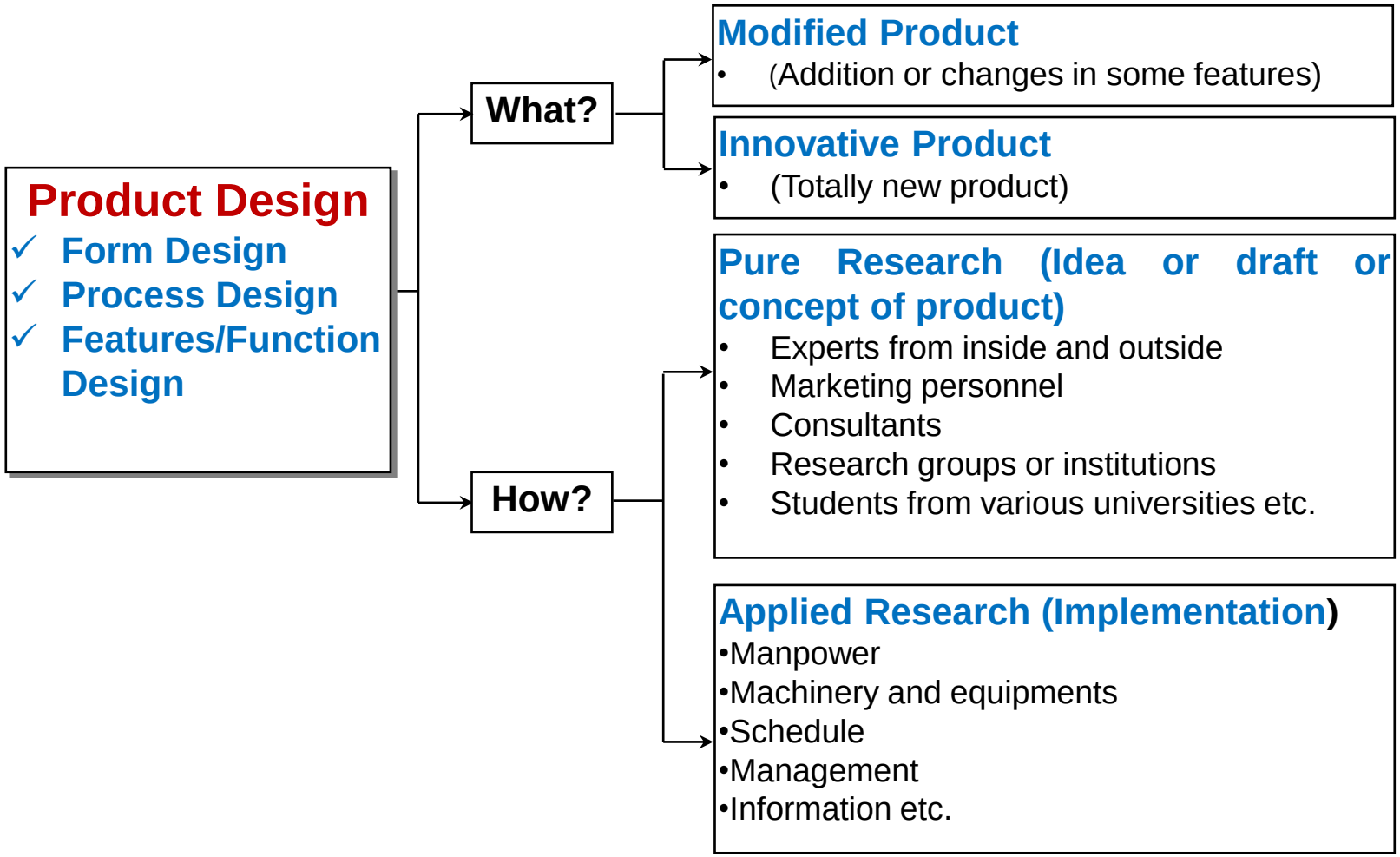
Outlines of CH-3

- Concept on Product and Service Design
- Product Development Process
- Difference between Product and Service Design
- Emerging Issues in Product and Service Design
- Value Analysis
- Concurrent Engineering
- Quality Function Deployment (QFD)
- Waiting Line Theory (Single Channel Only)

Concept of Product Design

- The product designing and manufacturing environment is changing rapidly just because of dynamic nature of demand from the targeted customers today.
- Last year's successful product may or may not be successful in years to come too. Therefore, as an operations manager, we should always be ready to change our product time to time as per requirement.
- A new product design does not always mean a new conceptual product (or innovative product) based on new research, modification of existing product and featuring additional (or modified product) also taken as new product design.
- Effective design is very much essential to stay in competitive market. Poor designs may not meet customer needs or may be so difficult to make that quality suffers. Costly designs can result in over-priced products that lose market share. If the design process is too lengthy, a competitor may capture the market by being the first to introduce new products, services, or features.

