

Locating ATMs in Urban Areas

Mehdi MoradiTabar^{#1}, Omid Bushehrian^{*2}, Reza Askari Moghadam^{#3}

[#] Graduate Student of PNU University
Iran

MehdiMoradiTabar@yahoo.com

^{*} Shiraz University of Technology
Iran

Bushehrian@sutech.ac.ir

[#] Faculty of New Sciences and Technologies University of Tehran
Iran

r.askari@ut.ac.ir

Abstract— In recent years, the banks and financial institutions have considerably attempted to provide better and more varied services to the customers. These varied services may satisfy needs of different group of customers. In this regard, the location of these services as well as their level of accessibility (access to these services) is greatly important. The importance of these issues is well recognized by responsible managers of the financial firms. In other words, the managers accept the importance of these services and they know that the quality and location of these services significantly affect their success in the business. Therefore, bank managers sought scientific methods, which may facilitate the locating process for their services. How to select the most effective methods and how to use these methods in this regard depend on following factors: the customers' demands, local capacities and fair distribution of the services, etc. The effective impact of these factors as well as the interactive relationship between them should also be noted in the application.

This study is a descriptive kind of research, which is applicable in various areas. Library and environmental studies were used to conduct the study. Considering the parameters that considerably affect the level of acceptability of ATMs services and analyzing the importance of these parameters according to this criterion, the researchers tried to use multiple attribute decision-making model. A heuristic algorithm was used in the context of this approach. Then, the most appropriate locations around the optimal locations were introduced based on fuzzy concept as well as quantitative and qualitative factors, including the minimum cost and maximum coverage according to the customers' demands. The case study was located in the 13th district of Tehran city.

Keywords: Locating, Multi Criteria Decision-Making, Heuristics Algorithms, ATM

I. INTRODUCTION

ATM(automated teller machine) services are considered as one of the most important services among different kinds of banking services. These services are provided within certain locations, either within the area of the bank branches or outside the area of the bank branches (Indoor ATM payment kiosk). ATMs located within the bank branch (branch ATM) are considered as multifunctional, highly advanced and supplementary facilities while Indoor ATM payment kiosks (which are the particularly considered in this study) are often used for cash payments. These services were initiated over 35 years ago for the first time and since then these services were gradually developed day after day to meet customers' demands. These services are also essential for successful development as well as susceptible stability of the financial institutions. A large percentage of the customers considered their easy access to ATMs as an important criterion for selecting the appropriate enterprise they want to do business with. ATM services were initiated in by Sepah Bank in Iran(1991) for the first time. In recent years, cards and ATM services are among the basic services of most banks and financial institutions, which should be suitably provided for the customers. These services mainly aim to promote the application of electronic kiosks instead of bank branches. They also aim to reduce the percentage of physical presence of the customers in the bank branches. By developing these services, the business enterprises are no longer constrained to offer their services within certain time and space limitations.

On The other hand, micro-payments are highly important because they are the sensitive spot of the connection between banking networks and the public. Development of the ATMs services not only affected economic status of the country but also have several deep social and cultural effects on quality of lives of the individuals. The statistics provided by the Central Bank of Iran (August 2012) confirmed the positive effects of these services. Approximately 62.74% of the amount of the banking transactions is done through ATMs services. Unfortunately, in the past years, ATM services did not receive the necessary support they deserved to receive (according to the Central Bank Statistics).

In October 2008, there were 2461.521 numbers of cards for every ATM in Iran while there were 6995.883 numbers of cards for every ATM in August 2012 in Iran. It is evident that the growth of the cards' numbers is higher than the ATMs' number. If this trend increases in the long term, the customers will no longer be motivated enough to continue working with ATMs. They may attribute the poor performance of the ATM to the bank they are working with. Therefore, they may intend to change their bank and work with some other bank with better support and better qualified services or at least the banks that roughly meet their demands. Clearly, in the conditions in which the banks are obliged to increase the number of their ATMs within the city, it is necessary that the financial managers attentively pay attention to the matters that greatly affect the performance of ATMs.

