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Deployment of Citizen Service Centers Using Simulated Annealing Method Applied Study on Damascus the Capital City of Syria

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ABSTRACT

This study shades a light on a modern field, which is a system of E-Government, and try to find the best strategy to deploy Citizen Service Centers ”CSC” in Damascus, the capital city of Syria. The search tool designed to find the optimal solution, is a high performance algorithm based on simulated annealing. Graphical data gathered from Google Earth, and supported by information collected from Syrian agencies. Experiments have been implemented using Matlab, and the results propose a location of ”CSC” which is optimal. At the end, a comparison made between actual and proposed locations, in order to obtain valuable recommendations.

Keywords :- Citizen service Centers: CSC, Simulated Annealing Algorithm CSC-SA. Percentage Coverage: PC. Citizen Utility matrix: CU.

I. INTRODUCTION

Due to the recent population growth and technological progress, the role of governments has rapidly changed, from controlling their citizens to serving them. This change affects not only governments, citizens’ attitude toward their governments as well been affected, e.g. recent citizen needs won’t be satisfied, with government services be supplied in traditional government offices, especially in this digitalism Era. This impulse government to modify themselves to be accepted by their citizens, through proposing a new term called E-Government, which pay much attention to what citizen needs, and which is the best channel to supply public service to him. In Syria, the wave of changes from digital world, has reached. Syrian government has to adopt non-voluntarily these changes. The first real project related directly to E-Gov, was initializing Citizen Service Centers, ”CSC”, aiming more convergence with citizens, by centralize these Centers, as much as closer to citizens places. Thus, in order to efficiently manage E-Government system in Syria, the availability of an algorithm specifying the ”CSC” to a specific Locations is fundamental.

II. PROBLEM OF THE STUDY

In order to govern, Governments need to anticipate their citizens needs, respond much more rapidly to competitive changes in the world, and create new sources of modern services. Its a big challenge for any government to channelize efficiently its services in such away, to reach the whole society. The modern form of government, ”E-gov” has changed these affiliated agencies, to become an integrated service centers provide all type of government services. But, if these centers are randomly deployed, it won’t achieve the object of its constructing them. This study proposes a high performance method to theoretically deploy Citizen ”CSC”, by using simulated annealing method, and apply it in Damascus the capital city of Syria.

III. STUDY HYPOTHESES

Hypothesis I: The actual locations of Damascus’ ”CSC” are ideal, in term of citizen satisfaction, thus Citizens are satisfied from E-Gov services.

Hypothesis II: The theoretical Locations of Damascus’ ”CSC” proposed by ”CSC-SA” Algorithm, are better than reality, and well optimized in term of citizen satisfaction.

IV. STUDY ASSUMPTIONS

In order to simplify the complicated structure of the problem, and gain control over the variables and experiments, some assumptions are required to be set as follow:

1) Citizen service centers ”CSC” are homogeneous, i.e. : all centers supply identical types of services. As well as all centers have the same size and human resource capacity. In line with this, there exists only one matrix ”A”, which represents the degradation of ”CSC” utility as one moves away from its location, it is predetermined and held constant for all ”CSC”.
2) Information gathered from GIS system are adequate to generate Citizen Utility matrix ”CU”.

V. OBJECTIVES OF THE STUDY

The idea behind this study, is to find the sequence order of ”CSC”, that maximize the percentage coverage function ”PC”, using an approximation algorithm derived from the simulated annealing method. Thus all objectives are derived from this point:

1) Finding the feasibility of actual ”CSC” locations exist in Damascus.
2) Designing an effective search tool, could deploy ”CSC” optimally.
3) Mapping the actual and the theoretical locations, and extracting the inferences.
4) Determining the sufficient number of ”CSC”, to be constructed.

VI. IMPORTANCE OF THE STUDY

The theoretical importance of this study emerges from, Firstly: The volume of the problem, which covers the whole country, where the study limits it to cover the area of Damascus city. Secondly: The Complexity of the Problem: Most of Optimization Problems have high degree of complexity, an example from this study: ”Determine 19 ”CSC” locations from 228 locations in Damascus city, which achieve highest Percentage Coverage ”PC”. Thirdly: The methodology used, which combines between mathematics, computer science and economics to design an effective search tool ”CSC-SA”, which is feasible tool, could reach the optimal solution in a reasonable processing time. The applied importance of the study comes from, the simulation results reached: The solution proposes, an optimal locations of ”CSC”, ordered in a matrix, and covers Damascus area, which could be used for comparison with actual locations, or to suggest a new locations when government decides to add more. These strategies also provide greater cost efficiency by finding the optimal number of ”CSC” to be installed. and greater profitability by increasing the ”CSC” user base in order to earn much more transactions and services fees [1].