Fig. Idea about Product Design



Product design is concerned with the designing of three issues as form, process and function of a production.

1. Form Design

It is concerned with the appearance, and aesthetic considerations and also the size, volume and weight of the product which are secondary to the performance of the product.

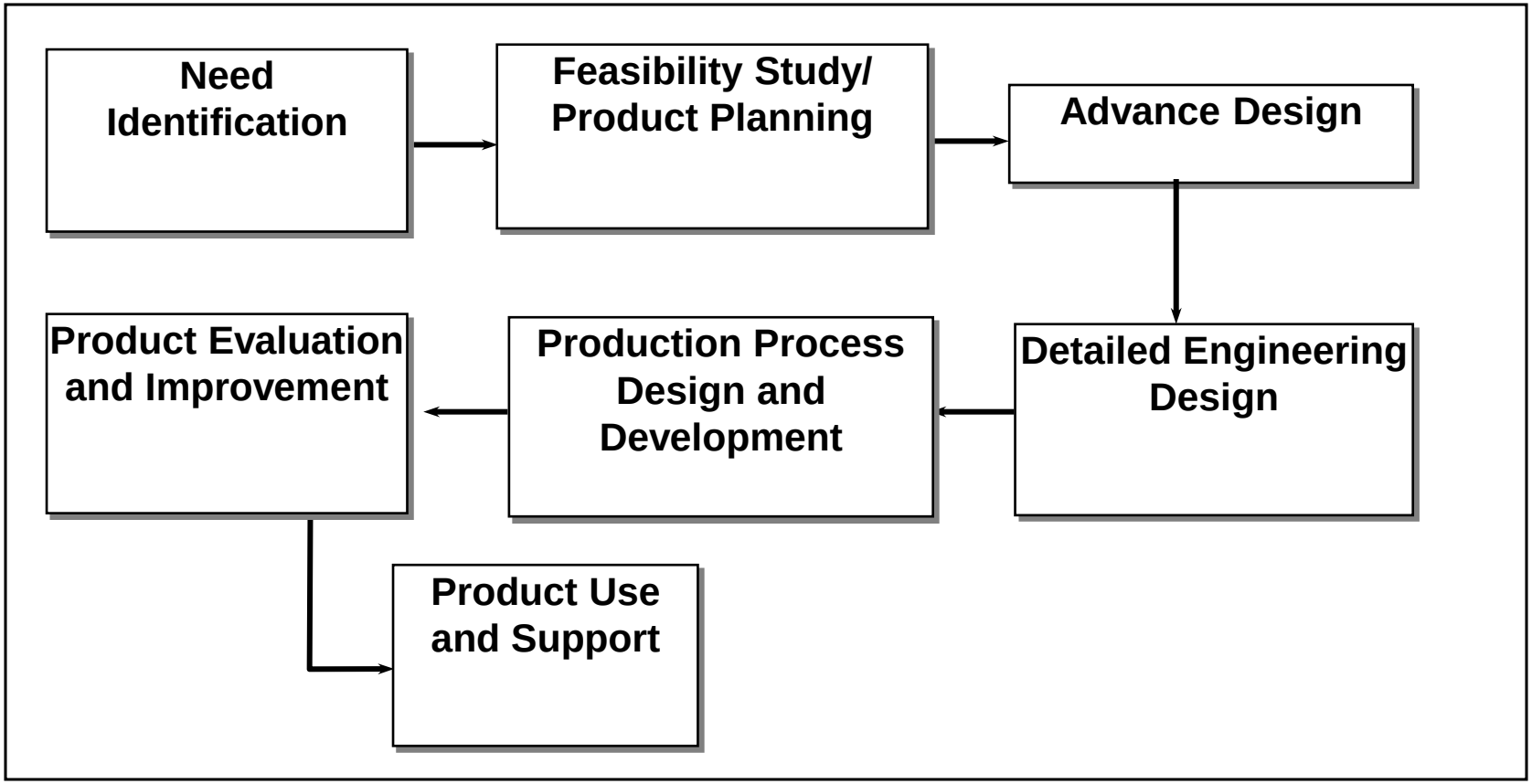
2. Process Design

There are different types of process designs are so popular for manufacturing organization like project process technology, job-shop process technology, batch process technology, assembly line process technology, continuous flow process technology etc. Among the processes an operations manager should be able to select right process on the basis of nature of products or organization. It is concerned with the overall sequences of operations required to achieve the design specifications of the product. It specifies the type of work stations that are to be used, the machines and equipments necessary to carry out the processes to produce the product.