This study attempts to provide a practical model for allocating and locating ATMs. This process is done by particularly considering following factors: the customers' characteristics (demands) such as their age, income, level of education, etc. Following factors should also be considered in this context: proper and fair geographic distribution of the services, application of existing local capacity of the areas within the city, increased access to potential clients, minimum number of the resources and international standards in this context. In the end, this study tries to accomplish various objectives including: social justice through increasing level of accessibility of various segments of the public people to the financial institutions, improving the level of customer satisfaction, increasing earnings quantity for banks by reducing the costs and increasing efficiency of the ATMs, etc.

Definition of basic terms and concepts related to the subject matter of the study and review of the existing literature in this field of study is presented in the next section. The third section introduces the initial approach of this study titled as "the complexity-based ATMs locating process" [19]. The proposed approach and its relevant details are introduced in the fourth section. The implementation of the proposed model in a municipality district in Tehran is presented in the fifth section. The last section summarizes the discussions and provides conclusions of the research.

II. INTRODUCING THE SUBJECT MATTER OF THE RESEARCH AND REVIEW OF THE LITERATURE RELEVANT TO THE SUBJECT MATTER

Fuzzy thinking method: This method was presented by Professor LotfiZadeh in 1965. This method made possible accurate analysis of the problems by providing following conditions: considering the ambiguity and uncertainty issues in the model (rather than eliminating and ignoring these matters), promoting multi-valued logic rather than two-valued logic (true and false).

This study attempted to provide a model for decision making process as well as locating indoor ATMs based on multiple criteria using fuzzy logic. The criteria of the research included both qualitative and quantitative criteria. The reason behind using this method lies in the fact that a high constructive interaction should be established with the ambiguities of human judgment. Moreover, more realistic and accurate grounds for the managers should be created, so that they can make better decisions.

The articles and researches conducted on the ATM issue are classified in three categories:

- a. Knowledge of the characteristics and features of most consumers [21]
- b. Knowledge of the benefits and the present status of the provided ATM services and similar products [9]
- c. Identifying the ideas and processes relevant to solving the locating problem [8] [10] [11] [12] [13] [14] [17]

Partial knowledge of the above-mentioned classification is very beneficial for recognizing the general principles and practical aspects of this study as well as making hypothesis in this field.

The previous research projects in the field of ATMs conducted in abroad or within Iran were implemented using three methods which is depicted in the table 1:

TABLE I
CLASSIFICATION OF THE RELATED LITERATURE

Theoretical methods	Software methods	Algorithmic methods
the benefits related to the development of ATMs	using geographic information system software	an approach with an optimal solution
the dominant characteristic of the customer	other software	an approach with a solution around the optimal solution

■ Theoretical approaches include a large scale of the studies whose subject matters are as follows: the characteristics of both cards acceptors and ATM, the financial institutions' expectations from the ATM, etc. These methods provide proper recognition of the concept of locating ATMs; identify the amount of work, which should be done to this task. These methods also properly determine which factors are the most effective

parameters in this context. In other words, the locating process and the way to locate ATMs and the effective factors on ATMs locating may be identified through theoretical methods. The results of theoretical analysis can be used as valuable references for the managers, so that they can make decisions with reference to these results. In other words, in this method, a specific location is not proposed for installing ATM. In this method, only the characteristics and specifications of various potential locations for installing ATMS are presented. Then, the manager decides which location is the proper location for installing ATM. His decision is based on the specifications provided by theoretical methods. However, using theoretical methods, summarizing the collected data and analyzing them as well as classifying their benefits and priorities demand a lot of energy and effort. This task is both time consuming and expensive. As a result, using this method may result in making inefficient decisions by the managers since using theoretical methods demand huge amount of trial and errors. Moreover, this method is neither scientific nor empirical for locating process. [2] [3] [4] [5] [6] [20]

