# Literature Review on Total Covering Problems and their Applications

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**Abstract:** ***This paper discusses different types of total covering problem and their real-life applications. The covering problem can be classified into total covering problem and partial covering problem. The aim of Total covering problem is to cover all the customers with the minimum number of facilities. The aim of partial covering problem is to cover as many customers as possible with the given at the greatest number of facilities.***

**Keywords:** Partial Covering, Total Covering, Minimum cost

## 1. Introduction

Facilities location problem is considered to be an important component of logistic system. Covering problem is a special kind of facilities location problem. The meaning of the term "Cover "is explained as follows. If a customer (i) is located within a distance (dij) say 5 km from a facility (j) from which the customer gets service, then the customer (i) is said to be covered by the facility j. Consider, the problem of covering each residential region with a ration shop such that no ration card holder travels more than 5 km to get provisions from the respective ration shop. In this type of problem, the covering co-efficient is defined as follows:

Cij = 1, if dij 5 km
= 0, otherwise

Consider a set of residential regions (Customers) in a state which are to be covered by a set of dealer'sfacilities) of a particular company. A residential region is said to be covered if there is a dealer located within say, a 30 km distance from that residential region. In this example, the objective is to cover all the residential regions with the minimum number of dealers. Hence, it is called as a total covering problem. In general, all the emergency -service, essentialservice-related situations are formulated as total covering problems.

Locating fire extinguishers, emergency food grain reserve stations, railway accident relief equipment stations, health centers, branch banks, schools etc., are some more examples of the total covering problem.

But there is another version of covering problem involving cost. Let us consider the problem of locating minimum number of raw material warehouses to serve a given set of plants as the total covering problem. In this problem the objective is to determine the minimum number of warehouses such that the total of the cost of transporting the materials from the warehouses to the plants and the cost of operating the warehouses is minimized.

If there is limitation in providing facilities, then the objective of the covering problem is to cover as many customers as possible with the given at the greatest number of facilities. This is called as the partial covering problem.

## 2. Types of Covering Problem

The covering problem can be classified into total covering problem and partial covering problem.The objective of the total covering problem is to cover all the customers with the minimum number of facilities where as the objective of partial covering problem is cover as many customers as possible with the minimum number of facilities without exceeding the limit on the at the greatest number of facilities to be operated as suggested by the management. Also, the covering problem can be classified into the following categories.

- Covering problem with 0-1 co-efficient
- Covering problem with non-0-1 co-efficient.

All the emergency facilities location problems and other public utility location problems such as post offices location, branch banks location, police stations location etc.. will come under the covering problem with 0-1 covering co-efficient.

The problem like warehouse location problem, variety reduction problem etc will come under the covering problem with non 0-1 covering co-efficient.

Just to have insight into the concept, a mathematical model for the total covering problem is presented below. since these problems come under combinatorial category, usage of heuristics is inevitable . For various models and heuristics in this area readers may refer that publications by Duskin (1981, 1983) , Panneerselvam ( 1990.1991.1997.1998.1999), Rajkumar and Panneerselvam (1991) and Panneerselvam et al (1996)

**Model for total covering problem with 0-1 covering co-efficient**

A well known zero-one programming model for the total covering problem is presented below.

Minimize Z = j=1 to N Yj
Subject to
J=1 to N CijYij 1, I =1,2, 3… M

Where Yj is equal to 1, if the site j is selected for assigning a facility and it is equal to 0 , otherwise . Cij is equal to 1, if the customer (i) is served by the facility j.It is equal to 0,otherwise. M is the total number of customers and N is the total numbers of proposed potential sites.

## 3. Practical Applications of Covering Problems in Production and Operations Management

In this section, the different applications of covering problems in production management are presented.

### 3.1. Applications in Industries

In this section, a sample set of industrial applications of covering problems is presented.

**a) Location of fire extinguisher in a plant:**

In large scale industries, we may be interested in locating minimum number of fire extinguishers to cover various departments such that there exists at least one fire extinguisher say within, a 100-meter distance from each department.