3. Function/ Features Design

It is concerned with the first and foremost requirement of a good product i.e., the product should effectively perform the function for which it is developed. For example, for a television set, the picture quality and the sound quality is more important than the appearance of the cabinet in which the picture tube is fixed.

Product Development Process



1. Need Identification

- The design process begins with understanding the customer and actively identifying customer needs. Ideas for new products or improvements to existing products can be generated from many sources, including a company's own R & D department, customer complaints or suggestions, marketing research, suppliers, and salespersons in the field, factory workers, and new technological developments. Competitors are also a source of ideas for new products or services. Pure research and applied research is also used for identification of customer needs.

2. Feasibility Study /Product Planning

- The feasibility study includes several types of analyses, beginning with a market analysis. The market analysis assesses whether there's enough demand for the proposed product to invest in developing it further. If the demand potential exists, then there's an economic analysis that looks at estimate of production and development costs and compares them to estimated sales volume. Finally, there are technical and strategic analyses that answer such questions as:
  - ✓ Does the new product require new technology?
  - ✓ Is the risk or capital investment excessive?
  - ✓ Does the company have sufficient labour and management skills to support the required

3. Advance Design

- Rapid prototyping creates preliminary design models that are quickly tested and either discarded or further refined. Designers take general performance specifications and translate them into a physical product or service with technical design specifications. The process involves building a prototype, testing the prototype, revising the design, retesting, until a viable design is determined. It involves form, functional and production design.
  - a. **Form Design**: Form design refers to the physical appearance of a product – its shape, colour, size, and style. Aesthetics such as image, market appeal, and personal identification are also part of form design.
  - b. **Functional Design**: Functional design is concerned with how the product performs. It seeks to meet the performance specifications of fitness for use by the customer.
  - c. **Production Design**: Production design is concerned with how the product will be made. During the design stage itself the manufacturing aspects should be considered.

4. Detailed Engineering Design

- In this stage, a series of engineering activities to develop a detailed definition of the product, including its subsystems and components, materials, sizes, shapes, and so on. Design engineers now design the components that will constitute the product so that it has the required features and gives the desired benefits. Technical expertise of the company comes to the fore during this stage of the product development process.
- In this stage, operations managers should provide design engineers with information about the producibility of the components being designed. Operations managers should be included in decisions about equipment design, since they know more about equipment than do design engineers. If the product requires a new material that has special properties, materials managers and suppliers should be consulted.

5. Production Process Design and Development

- Working with the detailed product design, engineers and manufacturing specialists prepare plans for materials acquisitions, production, warehousing, transportation, and distribution. Activities here, however, go beyond just hardware considerations: This stage involves planning, too, for production and control systems, computer information systems, and human resource systems (Everette E., et. al. 1992).

6. Product Evaluation and Improvement

- Customers' feedback is tracked, and failure data are analyzed. Formal research is conducted to understand customers' experience of the product. The company keeps itself updated on product's underlying technologies and process technologies. Product is redesigned if customer's feedback is persistently negative or if new technological breakthroughs enable design and production of a better product.