■ A large amount of studies and researches conducted on ATM locating were performed using software-based approaches in Iran. It was often performed by the experts in the course of geography and management with geographic information systems (GIS) facilities. Their procedure was based on a model designed according to the area under study. The effective parameters and variables were entered in the model layer after layer. In the end, the suitable locations for ATM location were introduced according to the scores, which were given to the locations based on the factors under study (the suitable location for installing ATMs was proposed based on the scores of the location. The location with the highest scores was introduced. These scores were given to the locations by studying the pre-mentioned factors on that area and giving a score to every location in that area. Then, overall scores of the potential location were the criteria for introducing the appropriate locating for installing ATM). Most of the projects on this issue can be properly conducted using this method. However, when using this method, there should not be any preinstalled facilities (ATM services) in the under study. Moreover, installing the ATM should be done exclusively by considering the location with the maximum target score (the ATM service should only be installed in the location with highest overall score). This method is not applicable when the qualitative factors (including maximum urban coverage) are included in the model as well [1].

■ A few numbers of the researches were conducted on the ATM locating using algorithmic methods. Unfortunately, theoretical principles and the basic standards were not observed in these kinds of researches. In other words, a proper strategy or solution was not introduced for the locating process based on previous locations in these researches. In the Similar studies conducted on ATM locating using algorithmic techniques, quantitative indicators were also be applied. Therefore, the operational space was greatly reduced since qualitative indicators were considered in these kinds of researches. Moreover, examining all the spots on the location under study in these researches require high processing costs and time (is time-consuming and expensive), especially in researches in which algorithmic approaches with optimum solutions were used. Usually, these expenses are not cost-effective for a number of researches. Therefore, the researchers tend to use algorithmic methods with the solutions around the optimal solutions [18] [19].

III. AN OVERVIEW OF BASIC PRINCIPLES OF "THE COMPLEXITY-BASED ATM LOCATING " [19]

This study is among a few studies conducted on ATM locating in the software engineering field. This approach was first introduced by Aldajani and Alfares in 2009. The variables used in this study are presented in Table 2.

TABLE II
THE VARIABLES OF THE INITIAL APPROACH

Descriptions	Variable
The number of ATMS	N
The matrix of scores of the spots of the area under study	D
The matrix of the difference between the provided service and scores of the spots of the area under study after installing n ATMs	En
The matrix of the location with n ATMs	Ln
The matrix of the service provided from n ATMs	Sn
The matrix of n ATMs coordinate	(Un, Vn)
The matrix of the service provided from overall n ATMs	Qn
The matrix of constant decline of the ATM services	A
Constant	α

This approach aims to minimize the number of ATM kiosk in the area under study. This can be accomplished providing that the service provided in the area would be greater than the scores of the spots of the area under study. The author stated that the main advantage of this approach relies in the fact that the mode of providing

service for the customer and the area are flexible. In addition, it is easy to model this approach for a human user. The disadvantage of this approach is that this approach is unsuitable for large areas because it likely to be trapped in local optimization. The flowchart of this approach is shown in Figure 1.