VII. STUDY METHODOLOGY

This study relies on two approaches, first: Descriptive analytical approach, which has been used to describe and critically analyze the real situation in Damascus related to the problem. Second: Mathematical approach, has been used to formulate the problem mathematically, producing: a fitness function ”PC”, Matrices: Citizen Utility matrix ”CU”, Service Utility matrix ”SU”, Location matrix ”L”, search tool: ”CSC-SA” algorithm, which has been coded by programming language, used in artificial intelligence methods.

The rest of the study is structured as follows: Section (8) indicates some important related works.. Actual distribution of Citizen Service Centers in Damascus city is presented in section (9). Simulated Annealing Method is presented in section (10). Section (11) presents Problem formulation. Section (12) presents the Algorithm used to deploy ”CSC” in Damascus City. Simulation Results is presented in section (13). Recommendations and conclusion are presented at the end.

VIII. LITERATURE REVIEW

Service location problem, first introduced by Alfred and Friedrich in 1962 [2], is a classical and well-studied problem. The goal of the study is to find optimal locations to build facilities so, that the solution of the problem can serve the consumers or clients with the least cost. Generally, the service location problem could be divided into median problem [3], covering problem [4] and [5], center problem [6], dynamic location problem [7]. All these branches are applied to many fields like fire fighting units, emergency services, healthcare location, gas marketing hubs, factory sites, supply chain network, and so on. Thus, this study could be considered, follows the same context, as it tries to centralize ”CSC” to maximize percentage coverage ”PC”.

More detailed study [8] aimed to propose an integrated municipal solid waste management network covering multiple types of wastes concurrently and utilize a location-routing problem framework. The defined problem consisted of the concurrent site selection of the locations of the systems all facilities among the candidate locations, and the determination of routes, and amount of shipments among the selected facilities, to minimize the total cost of transportation and facility establishment. As the addressed problem exhibits the non-deterministic polynomial-time hardness (NP-hardness), an adaptation of the simulated annealing algorithm is proposed in the stud. The considered problem was formulated by a mixed-integer programming. The problem involved concurrent optimization of the locations of the systems all facilities (i.e., transfer stations; recycling, treatment, non-hazardous disposal and hazardous disposal centres), and optimisation of routing wastes to and from the facilities. ”SA” algorithm as an efficient meta-heuristic method was applied to solve the problem. The experiment results, when compared with the exact solutions, obtained by mixed-integer programming, in terms of solution fitness and computing time, implied that, the employed ”SA” algorithm works effectively and efficiently, it could solve the problem within a practical computing time even for large size cases.

Study [9] coped with the facility location problem, a method based on simulated annealing and ”ZKW” algorithm are proposed in the article. The method was applied to some real cases, which aims to deploy video content server at appropriate nodes in an undirected graph to satisfy the requirements of the consumption nodes, with the least cost. Simulated annealing could easily find the optimum, with less reliance on the initial solution. ”ZKW” algorithm could find the shortest path and calculated the least cost from the server node, to consumption node quickly. The results of three kinds of cases illustrated the efficiency of study’s method, which could obtain the optimum within ”90s”. A comparison with Dijkstra and Floyd algorithms showed that, by using ”ZKW” algorithm, the method could have large iteration with limited time. Therefore, the proposed method was able to solve this video content server location problem.

The last study [10] described a solution to the Student Project Allocation ”SPA” problem based on simulated annealing ”SA”. ”SPA” was encountered at the majority of British universities. ”SPA” problem involved assigning students to projects, where each student has ranked a certain Fixed number of projects in order of preference. Each project was offered by a specific supervisor, the goal is to find an optimal matching of students to projects that takes into account: (i) the students’ preferences; (ii) the constraint that only one student can be assigned any given project; (iii) the constraint that supervisors have a variable maximum workload. The study showed that, when applied to a real dataset from a university science department, simulated annealing allowed the rapid determination of high quality solutions, to the ”SPA” problem. The solution quality is quantified by a student satisfaction metric that derives from empirical survey data. The Study approach provided high quality allocations in a matter of minutes.