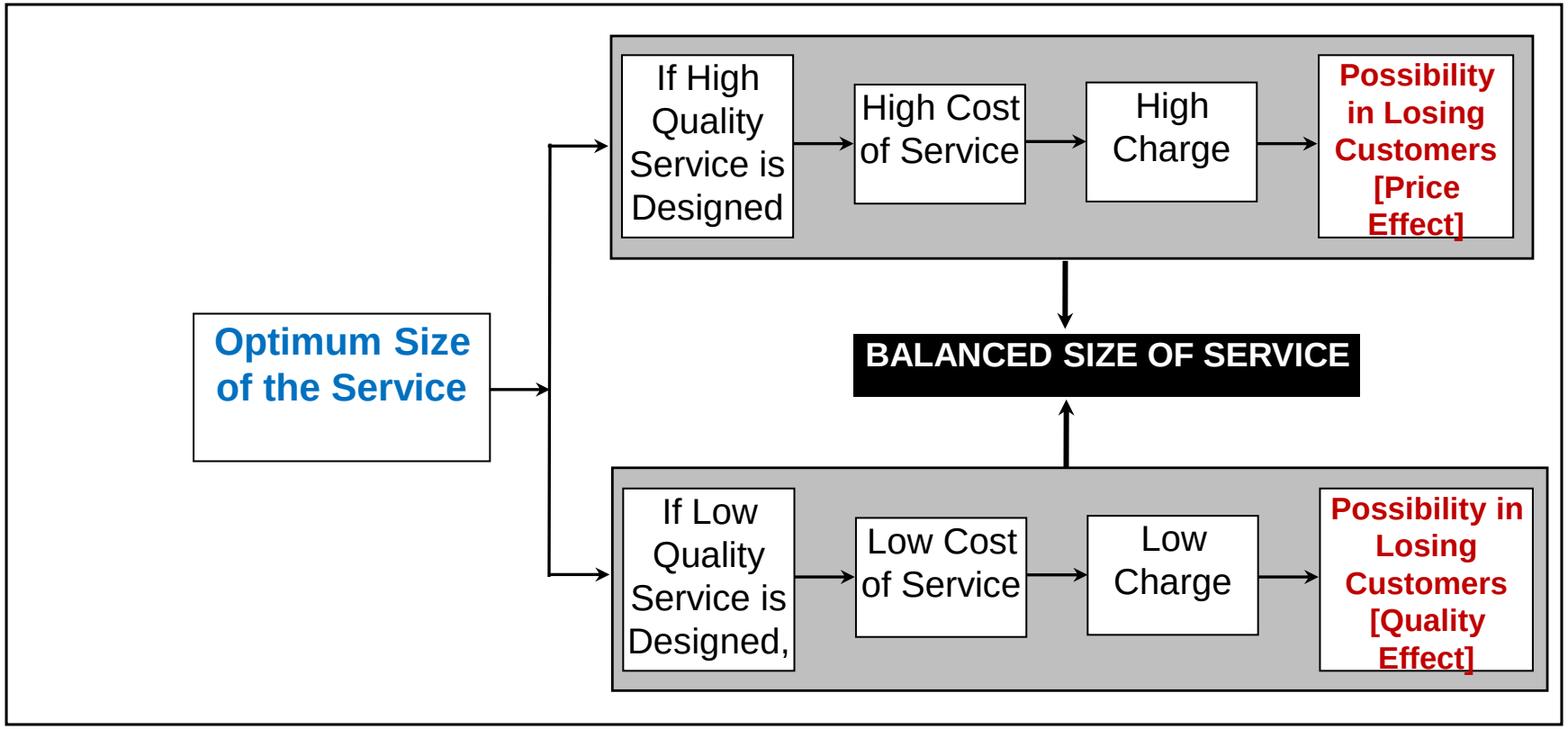
7. Product Use and Support

- Customers are trained to use the product. It is important that customers use all the feature of the product and get all the benefits that the product is capable of providing. Customers will not rate the product highly if they do no use all the benefits that the product is capable of providing. For example, less tech-savvy customers use their smarts phones just to make calls and send messages.

Service Design

- Service is an intangible and perishable benefit. Services are created and used simultaneously. While a service cannot be stored for later use, its effect may last over time.
- Services are acts, deeds, performances or relationships that produce time, place, form, or psychological utilities for customers.
- Service design begins with the choice of a service strategy, which determines the nature and focus of the service, and the target market.
- This requires an assessment by top management of the potential market and profitability (or need, in the case of a nonprofit organization) of a particular service, and an assessment of the organization's ability to provide the service.
- Two key issues in service design are the degree of variation in service requirements and the degree of customer contact and customer involvement in the delivery system. These have an impact on the degree to which service can be standardized or must be customized.

- An effective and efficient manager must try to identify optimum size of the service in a competitive situation for his/her organization; otherwise organization may lose valuable customers. The concept of optimum size of the service can be illustrated with the help of figure given below:



Steps/Process of Service Design

1. Target The Customers

[Gender, age, income, area etc.]

2. Develop The Service Concept

[Pure research and applied research with involvement of customers]

3. Develop Service Strategy

[Cost/price, quality, quick response, timing, differentiation etc.]

4. Develop Service Delivery System

[Capital-intensive vs Labour-intensive including home delivery, office delivery etc.]

Difference Between Product and Service Design

Service Design	Product Design
Service design often focuses more on intangible factors (e.g., peace of mind, feel etc.)	Product design often focuses more on tangible factors (e.g., size, weight etc.)
In many instances services are created and delivered at the same time (e.g., a haircut, a car wash).	Products are, normally, designed on the basis of general survey that done in past.
Services cannot be inventoried. This poses restriction on flexibility and makes capacity issues very important.	Products can be inventoried. Uniformity is very essential to maintain on product size, shape and quality in designing process.
Services are highly visible to consumers and must be designed with that in mind; this adds an extra dimension to process design,	Normally, product design is completed with a single process as per the requirements or the nature of the product.
Location is often important to service design, with customer convenience as a major factor. Hence, design of services and choice of location are often closely linked.	Location is not so important, as important in service design, in the designing phases of product. Selection of location for the product is for manufacturing convenience.

Emerging Issues in Product and Service Design

- The emerging issues or challenges facing by operations manager in products and service design are as follows:

1. Managing Multiple Customers

- It is very essential for the organizations to build up the customer relations. Organizations serve products and services to various kinds of customers according to their, needs and expectations. It is difficult task for the operations manager to develop good customer relationships and manage their various needs and expectations.