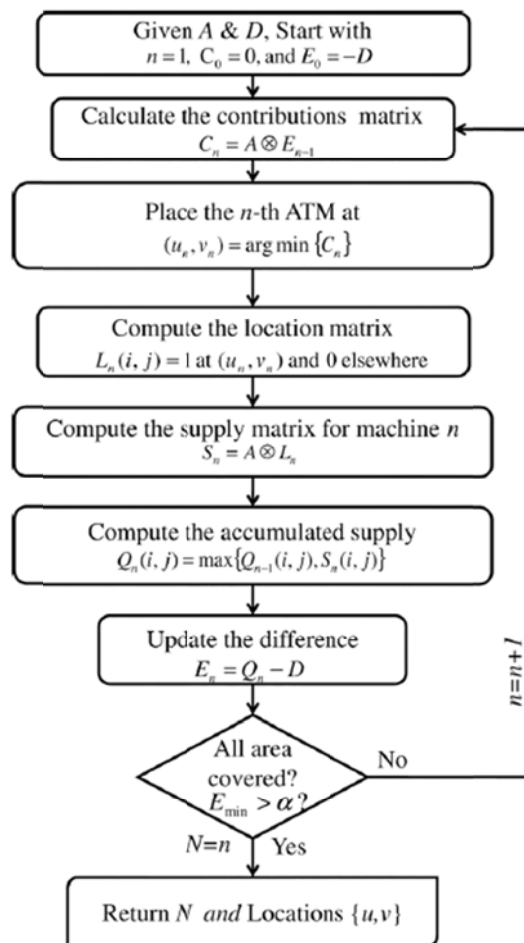


Fig. 1. Flowchart of the initial approach

IV. THE PROPOSED APPROACH

The proposed approach of this study attempts to improve the challenges introduced of the previous approach [19]. The main challenges identified in the previous study included entrapment in local optimization. This issue results in a time-consuming process for analyzing the collected data. As a result, it took a great deal of time to achieve results by using this approach. The entrapment in local optimization is the essence of this greedy model. In other words, if this approach is used, entrapment in local optimization is inevitable. Unlike previous approaches, in the proposed approach for locating ATMs, the criteria of locating not only included the effective factors, but also two criteria of human coverage and coverage of the mentioned area. Considering these two criteria as the standard for installing ATMs is considered as the desirable privilege of this study. In the end, several spots in the area under study were introduced for allocating to the ATM service (or for installing ATM service). In total, these introduced spots should better cover (or should have better scores in) the effective factors, demographic factors as well as provided service compared to the other spots (according to Figure 2).

The proposed approach minimized the risk of entrapment by dividing the area under study into several sections. The locating process was separately performed in each section. Then, the section with the highest score in the effective factors was selected for the locating process. This process was continued until the difference between the provided services with potential scores of the spots in whole of the area under study would be higher than a certain positive value. In other words, the number of services was higher than the potential score of the spots.

In the following section, we will describe the details of this process.

First, the relevant literature in this field was reviewed. the information relative to the effective factors for similar services in the financial institution was obtained. Approximately 100 questionnaires were distributed

among the customers and experts of the financial institution. The answer sheets were collected. The common perspectives were classified in certain categories. These common perspectives included the items whose responses were somehow the same. The items in which more than half of the respondents wrote unanimously, were classified separately in certain categories. Based on these categories, the experts had classified the effective factors affecting ATM locating process to four major factors and twenty-four dependent factors.

Three two-dimensional matrixes with length and width of the area under study were defined and initialized. These three matrixes were named as G1, G2 and G3. Each element of G1 matrix corresponds to a location or a region in the area under analysis. Every element of G1 matrix calculates the importance of the overall effective factors on installing ATM. Moreover, these are defined within the range of real numbers. Each element of G2 matrix corresponds to a location or a region in the area under analysis. Each element of G2 matrix calculates the importance of human coverage on installing ATM. Moreover, these values are defined within the range of positive real numbers. Each element of G3 matrix corresponds to a location or a region in the area under analysis. This element calculates the importance of area coverage in installing ATM. Moreover, they are defined within the range of real numbers whose range is between zero and one.

The area under study was divided into several sections whose surface was equal to the maximum area in which an ATM indoor kiosk can be serviced. The element or elements of the G1 matrix with the highest score were fetched for each section. The factors relevant to population density and the amount of space for providing service were examined for that spot or spots. In the end, the spot with the highest scores in the overall factors was selected as the spot for installing ATM indoor kiosk (based on the Figure 2). After determining the suitable location to allocate to the ATM indoor kiosk, the three matrixes of G1, G2 and G3 were updated based on the location the ATM would be installed. This process was repeated until the terms of Formula do not met with any spot in the area under study.

$$G_{final} = \text{choise} (x_i, y_j) : \forall (x, y) \in \{n, n\}$$

$$\begin{cases} G_1(x_i, y_j) > 0, G_1(x_i, y_j) \geq G_1(x, y) \\ G_3(x_i, y_j) * G_2(x_i, y_j) \geq G_3(x, y) * G_2(x, y) \end{cases}$$

Fig. 2. G_{final} function

The G_{final} function with the following expression introduces a location, which has the highest scores in the standard and effective factors on installing ATM. This process is shown in Figure 3.

