iftikhar Mubbashir		
Course Code:	SE405	Document	Chapter-2

This topic is a continuation of the previous topic; here again, we will perform simulations without the aid of computers, but this time, we will do so for inventory systems.

Inventory Theory

Inventories are materials stored, waiting for processing, or experiencing processing. They are ubiquitous in modern business. Almost any company's balance sheet reveals that a significant part of its assets comprises inventories of raw materials, products within the production process, or finished products. Most managers don't like inventories because they are like money placed in a drawer, assets tied up in investments that are not earning money. They also incur costs for the care of the stored material and are subject to spoilage and obsolescence. Programs such as "just-in-time" manufacturing aim to reduce inventory levels.

Despite all these destructive features, inventories do have positive purposes. Raw material inventories provide a stable source of the materials required for production. A large inventory requires less replenishment and may reduce ordering costs because of economies of scale. In-process inventories mitigate the impacts of the variability of the production rates in a plant and protect against failures in the processes. Final goods inventories provide for better customer service. The variety and ease of availability of the product are essential marketing considerations. There are other kinds of inventories, including spare parts inventories for maintenance and excess capacity built into facilities to take advantage of the economies of scale of construction.

Because of their practical and economic importance, inventory control is a primary consideration in many situations. Questions must be constantly answered as to when and how much raw material should be ordered, when a production order should be released to the plant, what level of safety stock should be maintained at a retail outlet, or how in-process inventory is to be maintained in a production process. These questions are amenable to quantitative analysis through the subject of inventory theory.

Terminology

- A simple inventory system is characterized by ***N*** and ***M.***
- ***N*** represents the length of the review period.
- ***M*** represents the max. Inventory level.
- **Lead Time** can be defined as the time between placing and receiving an order.
- The lead time of a system may be zero or nonzero.
- **Backordered units show an inventory amount below zero, a shortage**. To avoid shortages, a buffer or safety stock is needed.

Examples:

The newspaper seller's problem

- Let a paper seller buy the papers for 13 cents each and sell them for 20 cents each. Newspapers can be purchased in a bundle of 10. Thus, the paper seller can buy 50, 60, and so on. There are three types of news days, "good," "fair," and "poor," with probabilities of 0.35, 0.45, and 0.20, respectively. The distribution of paper demand each day is given in the table. The salvage value for scrap papers is 2 cents. The problem is determining the optimal number of papers the newspaper seller should purchase. This will be accomplished by simulating demands for 20 days.

Information…

(Tabel-1)Distribution of newspapers demand

	Demand probability distribution		
Demand	**Good**	**Fair**	**Poor**
40	0.03	0.10	0.44
50	0.05	0.18	0.22
60	0.15	0.40	0.16
70	0.20	0.20	0.12
80	0.35	0.08	0.06
90	0.15	0.04	0.00
100	0.07	0.00	0.00

(Table-2)Random digit assignment for the type of news day

Types of news day	Probability	Cumulative probability	Random digit assign
Good	0.35	0.35	01-35
Fair	0.45	0.80	36-80
Poor	0.20	1.00	81-00

(Table-3) Commutative Distribution and Random Digit Assignment For Days

	Cumulative distribution			Random digit assignment		
Demand	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**
40	0.03	0.10	0.44	01-03	01-10	01-44
50	0.08	0.28	0.66	04-08	11-28	45-66
60	0.23	0.68	0.82	09-23	29-68	67-82
70	0.43	0.88	0.94	24-43	69-88	83-94
80	0.78	0.96	1.00	44-78	89-96	95-00
90	0.93	1.00	1.00	79-93	97-00	
100	1.00	1.00	1.00	94-00		

Formula for profit calculation

- **Profit** = ***revenue from sales – cost of newspaper – lost profit from excess demand + salvage from sales.***

- **Let us suppose that the inventory level is 60 newspapers.**

Simulation table

Inventory Model Newspaper Seller Simulation									
Day	**Random Digit for a Type of Newsday**	**Type of Newsday**	**Random digit for demand**	**Demand**	**Revenue from Sales**	**Loss Profit from Excess Demand**	**Salvage Value**	**Profit per Day**
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Find…

- What Number of newspapers should he buy to deliver them to his customers?