This study has explored the high performance of ”SA” algorithm, used in the previous studies, thus it developed and modified it, to be appropriated to ”CSC” allocation problem.

IX. ACTUAL DISTRIBUTION OF CITIZEN SERVICE CENTERS IN DAMASCUS CITY

Citizen service Centers ”CSC” are centers, provide some or all type of government services, at the same place. When government runs such these centers, that means, it reaches an advanced level of its E-gov project. Damascus runs more than 20 ”CSC” as it is depicted in table(I) and table(II), some of them called Single Window Centers ”SWC”, but in fact, they are following same E-gov project. In this study, the number of ”CSC”, limited to the studied geographic area of Damascus, which runs 19 ”CSC”. Data for table(I) have been collected from these references [11], [12], [13], [14], [15], as well as, for data organized in table(II) which have been collected from: [16], [17], [18], [19], [20], [21], [22], [23], [24], [25].

As reported by Damascus Governorate [26], states that more than 252 thousand transactions has been carried out in the centers of citizen service since first of January 2017 till first of august 2017 . The number of citizens come to citizen services centers, approached 3000 citizen per day. The time of fulfilment the fast transaction is about 10-30 minutes, while the transactions related to real estate and external affairs certificates, take one day to be fulfilled. Some of ”CSC” provided Services, are presented below:

1) Financial Services: Utility Payment, Taxes: Tax on Capital Transfer for Vehicles.
2) Administrative Allowances: Commercial, industrial, administrative and sanitary careers.
3) Real estate services: Allowances, construction permissions, construction violation complaints. Construction violation adjustment, real estate determination, rent contracts.
4) Juridical record: No decree certificate.
5) Civilian record: Marriage, divorce, born and death data, Individual and family , unemployment certificate.
6) Transport services: Vehicles statement, property statement, mortgage release, driving certificate..etc.

TABLE I

CITIZEN SERVICE CENTERS IN DAMASCUS CITY

Symbol	Center	Num of Trans 2017	Address
CS1	Main Governorate Center	136000	Yosef Aladmah square Governorate building
CS2	Old Damascus Center	15136	Damascus old City Almotwally Avenue
CS3	Almaidan Center	14701	Bab Mosallah Cross Criminal Security Building
CS4	Alkanawat Municipality Center	11514	Alkanawat – Bab Srejah Alkanawat

			municipality
CS5	Mazeh Center	20000	Mazeh Jabal - Alfateh Mosque-Mazeh municipality
CS6	Temporary Record	15362	sabaa bahrat
CS7	Almhajreen	14592	Almhajreen-aljesr Alabyad Naseeb Albakree street
CS8	Financial Directorate hall	4747	Aljesr Alabiad Financial Directorate hall
CS9	Kafarsousah	-	Kafarsousah Cabinet Building
CS10	Damascus Traffic Branch	-	Bab Mosallah
Out of Range	Masaken Barzeh	-	Masaken Barzeh (Out of boarder)
Out of Range	Jdedah Artoaz Center	51000	Jdedah Artoaz (Out of boarder)
Out of Range	New Damascus Center	11416	Dommar Project Altaquah Mosque-
Out of Range	Dommar Albalad	7316	Dommar Albalad municipality building

TABLE II

SINGLE WINDOW CENTERS IN DAMASCUS CITY

Single Wind	Agency	Address	Services
SW1	Syrian Investment Agency	Kafarsousah Cabinet Building	Custom services Financial services Administrative allowance Job affairs Services Trade services Immigration services
SW2	Ministry of Electricity	Al Argentin street	Related Electricity Services
SW3	Ministry of Finance	Maysaloon Street	Retirement Salary Other compensations
SW4	Ministry of Finance	Abd Alrahman Aldakhel	All types of Custom transactions
SW5	Ministry of Justice	Fakhri Al Baroudi street	Issuing Civilian Individual registration
SW6	Ministry of Higher Education	Mazeh	All Educational related issues
SW7	Ministry of Higher Education	Baramkeh-Damascus university	University' students related issues
SW8	Ministry of Interior	Almarjeh	Issuing Civilian status related certificates
SW9	Ministry of tourism	Victoria-Shukri	Related tourism Services
SW10	Ministry of Transport	Bab Sharki	Issuing Electronic Driving licenses

X. SIMULATED ANNEALING METHOD

A. Definition of Simulated Annealing

Simulated Annealing is a general probabilistic search algorithm, introduced in 1983, by Cerny and Kirkpatrik in order to solve combinatorial optimization problems [27].