2. Understanding the Product and Service Concept

- The products and services which are offered to the customers by the organizations may have different views and concepts. Understanding and delivering the real service concept is critical for classifying the organization's service product to all the customers and for ensuing that can be delivered to customer's specification.

3. Managing the Outcome and Experience

- There is no clear boundary between experience and the outcome for many products and services. For instance, customers in a restaurant are buying both the meal and way they are served. The intangible nature of the experience provides particular problems for both specifications and control. Some organizations try to manage the intangible parts of the service by attempting to make them more tangible.

4. Managing in Real-time

- Many products and services cannot be delayed or put-off, they happen in real time. For example, aircrafts coming to land cannot be put on hold while controllers take a break. In manufacturing operations, it is possible to scrap defective products and remark them, but in service operations it is not possible to undo defective service rendered to a customer. For example, a wrong surgery done on a patient may take the life of the patient. Managing resources, managing staffs and employees and creating an appropriate culture are key tasks in managing real time services.

5. Knowing, Implementing and Influencing Strategy

- Operations of the business are responsible for implementing the strategy of the service organizations. Product and service operations managers must understand their role, not only in implementing strategy but also in contributing to it or influencing the strategy. The service operations managers are responsible in providing the platform for their organizations for competitive advantage through competence in service operations.

6. Continually Improving Operations

- The product and service operations manager should always be attentive of how continually to improve and develop their real improvements. They should manage the increased complexity resulting from the change and also improve efficiency as well as quality of product and service operations that are to be delivered to their customers.

7. Encouraging Innovations

- Innovation is viewed as what is new rather than improving the existing product and service operations. Innovation usually requires an element of financial risk because innovations require time and money and personal risk for service managers who accept change by putting their reputation on line. Product and service operation managers should be always alert to seek out new ideas and also have the will and support to assess them carefully and follow through if appropriate.

8. Managing Short-term and Long-term Issues Simultaneously

- Organizations are always under pressure to perform in the short-term which leaves little time for medium-term operational improvement or long term strategic planning. Many product and service operations managers focus their time and effort on managing day-to-day operations to ensure the delivery of an appropriate quality of service at an appropriate cost (Joshi, Fago, Aryal, 2012).

Value Analysis

- Value analysis is carried out to eliminate unnecessary features and functions of a product or a component.
- In other words, value analysis is an organized method of cost reduction of a product by attacking in its basic design.
- The value analysis questions the product design itself, with a view to evolving a cheaper design system that can perform the intended function.
- In the search for cheaper design, quality is not sacrificed, rather, it often leads to improvement in quality. Value analysis as a formulized technique, is of recent origin.
- It was first put forward by L.D. Miles in the early 1950s based on his work with General Electric. During the short span of 20 years, its effectiveness has been proved beyond doubt and a new discipline, namely Value Engineering has come in to being.
- A successful value analysis study results in reduced cost for the same quality or improved quality with the same cost. Either way, it increases the quality contribution (the difference between value and cost of quality) and thus furthers the overall aim of quality management.

Concurrent Engineering

- Concurrent engineering means bringing design and manufacturing people together early in the design phase to simultaneously develop the product and processes for manufacturing the product.
- Concurrent engineering helps to improve the quality of early design decisions and thereby reduces the length and cost of design process.
- Recently this concept has been enlarged to include manufacturing personnel, design personnel, marketing and purchasing personnel in loosely integrated cross-function teams.
- In addition, the views of suppliers and customers are also sought frequently. This will result in product designs that will reflect customer wants as well as manufacturing capabilities in the design stage itself.
- In other words, to achieve a smoother transition from product design to production, and to decrease product development time, many companies are using simultaneous development, or concurrent engineering.

Quality Function Deployment (QFD)