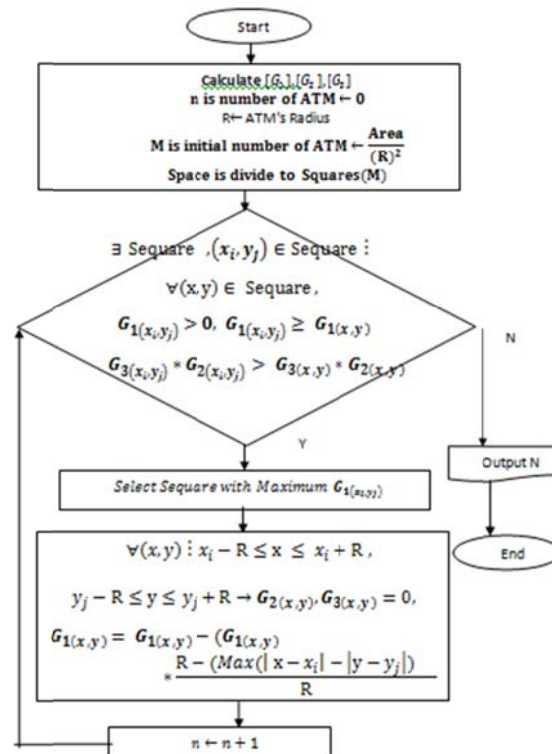


Fig. 3. Flowchart of the proposed algorithm

V. SIMULATION OF THE PROPOSED APPROACH

The 13th district of Iran-Tehran municipality was selected for the analysis of this algorithm. This district has 810 hectares. It is divided into four parts. It has 340,000 inhabitants. The reason behind selecting this district for this research lies in the fact that this area is adjacent to city borders. Moreover, a part of core of Tehran city's activities can be seen in this district.

This area is introduced as the developed areas of Tehran city. Following factors can also be seen in this area: dispersion in the distribution of the individuals' employment, public population and urban facilities, etc.

The simulation process was implemented on a computer with an operating system Windows Server 2008, CPU = Core2Quad 2.67 RAM = 4GB in the C # language 2007 edition. The census data related to 2007 year and a color image file with jpeg format (979 * 4500 pixels) were used as the reference data for region of the 13th district. After entering the data files into both approaches, 15 locations in the area under study were introduced as ATM locations. The first model performed the relevant calculations within 21 hours while the proposed model did this task within 16 hours.

It should be noted that the following assumptions should be used in the simulation:

- a. Similarity of the ATM types as well as quality of the services.
- b. Similarity of the cost of using ATMs

VI. CONCLUSION

In both papers, a greedy approach to solve the problem is presented. The criteria of the research was allocating one location after another to ATMs installation and selecting the best location for this purpose based on the highest scores obtained in the overall effective factors. In the proposed approach, the model of Divide and Conquer was added to the greedily approach. This new approach reduced the execution time up to 0.615 by dividing the predictive area for providing the ATM service to certain sections in which an ATM Indoor can be serviced. Moreover, the quality of the provided solution in this approach was approximately improved to 1.00044 times.

This study can be considered as a combination study of theoretical and algorithmic studies. In this study, a heuristic model for locating ATM for two-dimensional areas was presented. This heuristic model was based on the criteria and indexes, which affect the success of the stakeholders who provide the ATM service to the customers. Application of analytic hierarchical process (A.H.P) based on fuzzy logic determines how much the effective factors are important in locating process. It also identifies the extent of their importance, whether a factor's effect on the locating process is stronger or weaker than other factors. It doubles the possibility that the solution would be optimal. Considering international standards and the overall effective factors result in the fact that the quality of providing ATM service in Iran is approximately the same as those provided in the developed countries. Also, the number of required ATMs for development of these services was decreased. The flexibility of this approach is another institutional advantage of this approach. This advantage may be effective in solving the problems such as the locating process in centers including fire stations, hospitals, airports, etc.

