Presenting a model to find location of communication antennas under capacity and uncertain demands of users (case study: Ahvaz city)

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Abstract: In this study, the use of robust optimization approach for locating the proposed covering model for the antennas and telecommunications masts and the models proposed in the literature for the coverage will be used to present an appropriate and new model for its robustness. In the last decade, the use of mobile phone has been considerably increased. Mobile communication networks have been modeled in the form of cells and each cell has covered one area. One of the issues raised in the field of antennas and telecommunications masts is localization of the desired stations to offer an appropriate mobile service in terms of signaling. Different signaling radius of the stations, their localization and geographical conditions of the area make the localization of the stations to be NP-hard optimization problem. In this study, robustness - based modeling is used to evaluate the effect of uncertainty in subscriber's demand.

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Introduction

In this study, robustness - based modeling is used to evaluate the effect of demand uncertainty subscribers. In this approach, the issue and its parameters have been so considered that if uncertainty parameters were considered in the worst possible situations, in this case the optimal solutions would be so that we can properly carry out the planning and management process and customer demand is fully met. In this case, solutions will be evaluated as well as customer demand would be fully met by considering the changes in the scope of the underlying parameter uncertainty and relevant planning. In this study, it is tried to use the robust optimization approach to model the proposed covering localization for the antennas and telecommunications masts and the models proposed in the literature for the coverage will be used to give the new and appropriate model by its robustness.

Research background

The emergence of localization problems dates back in the early seventeenth century and the issue raised by Farrma. "Torricelli found that the location of equilateral triangles of environmental circles on the sides of the original triangle in the outer face will be the solution of the problem. The localization theory was emerged as it is used today, with the release of the book entitled as Vber den standortder indvstrien by Alfred Weber in 1909.

Serious studies on the localization began in 1964 when the objective function was introduced by Hakimie either in minimum or maximum model. From the 1960s to mid-1970s, the minimums and maximum were utilized in the private sector.

Goldman and Dearing (1975) and Church and Garfinkel (1978) were firstly suggested which later called as Mozer localization models.

Hypotheses

- Optimal localization of telecommunications stations operated by service capacity antenna can be modeled as coverage problem.
- Localization of telecommunications masts with limited capacity and uncertain demand of subscribers can be modeled as mathematical programming.
- Optimization is essential for the localization problem of telecommunications antennas.
- Using meta-heuristic algorithms can be useful for obtaining acceptable answer to the problem of locating telecommunications antennas.

Introducing the sample

In this study, the model proposed for the localization problem of telecommunication masts in Ahvaz has been studied as an example. Ahvaz is one of the major Iranian cities located in the central part of province known as Khozestan. The city's population is about 1112021 and is considered as the seventh most populous city in Iran. It is about of 7925 square kilometers area in the geographical position about 31 degrees 20 minutes north latitude and 48 degrees 40 minutes eastern longitude. It is located in the Khuzestan lowland with a height of 18 meters above mean sea level.

The results of the model

Results of the model have been proposed in Table 1-4. For sensitivity analysis of demand parameter uncertainties, tolerance and multi-scenario budget of uncertainty will be considered. Problem Sensitivity analysis for the uncertainty budget was computed as 0%, 10%, 25%, 50%, 75%, 90% and 100%, respectively. If uncertainty budget is equal to 0%, the definitive solution is the same definitive solution. Results for problems were calculated and presented in in Table 4-5.

Table 1-4. The results of the model solution for different levels of uncertainty ($\omega = 0.5$).

The results show, according to data available for candidate's locations to deploy masts in the city of Ahvaz as well as their covering, 58 locations should be selected for the deployment of the telecommunications masts; therefore the deployment of them was calculated £ 6975 million, respectively. As it is seen, the optimal value of the objective function will be increased by increasing the level of demand' uncertainty parameter.

Table 4-1 Second objective function modifications by changing the level of uncertainty

Time Resolution (s)	**The optimal value of the objective function metric LP-**	The optimal value of the objective function	**The optimal value of the objective function1**	**Uncertainty percent**
14/0	0	1848000	6975	**0%**
156/0	0	1848260	6975	**10%**
125/0	0	1848650	6975	**25%**
125/0	0	1849300	6975	**50%**
172/0	0	1849950	6975	**75%**
156/0	0	1850305	6975	**90%**
171/0	0	1850500	6975	**100%**

Table 4-2. Summary of the results of the second objective function value changes with increasing levels of uncertainty