B. Origin of Simulated Annealing

1) Monte Carlo Scheme: Simulated Annealing technique ”SA” , has been derived from Monte Carlo ”MC” simulation scheme, that is used for finding the global minimum of a function . It is particularly useful when the function is badly behaved, e.g: Function has many local minima. ”SA” is an adaptation of the Monte Carlo simulation technique, which is used to generate arrangements ”a” of the constituents of a physical system with the correct probability ”P”, for a system of particles. Suppose one is interested in an observable ”Q” whose value depends on the particular arrangement ”a”. The average value of ”Q” is given quite generally by equation (1), Monte Carlo methods allow one to estimate ”Q”, by approximating the sum in equation above. i.e.: MC runs over all possible arrangements of the particles.

$$PC = \sum_{\alpha} (P(\alpha) Q(\alpha)) \quad (1)$$

2) Metropolis Algorithm: The acceptance criteria used in ”SA” (Seen later), has been derived from. Metropolis Algorithm, that implements a filter which ensures the only arrangement, that contribute most to the sum are sampled. This is known as importance sampling and operates via a Markov process [28].

C. Concept of Simulated Annealing

Simulated annealing: is an approach based on, concepts of mechanical statistics, and is motivated by an analogy with the behavior of the physical systems, during the cooling process. Such analogy is best illustrated in terms of physics of crystals.

The formation of a crystal begins from melted raw materials. The temperatures of this ”melted crystal” is then reduced until the its structure is ”frozen”. If the cooling process is executed quickly, some undesirable phenomena take place. In particular, some very extended roughnesses, are embedded in the structure of the crystal, and the absorbed level of energy is much higher than the one, that there would be into perfectly saturated crystal. When the formation of crystals begin, the risk of a local poor maxima is avoided by lowering the temperature very gradually, with a process called ”Accurate Annealing”. In this process the temperature comes down very slowly through a series of levels, everyone maintained enough along so as to permit the search of the crystal ”equilibrium” to that temperature. While the temperature is higher than zero climb movements are still possible. If the temperature diverges from that compatible with the energetic level of the running equilibrium, local optima can be hopefully avoided until the relatively near reaching of the fundamental state. When the temperature is, theoretically, at the absolute zero, no state transition can carry towards an higher energy state. Therefore, like in the local optimization, climb movements are forbidden and the consequence of that can be undesirable. Local and Global Maxima are well presented in study [29], figure (1), shows: up-hill moves, ones that rise the system energy, are always accepted. By contrast, down-hill moves, ones that reduce the system energy, are exponentially suppressed, being accepted with a probability ” $e^{\frac{-\triangle E}{T_k}}$ ”. This possibility for downhill movement, allows the sample to escape local maxima, in the space of solutions that it may get trapped in, provided the depth of the maxima is not much greater than ”Tk”.

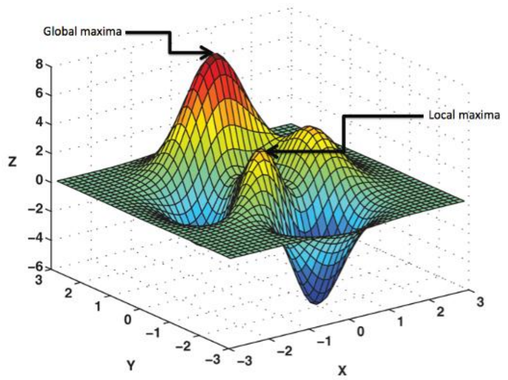

Fig. 1. Local and Global Maxima

TABLE III
THE ANALOGY BETWEEN ACCURATE AND SIMULATED ANNEALING

Physical System	**Optimization Problem**
Accurate annealing	Simulated annealing
State	Feasible solution
Energy	Percentage coverage "PC"
Fundamental state	Optimal solution
Express cooling	Local search