In the process of implementing the research project, the researchers tried to exclude personal and sectional views and ideas at all stages of the project. This research is merely designed based on demands and expectations of the customers and managers. The personal ideas that were not included in the process of implementing the research project are as follows: defining prohibited areas in the model, studying gender distribution in the area under study, penalty rates in border areas, including the individuals' desires in the model (the customers' desire which expresses that the location of the ATM service should be near their house as much as possible), the rate of trip to purchase goods, the approximate time it takes to reach the ATM service per kilometer/hours, etc..

REFERENCES

- [1] R.Fukordy, "locating bank branches and ATMs by application of Analytical Hierarchy Process AHP", 2009
- [2] D.Venus and M.S.Moman, "identifying the factors affecting the tendency of the bank customers to use bank ATM systems"
- [3] S.Phili, A.Modarresi and M.M.Niknafs, "studying the effect of level of the education of the customers on the percentage of using magnetic cards."
- [4] M.Hemmati, M.Shahhosseini and M.Javidnia, "Identification and prioritization of the effective on customer acquisition by [improving the quality of] ATM services"
- [5] M.Sattari, " Customer Satisfaction of ATM Service", PNU, 2010
- [6] *Global Market Report on the ATM services and predicting the rate of using ATMS by the customers by 2015*, Retail Banking Research, September 2010
- [7] M.Moradi, *optimizing the construction site for establishing bank branches in a certain district in one province in Iran using fuzzy logic*, 2009
- [8] N.Mousavi, "TOPGIA hybrid model for locating bank branches", 2001
- [9] H. Tavakkolian, "Statistical orders in electronic payment systems in Iran, *Journal of New findings in Economics*"
- [10] M.Rostami and J.Shaeli, "Analysis of spatial distribution of the urban utilities in Kermanshah city"
- [11] M.Talei, M.S.Mesgari and A.Sharifi, "Development of a fine spatial algorithms to evaluate accessibility level to urban services", 2008
- [12] O. A.Niknam, "the formulation of a decision making procedure for optimal locating for establishment of the insurance branch using fuzzy logic-based approach", *Insurance Industry*, Fall 2008, Number 3, pages 29 to 50

- [13] M.Majlesi and H.D.Afshan, "*locating process for predicting the optimal location for municipal waste landfill in Dezful city using GIS software (geographical information system)*", Twelfth National Conference on Environmental Health, Shahid Beheshti University, Aban, July
- [14] R.Magdi, "*Application of GIS in optimal locating process for predicting an optimal location for establishing a new hospital in Tabriz*", Third National Congress on Civil Engineering, 2007
- [15] A.Azar and A.A.Memariani, "*novel AHP technique for decision making process*", Journal of Management Knowledge, Spring 1995
- [16] S.M.Zanjiri, "*fuzzy hierarchical analytical process*", Sanei Publication, 2011
- [17] A.Alam, Tabriz, M.Zandiye and A.R.Mohammad Rahimi, "*super-initiative algorithms in combinatorial optimization*", Saffar Publication, Eshraghi, 2008
- [18] A.Alhaffa and W.Abdulal, "*A Market_Based study of optimal ATM's Deployment Strategy*", international journal of machine learning and computing, Aprill 2011
- [19] M.A.Aldajani and H.K.Alfares, "*Location of banking automatic teller machines based on convolution*", Computers&Industrial Engineering, 2009
- [20] EL Haddan, "*ATM banking behavior in Kuwait: A consumer survey*", International Journal of Bank Marketing, 2010, 232-250
- [21] Kh.AL Hashash and A.Hossain Bahzadi, "*Bank's Customer satisfaction in Kuwait: an Exploratory Study*", University Malaysia, 2008
- [22] www.CBI.ir
- [23] www.EBINews.com
- [24] www.ITNA.ir
- [25] www.HamshahriOnline.com