Increase	**The second objective function of the level of uncertainty**	**Uncertainty percent**
0	0	**0%**
014/0	014/0	**10%**
021/0	035/0	**25%**
035/0	070/0	**50%**
036/0	106/0	**75%**
019/0	125/0	**90%**
01/0	135/0	**100%**

Table 4-3 Results of optimal solution with uncertainty of 100%

Zeiton karmandi	**Koye Naft**	**Hasirabad**	**Naderi**	**Sepidar**	**Ziba Shahr**	**South Shariati**	**Baharestan**	**Gholestan**	Farhang shahr	Export	Armored army	Kianpars	Selected Location
1												1	**1**
1												1	**2**
1												1	**5**
												1	**6**
1											1	1	**7**
1											1		**8**
		1								1			**17**
		1											**18**
		1								1	1		**22**
										1			**30**

Zeiton karmandi	**Koye Naft**	**Hasirabad**	**Naderi**	**Sepidar**	**Ziba Shahr**	**South Shariati**	**Baharestan**	**Gholestan**	Farhang shahr	Export	Armored army	Kianpars	Selected Location
										1			**32**
									1	1			**33**
									1				**34**
									1	1			**36**
									1	1			**40**
									1	1			**41**
								1	1	1			**42**
						1		1	1				**44**
						1		1	1				**45**
						1		1					**47**
						1		1					**49**
							1	1					**51**
							1	1					**55**
							1				1		**58**
							1				1		**60**
							1				1		**66**
							1				1		**67**
					1						1		**73**
					1	1							**77**
					1								**83**
				1	1								**84**
				1	1								**86**
				1	1								**87**
				1			1						**90**
					1	1							**93**
				1									**100**
			1	1									**101**
			1	1									**102**
			1	1									**103**
			1										**105**
			1										**106**
		1	1										**107**
		1	1										**108**
			1										**109**
			1										**110**
		1	1										**111**
			1										**112**
	1	1											**113**
	1	1										1	**119**
		1										1	**120**
	1	1										1	**122**
	1											1	**123**
	1											1	**124**
1	1											1	**125**
1												1	**126**
1	1												**129**
1	1												**130**
1												1	**135**

Table 4. 4 Results of model for different levels of uncertainty ($\omega = 0$)

Time Resolution (s)	The optimal value of the objective function metric LP-	The optimal value of the objective function2	The optimal value of the objective function1	Uncertainty percent
141/0	0	1848000	16650	**0%**
062/0	0	1848260	16650	**10%**
171/0	0	1848650	16650	**25%**
14/0	0	1849300	16650	**50%**
121/0	0	1849950	16650	**75%**
10/0	0	1850305	16650	**90%**
156/0	0	1850500	16650	**100%**

Table 4-5 Results of the model for different levels of uncertainty ($\omega = 0.25$)

Time Resolution (s)	The optimal value of the objective function metric LP-	The optimal value of the objective function2	The optimal value of the objective function1	Uncertainty percent
156/0	0	1848000	6975	**0%**
14/0	0	1848260	6975	**10%**
151/0	0	1848650	6975	**25%**
172/0	0	1849300	6975	**50%**
142/0	0	1849950	6975	**75%**
156/0	0	1850305	6975	**90%**
171/0	0	1850500	6975	**100%**