It is this feature of the Metropolis algorithm which is exploited by simulated annealing to increase the chance of finding the global maxima of the function. The process of express cooling, could be considered analogous to local optimization. The states of the physical system correspond to the solutions of a combinatorial optimization problem. The energy of one state corresponds to the fitness function of one solution, and the ”Minimal-Maximal” energy, or ”Fundamental State” corresponds to an optimal solution [30]. table (III) presents the analogy between Accurate and Simulated annealing [31]:

D. Basics of Simulated Annealing

1) Initialization: Theoretically, Choosing of an initial solution, does not influence the quality of the final solution, that is to say that the solution converges to the global optimum independently from the initial solution [32].

2) Acceptance Probability: Simulated Annealing algorithm does not show tendency to end up in a local minima or local maxima, that is because the new solution acceptance or rejection, is characterized by a probability function [33]. As shown in equation (2):

$$P(\triangle E) = \begin{cases} e^{\frac{-\triangle E}{T_k}} & \text{if } \triangle E < 0 \\ 1 & \text{otherwise} \end{cases} \quad (2)$$

Where: ”P(ΔE)”= Acceptance probability of new solution. ”ΔE = E(y) - E(x)” : Difference of the Fitness function between the current state and the fitness function state (temporary best stored state). ”T_k” = Current Temperature.

Acceptance Logic Once the new state solution is created, i.e the solution by perturbing the previous solution or by moving to the neighboring state configuration, the quality of the solution (Fitness function solution) will be compared with the quality of the current state solution. If the quality is better than the current state solution, i.e ” $\Delta E \geq 0$”, then the neighboring state solution is definitely accepted, probability is ”1” for such a scenario as shown in previous equation (2). If the neighbor state solution is of lesser quality, i.e ” $\Delta E < 0$” then the acceptance probability depends on ” ΔE”. The probability is inversely proportional to the magnitude of ” ΔE”. Temperature ”T” also is a control parameter, acceptance probability is directly proportional to temperature and reduces gradually with the temperature. At high temperatures the acceptance probability would be high, giving enough chance for the algorithm to accept lower quality solutions and escape from the local maxima and reach the global optimum.

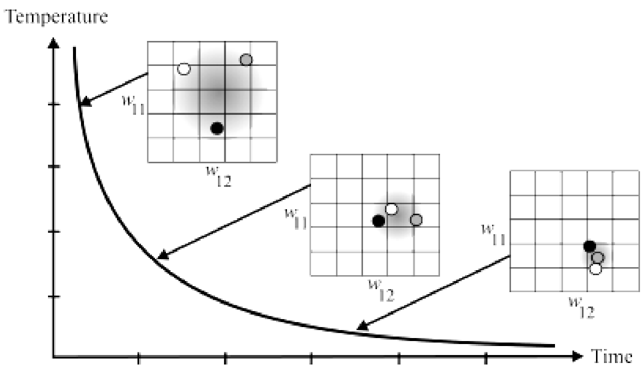

Fig. 2. Simulated Annealing Search Phases

3) Search Phases: Simulated Annealing search, has two search phases: global search phase and local search phase. Initially at higher temperatures, algorithm can explore the search space erratically, this mimics the global search phase. As the temperature is gradually reduced, the acceptance probability is gradually lowered and only good solutions are accepted making the algorithm tend towards Hill Climbing logic (local search phase) [30]. The logic of this algorithm can be visualized as shown in figure (2) [34]:

4) Cooling Schedule: Cooling schedule describes how the control parameter "T" (temperature) is reduced during the optimization. Reduction of temperature has major influence on the performance of the algorithm. The temperature will be set to initial temperature which will be greater than zero and reaches zero at the end of optimization. There exists wide range of temperature scheduling methods, some of them are reducing the temperature linearly, exponentially, or in logarithmical manner etc. This study uses the exponential scheduling method of temperature [35], equation(3):

$$T(t) = T_0 \alpha^t \quad (3)$$

Where: T(t): Actual temperature value. T0 = Initial temperature. α = Constant factor to repeatedly lower the temperature (0 < α < 1). t = Time, which is also the step count.

