CHAPTER 5

Conclusion and Discussion

This thesis has been conducted to study the facility location problem. In general, the facility location problem is large scale problem. A method to modified problem is then proposed to reduce the size of the problem. The facility location problem consists of setup and transportation costs, 3 methods with the different optimization routine are constructed. The first method gives priority to the setup costs, on the other hand, the second method gives priority to the transportation costs. The last method gives priority to the distribution of facility location. The objective of p-center problems is to minimize the maximum distance between each client and its assigned facility. This objective is appropriate to choose facility under priority to the facility distribution. A method for solving $p-$center problem is improved in this work, to choose the locations for facilities in the method that gives priority to the facility distribution. The conclusion and discussion are divided into 3 parts: 1) method for the modified problem by reducing size, 2) method for solving $p-$center problem and 3) method for solving facility location problem.

The facility location problem is reduced by combining the node that has a degree of 1 or 2 to the nearest node that has a degree of more than 2. The results of the illustrative example show that if the problem is reduced by removing the nodes that have degree 1 out of problem, the nodes in problem are reduced to 79.86% of the original problem while the error bound in this case is 6.64%. If the problem is reduced by removing the nodes that have degree 1 and 2, the nodes in problem are reduced to 57.97% while error bound in this case is 10.33% from the original problem. The problem with the size (or nodes) reduced by this method returns the error in the problem. In the illustrative example, the optimal total costs obtained from the modified problem are less than optimal total costs of the original problem. The optimal solutions obtained from modified problems can be transformed to the original problem solution and are feasible for the original problem. If a solution of a modified problem is feasible for the original problem, the optimal value of the modified problem will be worse than that of the original problem. In this case, the method for the modified problem removes nodes that have degree 1 and 2 out of the system and the transportation costs of the removed nodes are estimated by multiplying the transportation costs of the remaining nodes with the number of the associated removed nodes. Since, the transportation costs between the removed nodes and the remaining nodes are not included in the modified problem, the transportation costs of the modified problem are less than the transportation costs of the original problem. The error bound of the modified problem is proved in Section 3.1.3. To avoid this error, we suggest that the problem should not necessarily be reduced if it is not so large that the method used cannot solve the problem. Also in the case that the calculation time is involved in solving the problem, the problem size reduction method proposed in this work can be applied before solving the problem.

Next, the method for solving $p-$center problem is improved by indexing the element in the distance matrix and updating the lower and upper bounds of the problem via the maximal client coverage problem with a fixed radius. Our method is appropriate for problems with the normal distribution of the distances between the client and facility. The method given in [2] is appropriate for problems with the non-normal distribution of the distances between the client and facility. We compare the results of this method with the method that is given in [2] and the optimal solution obtained from CPLEX. The total of 100 cases are tested and the average of the results in this thesis indicates that the proposed method is statistically faster than the method in [2] with a significance level of $\alpha = 0.01$ in both the uncapacitated and capacitated cases. Moreover, the results of the simulation data in this research show that the average percentage errors of the proposed method is found to be similar to the average percentage errors of the method given in [2] at $\alpha = 0.01$ significance level for both cases.

Finally, 3 methods for solving facility location problem are proposed. The assumptions to classify the facility location problems in 3 categories are proposed in this thesis: 1) higher setup cost, 2) higher transportation cost, and 3) balanced cost. The optimization routine of each method is corresponding to the type of the problems. First, 3 hypotheses constructed in Chapter 3 are tested. The simulation results in this thesis show that the total costs obtained by Method A is less than the other methods in the problem with higher setup costs. For the problem with higher transportation costs, the total costs obtained by Method B is minimized. From a statistical test, we can conclude that Method A and B are according to the Hypothesis 1 and 2 at $\alpha = 0.01$ significance level for both cases with p-value 0.315 and 0.247 respectively. For the Hypothesis 3, the Method C is not according to the Hypothesis 3 at a significance level of $\alpha = 0.01$ with p-value 0.0012. Moreover, 3 methods are tested in 4 different systems: 1) the municipal waste system in Chiang Mai city, 2) the agricultural waste system in Chiang Mai city, 3) the municipal waste system in 5 provinces of Northern Thailand and 4) the agricultural waste system in 5 provinces of Northern Thailand. The 4 case studies are according to the balance cost case, higher setup cost case, higher transportation cost case, and higher setup cost case, respectively. The results of the illustrative example is consistent with the simulation results. From the results, we can conclude that Method A is suitable for the problems with higher setup cost, Method B is suitable for problems with higher transportation cost and Method C is not suitable for both cases. However, the solutions obtained from Method B is not much different than those from Method A in problems with higher setup cost. Therefore, Method B should be picked to solve the problem if the problem is not categorized.