In this problem, initially a set of potential sites for locating fire extinguishers is proposed. Then, a 0-1 covering coefficient matrix is formed by satisfying the distance constraint.Finally, either a 0-1 programming model or an efficient heuristic may be used to find the final result depending on the size of the problem.

**b) Locating costly handling equipment:**

Now -a- days, automated guided vehicles are used in industries. Since, these are costly handling equipment, management will have a limit on the number of such equipment to be installed in a plant.

This problem can be mapped as a total covering problem with 0-1 covering coefficient as follows: initially, a set of potential sites within the plant to locate AGVs is to be proposed. A department in the plant is covered by an AGV if it is within say 20 meters of distance from any of the proposed sites.

Then, the objective is to determine the at the greatest number of sites for locating AGVs which is less than the limit given by the management such that each department is covered by at least one AGV.

**c) Variety Reduction problem:**

Consider the example of fasteners manufacturing industry which manufacturers different types of fasteners. In such Industries, the basic raw material for making fasteners is improved rod in different diameters.

The organization is left with the choice of importing rods to the exact dimension of each bolt with specified allowance for diameter or improving rods only with limited sizes for diameter and then making the bolts using drawing operation from some rods with higher diameter. The first option will result in excessive inventory and reduced flexibility of the usage of the raw materials. The second option will result in excessive processing cost. So, one has to seek the trade off between these two options.

In this process, the organization has to decide the number of sizes of rods (n) which are to be imported to manufacture the given number of sizes of bolts (m) ($n<m$) which will minimize the total cost of the problem.

This problem comes under the total covering problem with non-0-1 covering co-efficient.

**d) Group Technology:**

In layout design, group technology-based layout is considered to be the best form of layout for batch production system.

In this system of production, there will be n components requiring processing on m different machine types. The objective of GT based layout is to group these m machines into a desirable number of machine groups with a corresponding number of component groups such that the inter cell movement is minimized.

This problem can be modelled as a covering problem in which initially, a set of desirable number of machine groups is proposed to process the given set of components. If the number of proposed machine groups is more, there will be excessive idle time cost of machines, otherwise there will be excessive materials handling cost.

So, the objective is to obtain a desirable number of machine groups to process the given set of components with the minimum total cost of idle time and materials handling . Balasubramanian and Panneerselvam (1993) have developed a covering technique-based heuristic for this situation. This problem comes under the total covering problem with non-0-1 covering co-efficient.

**e) Locating warehouses:**

If there are m plants in an organization, then there are two extreme alternatives left to the organization as listed below:

- A separate warehouse for each plant.
- This will result in least material handling cost but increased overhead cost of operating and maintaining the warehouses.
- A single warehouse for all plants.
- This will result in least overhead cost of operating and maintaining the warehouse but increased cost of materials handling.

So the objective is to determine the desirable number of warehouses to be operated to meet the demand of all the plants such that the total cost of materials handling and overhead is minimized. This problem is under the total covering problem with non-0-1 covering coefficient

### 3.2. Applications in service organizations

In this section, a sample set of applications of covering problem in various service organization is presented.

Some of the examples of covering problems are as follows:

a) Locating minimum number of emergency food grain reserve stations to supply food grain to various regions world wide such that there exists at least one emergency food grain reserve station say within, a distance of 500 km from each region. This example is based on the International Emergency Reserve (IER) Program operated by the world food program.
b) Locating minimum number of railway accident relief equipment stations to attend to accident relief work in the event of accident at various regions such that there exists at least one such station say within, a distance of 200 km from any place of accident in any region

## 4. Conclusion

Facilities location problem is an important module of any logistic system. Under this area, the concept of covering problem appears to be simple, but its solution procedures are challenging. In this paper, the different types of covering problem and their practical applications are presented.Also, a model to solve covering problems is given. Since these problems are under combinatorial category, usage of efficient heuristics is more important. Future research can be in the direction of developing efficient heuristics.

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