A. Procedures of Simulated Annealing Algorithm

The optimization steps of simulated annealing algorithm could be depicted as follows: Suppose that there is an optimization problem, which is, equation(4):

$$Max E(x) : x \in S \quad (4)$$

Where: "E(x)" is an fitness function. "S" is a finite solution space. and "x" is the current solution. The procedures of Simulated Annealing Algorithm, are as following:

1) Choose an initial solution "x P S" at random, and select an initial temperature "T0" as well as a final temperature "TF".
2) Generate a current state solution "y ϵ N(x)" , where "N(x)" is the domain structure of "x".
3) Calculate the increment of the Fitness function " ΔE= E(y) - E(x)".

TABLE IV
VARIABLE DESCRIPTION

Variable	Description
N	Total number of CSC
SU	Service Utility matrix which represents the supply side
CU	Citizen Utility matrix which represents the demand side
G	Gap or market clearance matrix.
A	Matrix that represents degradation of service utility, as a client moves away from each
L_n	Location Matrix indicates the location of the nth CSC.
(U_n,V_n)	Coordinates of the nth Kiosk.

4) If "ΔE< 0", then accept the new solution, "x=y", "E(x)=E(y)", and turn to the next step. Otherwise, generate a random number " ζ =U(0,1)".
5) According to the Metropolis criterion, if "$e^{\frac{-\triangle E}{T_k}}$ >ζ" accept the new solution, "x=y" and "E(x)=E(y)".
6) If the heat balance (the inner cycle number) larger than "n (T_k)" turn to the next step. Otherwise, go back to the second step.
7) Cool down the temperature "T_k", and "k –k+1", if "T_k<T_f ", stop the algorithm. Otherwise, go back to the second step.

XI. PROBLEM FORMULATION

CSC-SA Deployment problem is modeled and defined mathematically. The variables used in modeling of the intended problem are shown in the table(IV), The generation of previous matrices "CU", and "SU" are explained as following:

A. Citizen Utility Matrix "CU"

Any exercise to optimize the deployment of "CSC", must be started with a thorough understanding of the Citizen base, and identification of the priority of them. Based on "GIS" system, which provides free of cost, an important application, (Google Earth). Google earth is used to generate "CU" matrix, by following below procedures:

1) Map of Damascus city, has been divided to a grid of squares, each square, could be a candidate location "Lpi; jq", to construct a "CSC". Details about this procedures are presented in table (V):
2) A deep research has made, to gather information related to: The distribution of population, based on

the size of constructions in each predetermined area, Traffic system, based on number and importance of streets pass through the area, The distribution of governmental agencies, based on search tool offered by the application Google Earth, and information collected from Syrian governmental websites.

TABLE V

DAMASCUS GEOGRAPHIC DATA

Damascus map Area	High: 4.8 Km Width: 7.6 Km Area: 36.48 Km^2
Num of Squares in the grid	N in a row: 19 , N in a column: 12, Total N: 228
Square Side length and Area	Side length: 400 m Area: 0.16 Km^2

TABLE VI

GEOGRAPHIC VARIABLES SYMBOLS

Variable	**Symbol**
Population Density	PD
Traffic system	TS
N of Ministries	Min
N of Agencies	Agn
N of Communication centers	Com
N of Banks	Bnk

TABLE VII

DAMASCUS GEOGRAPHIC DATA

Ln	**PD**	**TS**	**Min**	**Agn**	**Com**	**Bnk**	**Index**	**% of Max index**
1	0	0	0	0	0	0	0	0
2	1	1	3	0	0	0	16	19
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
. . .								
106	3	4	0	0	0	0	15	18
107	2	8	0	0	0	2	28	33
108	8	8	2	4	0	0	48	57
109	9	9	0	10	8	4	84	100
. . .								
225	10	4	0	4	0	0	30	36
226	6	3	0	0	0	0	15	18
227	3	1	0	0	0	0	6	7
228	2	0	0	0	0	0	2	2