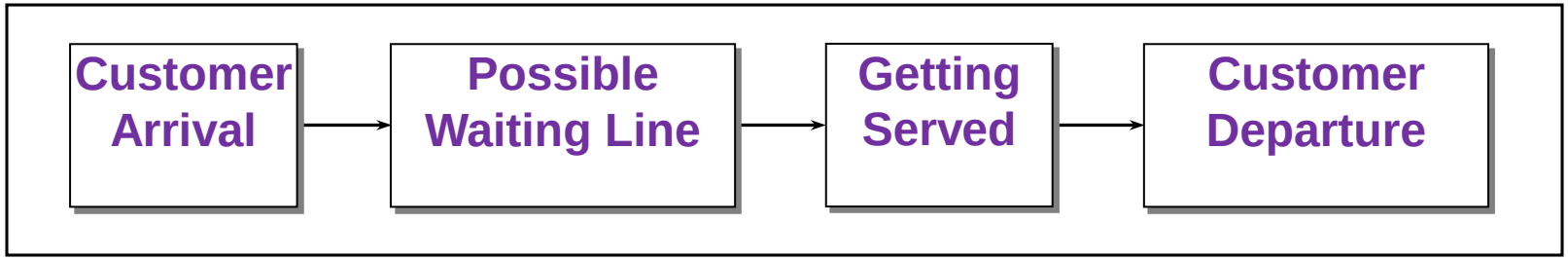
- Quality Function Deployment (QFD) is a structured approach for integrating the "voice of the customer" into both the product or service development process.
- The purpose is to ensure that customer requirements are factored into every aspect of the process. Listening to and understanding the customer is the central feature of QFD.
- Requirements often take the form of a general statement such as, "It should be easy to adjust the cutting height of the lawn mower." Once the requirements are known, they must be translated into technical terms related to the product or service.
- For example, a statement about changing the height of the lawn mower may relate to the mechanism used to accomplish that, its position, instructions for use, tightness of the spring that controls the mechanism, or materials needed.
- For manufacturing proposes, these must be related to the materials, dimensions, and equipment used for processing. The structure of QFD is based on a set of matrices. The main matrix related customer requirements (what) and their corresponding technical requirements (how).

- Quality Function Deployment approach uses inter-functional teams from marketing, design and manufacturing to incorporate the features sought by the customers in the product at the stage of product design.

Waiting Line Theory

- It is a common experience with all of us that for getting any sorts of goods and services from any shop or service centers like petrol pumps, cinema, halls, airports, clinic, banks, government offices, we are obliged to wait in a line for long time.
- These sorts of waiting not only cause irritations and dissatisfaction but also make it very expensive and time consuming.
- On the same side, it includes opportunity cost and time cost

- So, in order to reduce such problems of the long waiting lines, the principle of waiting line theory has played vital role to find the appropriate solution for that.
- This theory provides certain techniques to minimize the overall cost of waiting and servicing customer in the situation which have economic effect.
- The four stages of waiting line theory:



- A waiting line is a line or list of customers, who remain waiting for getting certain goods or services from service centers.
- Waiting lines are analyzed with a set of mathematical formulas which comprise a field of study called queuing theory.
- Queuing theory uses queuing models to represent various types of queuing systems that arise in practice.
- The main objective of the waiting line theory is to minimize two important costs i.e. time cost and opportunity cost.
- Providing too low service would cause excessive waiting which has a cost in terms of loss of goodwill, customer frustration and direct cost of idle employees.
- On the other hand, too high a service level would result in very high setup cost and idle time for the service stations.

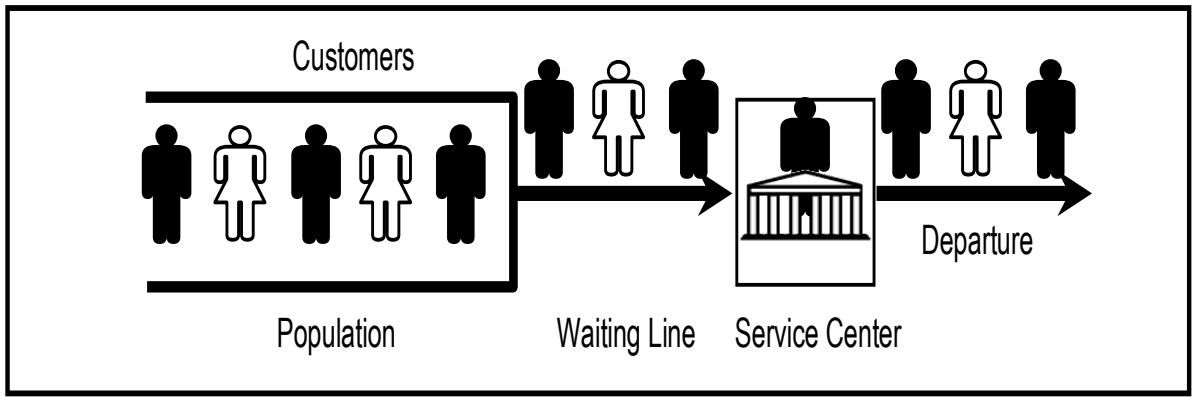
Types of Waiting Line System

- The waiting line system can be classified into following categories.

1. Single Channel System

- Under single channel system, there is one queue for one service center. This arrangement is done where the size of queue is expected to be small and the service center is not able to afford for more than one counter.