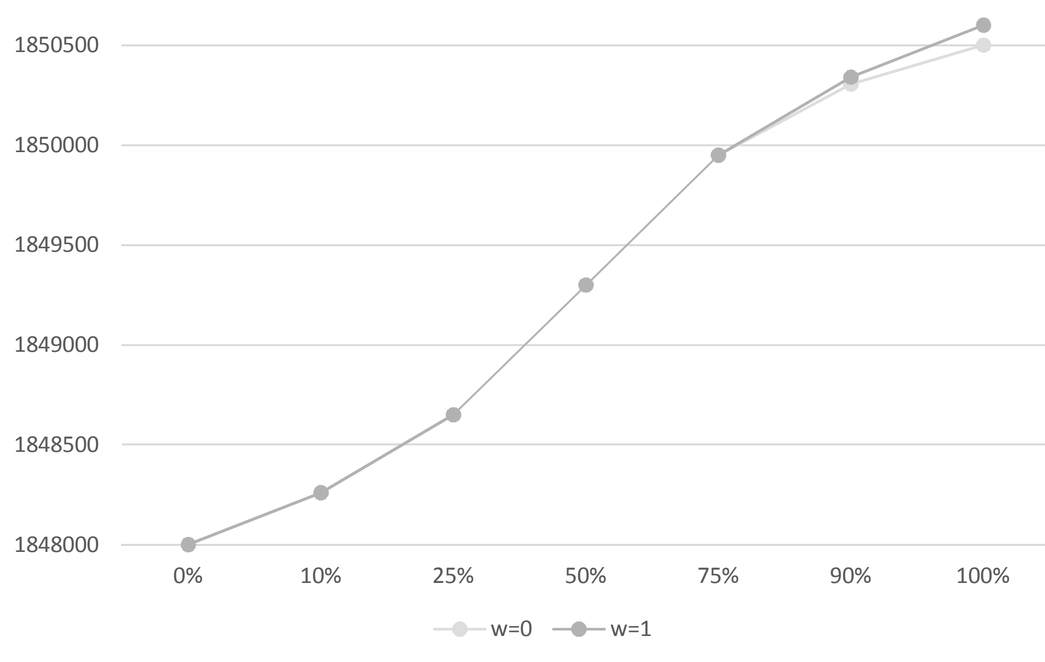

Figure 4-2 Comparison of optimum amount of the second objective function for different values of *w*

Table 4-6 Results of the model for different levels of uncertainty ($\omega = 1$)

Time Resolution (s)	**The optimal value of the objective function metric LP-**	**The optimal value of the objective function2**	**The optimal value of the objective function1**	**Uncertainty percent**
14/0	0	1848000	6975	**0%**
078/0	0	1848260	6975	**10%**
062/0	0	1848650	6975	**25%**
125/0	0	1849300	6975	**50%**
125/0	0	1849950	6975	**75%**
188/0	0	1850340	6975	**90%**
061/0	0	1850600	6975	**100%**

Problem solving of the sample by genetic algorithm

In this part, the case problem for localization of telecommunications antennas and cell phone towers in the city of Ahvaz with data previously evaluated by Gomez software was examined and the results of genetic algorithm to solve this problem were presented**.** In Table 4-8 problem solving results for different values of iteration were calculated and presented. In this case, the number of population genetic algorithm is equal to 50 and mutation rate is 0.1 and the possibility of merging has been considered equal to 0.7.

Table 4-7 Results of problem solving with genetic algorithms for different iterations of the algorithm.

Figure 4-11. Graph of the genetic target function changes by changing the number of iteration.

Figure 4-12. Graph of genetic algorithm execution time shifts by changing the number of iteration.

The results show, according to data available for candidate's locations to deploy masts in the city of Ahvaz as well as their covering, by increasing the number of algorithm iteration, the accuracy of the solutions will be increased.

Figure 13-4 shows the changes of the proposed genetic algorithms quality to solve the problem. As seen in Figure 13-4, 1000 solutions were achieved by iterations of the algorithm, but at the same time calculations have been increased. The trend of running time by increasing the number of repetitions is shown in Figure 14-4.

Table 9-4. In this case, the number of population genetic algorithm is equal to 50 and mutation rate is 0.1 and the number of iteration has been considered equal to 500.

Table 4-8. The results of problem solving with genetic algorithm for different values of merging probability.

Figure 13-4. Graph of genetic target function shifts by changing the amount of merging probability.

Figure 4-14 Graph of genetic algorithm execution time shifts with changes likely to merge.

In Table 4-10, the results for different values of the number of algorithms have been calculated and presented. In this case, the probable number of merge algorithm is equal to 0.7 and the number of iteration has been considered equal to 500.

Table 9-4 Results of genetic algorithms to solve the problem with different levels of population.

Figure 4-15. Genetics objective function value shift graph by changing the number of population.

Figure 4-16. Execution time shift graph by changing the number of population.

Results show, with the increasing number of algorithms, accuracy of the solutions and running time will be increased.

As seen in Figure 17-4, a population of 250 algorithm gives a better solution, but at the same time the commutation time will be increased. The trend of running time changes for the algorithm by increasing the number of repetitions is shown in Figure 18-4.

Conclusion

The conclusion of the thesis can be noted as follows:

• Presentation of localization model for coverage by considering the capacity of telecommunications masts and subscriber's demand;

• Uncertainty of parameters of the subscriber's demand in problem;

• Providing dual- objective model by minimizing setup costs and minimization of subscriber's allocation to masts;

• Use of metric LP- solving approach to solving multi-objective problems and problem-solving by GAMS software;

• Use of robust optimization and counterpart based modeling approach by considering the uncertainties parameter;

• Use of meta-heuristic genetic algorithm to solve the problem;

• Sensitivity analysis of genetic algorithms designed to studied case;

• Solving problem of the case and the sensitivity analysis by changing some parameters of the sample with Gomez software;

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