Simulation of an (M, N) inventory system

- Consider a probabilistic order-level inventory system. Suppose that the max. inventory level, M, is 11 units and the review period, N, is five days. The problem is to estimate, by simulation, the average ending units in inventory and the number of days when a shortage condition existed. In this example, lead time is a random variable. Assume that the orders are placed at the close of business and are received for inventory at the beginning of business.

  Data

Random digit assigned for daily demand

Demand	Probability	Cumulative probability	Random digit assign
0	0.10	0.10	01-10
1	0.25	0.35	11-35
2	0.35	0.70	36-70
3	0.21	0.91	71-91
4	0.09	1.00	92-00

Random digit assignment for lead time

Lead time (days)	Probability	Cumulative probability	Random digit assign
1	0.6	0.6	1-6
2	0.3	0.9	7-9
3	0.1	1.0	0

Simulation table for (M, N) inventory system

Simulation of (M, N) Inventory

Cycles	Day	Beginning Inventory	Random Digits for Demand	Demand	Ending Inventory	Shortage Quantity	Order Quantity	Random Digits For Lead Time	Day unit Order Received

Find all the Relevant Attributes

- A large mailing machine has three different bearings that fail to service. The cumulative distributive function of the life of each bearing is identical, as shown in Table 1. When a bearing fails, the mail stops, a repair person is called, and a new bearing is installed. The delay time of the repair person's arrival at the mailing machine is also a random variable, with the distribution given in Table downtime for the mail estimated at $5/min. The direct on-site cost of the repair person is $12/hr. It takes 20 minutes to change one bearing, 30 minutes to change two bearings, and 40 minutes to change three. The bearings cost $16 each. A proposal has been made to replace all three bearings whenever a bearing fails. Management needs an evaluation of this proposal.

Input Tables:

Life Time Distribution

Bearing life (hrs)	Probability	Cumulative probability	Random digit assign
1000	0.10	0.10	01-10
1100	0.13	0.23	11-23
1200	0.25	0.48	24-48
1300	0.13	0.61	49-61
1400	0.09	0.70	62-70
1500	0.12	0.82	71-82
1600	0.02	0.84	83-84
1700	0.06	0.90	85-90
1800	0.05	0.95	91-95
1900	0.05	1.00	96-00

(Table-I)

Delay time distribution

Delay time (mn)	Probability	Cumulative probability	Random digit assign
05	0.6	0.6	1-6
10	0.3	0.9	7-9
15	0.1	1.0	0

(Table-II)

Comparison

Compare the costs incurred in both situations and suggest which replacement method is more efficient and suitable for the company to adopt. The formula for cost for this situation will be:

Total cost = **cost of bearings+ cost of delay time+ cost of downtime+ cost of downtime during repair+ cost of repair person**.

- Let a squadron of bombers be ordered to destroy an ammunition depot (sketch given in the figure). If a bomb lands anywhere on the depot, a hit is scored. Otherwise, the bomb is a miss. The aircraft is flying in the horizontal direction. Ten bombers are in each squadron. The aiming is the dot located in the ammunition dump. The point of impact is assumed to be normally distributed around the aiming point. With a standard deviation of 600 meters in the horizontal direction and 300 meters in the vertical direction. The problem is to simulate the operation and make statements about the number of bombs on target.

Method for Calculation:

To generate inputs for simulation, use the following scheme:
We know that the standardized standard variate, Z, is distributed as:

$$Z = \frac{X - \mu}{\sigma}$$

Where X is a normal random variable, μ is the true mean of the distribution of X, and σ is the standard deviation of X. Then

$$X = \mu + Z\sigma$$

In this example, the aiming point can be considered as (0,0); that is, the value in the horizontal direction is zero, and similarly for the value in the vertical direction. Then,

$$X = \mu + Z\sigma_X, and\ Y = \mu + Z\sigma_Y$$

Where (X,Y) are the simulated coordinates of the bomber after it has fallen.