1. Figure 3.16: Single Channel Waiting Line System

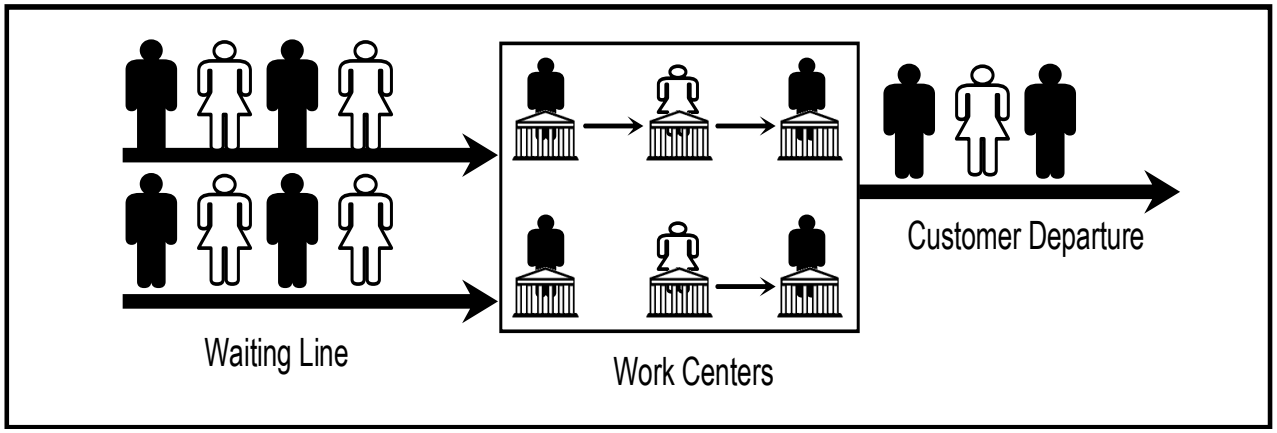


If the market is monopoly, keeping all things constant, we must use single channel system.

2. Multi-channel System

- Under multi-channel system, a service center opens a number of service counter and different queue are made according to service counter.
- When the size of the entire population is expected to be too large and the organization is able to provide for a large number of counters, this arrangement is suitable. If the market is elastic, we must use multi-channel system.

1. Figure 3.17: Multiple Channel Waiting Line System



- There are following reasons for providing service through multi-channel system:
  - ✓ Size and the types of the customers (Balking customers, jockeying customers and reneging customers)
  - ✓ Level of competition
  - ✓ Market nature (ie. elastic market)
  - ✓ Opportunity cost calculation.

Equations used in Queuing Theory

The problems of queuing system are solved using various models. Some of the formulae for solving the problems of queuing system are mentioned below:

1. The probability that service facility is idle (i.e. the probability of no customers in the system).

$$P_0 = 1 - \frac{\lambda}{\mu}$$

2. The probability that there are 'n' units (or exactly n customers) in the system.

$$P_n = P_0 \left(\frac{\lambda}{\mu}\right)^n = \left(1 - \frac{\lambda}{\mu}\right)\left(\frac{\lambda}{\mu}\right)^n$$

3. Utilization factor or traffic intensity defines as probability that service facility is being used.

$$\rho = \frac{\lambda}{\mu} = \textit{Average rate of Arrival/average rate of service}$$

4. Expected or mean number of customer (units) in the system or length of the system

$$L_S = \frac{\lambda}{\mu - \lambda}$$

5. Mean (expected or average) number of customers (units) in the queue waiting to service (average length of a queue)

$$L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = L_s - \frac{\lambda}{\mu}$$

6. Mean (expected or average) time a unit spends waiting in queue.

$$W_q = \frac{\lambda}{\mu}\left(\frac{1}{\mu - \lambda}\right)$$

7. Mean (expected) waiting time in system (time in queue plus service time):

$$W_s = \frac{1}{\mu - \lambda}$$

8. The probability that at least one customer in the system

$$(p \geq 1) = 1 - P_o$$

9. The probability that at least two customers in the system

$$(p \geq 2) = 1 - [P_o + P_1]$$

Examples

Example 1

- A new shopping mall is considering setting up an information desk managed by one employee. Based upon information obtained from similar information desks, it is believed that people will arrive at the desk at a rate of 20 per hour. It takes an average of 2 minutes to answer a question. It is assumed that the arrivals follow a Poisson distribution and answer times are exponentially distributed.
  a. Find the probability that the employee is idle.
  b. Find the proportion of the time that the employee is busy.
  c. Find the average number of people receiving and waiting to receive some information.
  d. Find the average number of people waiting in line to get some information.
  e. Find the average time a person seeking information spends in the system.
  f. Find the expected time a person spends just waiting in line to have a question answered (time in the queue).

Where, arrival rate (λ) = 20 customers per hour

service rate (μ) = 30 customers per hour

a. $P_0 = 1 - \frac{\lambda}{\mu} = 1 - \frac{20}{30} = 0.33 = 33\%$

b. $p = \frac{\lambda}{\mu} = 0.66$

c. $L_S = \frac{\lambda}{\lambda - \mu} = \frac{20}{30 - 20} = 2$ people

d. $L_q = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{20^2}{30(30 - 20)} = 1.33$ people

e. $W_s = \frac{1}{\lambda - \mu} = \frac{1}{30 - 20} = 0.10$ hours

f. $W_q = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{20}{30(30 - 20)} = 0.0667$ hours

Example 2

- At a certain Saloon, customers arrive in a Poisson distribution fashion with an average time of 20 minutes between arrivals. The interval between services at the saloon follows exponential pattern and the mean time for the purpose comes to 15 minutes. In the light of the above information, determine:
  i. the average length of the queue
  ii. the average length of the system in the saloon
  iii. the time spent by a customer in the queue
  iv. the total spent by a customer in the saloon

Solution

Arrival Rate (λ) = 20 minutes = 3/hour

Service Rate (μ) = 15 minutes = 4/hour

i. $Lq = \frac{\lambda^2}{\mu(\mu - \lambda)} = \frac{3^2}{4(4-3)} = \frac{9}{4} = 2.25 \approx 2$ customer

ii. $Ls = \frac{\lambda}{\mu - \lambda} = \frac{3}{4-3} = 3$ customers

iii. $Lq = \frac{\lambda}{\mu(\mu - \lambda)} = \frac{3}{4(4-3)} = 0.75$ hours = 45 minutes

iv. $Ls = \frac{1}{\mu - \lambda} = \frac{1}{4-3} = 1$ hour

Problems for the discussions

Problem 1

- The manager of a grocery store in the retirement community of Sunnyville is interested in providing good service to the senior citizens who shop in her store. Currently, the store has a separate checkout counter for senior citizens. On average, 30 senior citizens per hour arrive at the counter, according the Poisson distribution, and are served at an average rate of 35 customers per hour, with exponential service times. Find the following operating characteristics:
  a. Probability of zero customers in the system.
  b. Average utilization of the checkout clerk.
  c. Average number of customers in the system.
  d. Average number of customers in line.
  e. Average time spent in the system.
  f. Average waiting time in line.

[Ans: a. = 0.1429, b. = 0.8571, c. = 6, d. = 5.1429, e. = 0.20, and f. = 0.1714]

Problem 2

- Assume a drive-up window at a fast food restaurant. Customers arrive at the rate of 25 per hour. The employee can serve one customer every two minutes. Assume Poisson arrival and exponential service rates.

Determine:

i. What is the average utilization of the employee?

ii. What is the average number of customers in line?

iii. What is the average number of customers in the system?

iv. What is the average waiting time in line?

[Ans: i. = 49.8, ii. = 4.16 ≈ 4 customers, iii. = 5 customers, and iv. = 0.16 hours]

Problem 3

- What are the characteristics of queuing system? Students arrive at the Administrative Services Office at an average of one every 15 minutes, and their requests take on average 10 minutes to be processed. The service counter is staffed by only one clerk, Mr. Ramesh Karki, who works eight hour per day. Assume Poisson Exponential service times.

i. What percentage of time is Ramesh idle?

ii. What is the probability that an arriving student will find at least one other student waiting in line?

[Ans: i. = 0.33 hours or 20 minutes, ii. 0.67 hours or 40 minutes]

Problem 4

- At a certain Bank, customers arrive in a Poisson fashion with an average time of 5 minutes between arrivals. The interval between services at the Bank follows exponential pattern and the mean time for the purpose comes to 4 minutes. In the light of above information determine:

i. The expected number of customers in the systems

ii. The expected number of customers in the queue.

iii. The time spent on average by a customer in the system

iv. The proportion of time the system remains idle.

v. The probability at least one customer in the system.

[Ans: i. = 4 customers, ii. = 3.2 customers, iii. = 0.3 hours or 18 minutes, iv. = 0.2 hours or 12 minutes, and v. = 0.8 hours or 48 minutes]

Problem 5

- Customers come to client service desk at an average of one every 12 minutes and their requests take an average of 8 minutes to be processed. Client service desk is staffed by only one employee, who works eight hours in a day. Assume Poisson arrival and Exponential service pattern, find out the following;

i. Average number waiting in line

ii. Utilization of client service desk

iii. Average time waiting in line

iv. Probability that there are at least 2 customers waiting in line when a customer arrives

[Ans: i. = 1.3 customers, ii. = 0.67 hours or 40 minutes, iii. = 0.26 hours or 16 minutes and iv. = 0.45 hours or 27 minutes]