$$Cu_{i,j} = \begin{bmatrix} 0 & 12 & 21 & 5 & 0 & 1 & 6 & 0 & 6 & 12 & 24 & 30 \\ 19 & 14 & 15 & 0 & 1 & 1 & 4 & 4 & 10 & 11 & 33 & 40 \\ 0 & 4 & 4 & 4 & 4 & 1 & 0 & 6 & 8 & 26 & 33 & 46 \\ 0 & 0 & 0 & 4 & 4 & 1 & 13 & 6 & 15 & 31 & 39 & 39 \\ 0 & 0 & 0 & 4 & 4 & 1 & 7 & 17 & 43 & 27 & 11 & 0 \\ 0 & 0 & 0 & 4 & 5 & 15 & 33 & 36 & 4 & 19 & 10 & 7 \\ 0 & 0 & 0 & 14 & 7 & 5 & 45 & 27 & 30 & 5 & 2 & 6 \\ 0 & 0 & 11 & 35 & 26 & 5 & 25 & 45 & 21 & 4 & 2 & 7 \\ 0 & 4 & 17 & 23 & 24 & 44 & 30 & 29 & 33 & 38 & 20 & 24 \\ 6 & 8 & 40 & 45 & 20 & 62 & 29 & 17 & 27 & 49 & 24 & 21 \\ 12 & 14 & 32 & 86 & 42 & 18 & 35 & 42 & 27 & 35 & 32 & 15 \\ 12 & 26 & 54 & 32 & 49 & 33 & 49 & 24 & 26 & 29 & 12 & 12 \\ 27 & 49 & 40 & 67 & 86 & 57 & 37 & 24 & 35 & 29 & 23 & 11 \\ 2 & 25 & 71 & 71 & 81 & 100 & 38 & 57 & 31 & 37 & 37 & 37 \\ 8 & 23 & 39 & 42 & 43 & 54 & 15 & 17 & 25 & 26 & 23 & 24 \\ 8 & 30 & 23 & 10 & 7 & 37 & 12 & 11 & 48 & 23 & 30 & 36 \\ 26 & 33 & 25 & 30 & 7 & 29 & 17 & 17 & 19 & 35 & 29 & 18 \\ 30 & 33 & 36 & 45 & 11 & 19 & 21 & 30 & 15 & 14 & 20 & 7 \\ 38 & 60 & 27 & 36 & 17 & 19 & 33 & 24 & 14 & 8 & 14 & 2 \end{bmatrix}.$$

Fig. 3. Citizen Utility matrix $Cu_{i,j}$

$$A = \begin{bmatrix} 100/36 & 100/16 & 100/8 & 100/16 & 100/36 \\ 100/24 & 100/4 & 100/2 & 100/4 & 100/24 \\ 100/8 & 100/2 & 100 & 100/2 & 100/8 \\ 100/24 & 100/4 & 100/2 & 100/4 & 100/24 \\ 100/36 & 100/16 & 100/8 & 100/16 & 100/36 \end{bmatrix}$$

Fig. 4. Degradation of Utility matrix A

$$A = \begin{bmatrix} 50 & 70 & 50 \\ 70 & 100 & 70 \\ 50 & 70 & 50 \end{bmatrix} Convoluted \ldots with \ldots L_1 = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$CU_1 = \begin{bmatrix} 0 & 50 & 70 & 50 \\ 0 & 70 & 100 & 70 \\ 0 & 50 & 70 & 50 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Fig. 5. Simple example on Convolution

Table (VI) presents Geographic variables used in this study.

3) Data collected for previous variables, are presented briefly in table(VII).
4) Numerator: give ”2” degree to each geographical variable count.
5) Weighted grade Index ”WGI”, made to assign a relative importance according to the governmental agency level as a standard, equation(5):

$$WGI_{(i,j)} = aPD_{(i,j)} + bTS_{(i,j)} + cMin_{(i,j)} + dAgn_{(i,j)} + eCom_{(i,j)} + fBnk_{(i,j)} \quad (5)$$

Where: α =1, b=3, c=4, d=2, e=5,f=1. ”$WGI_{(i;\ j)}$” Index ranks the importance of locations in this sequence: Availability of communication centers, availability of ministries, availability of traffic system, availability of agencies, availability of banks, last rank assigned to population density. This rank is not fixed, because it represents the researcher opinion of variable importance, it may be changed by other researchers.

6) In order to calculate elements of Matrix ”$CU_{i,j}$”, the index assigns value ”100” to the highest value, then it takes other values as a ratio, equation (6):

$$cu_{(i,j)} = \frac{WGI_{(i,j)}}{MaxWGI_{(i,j)}} \times 100 \quad (6)$$

7) Generate ”$CU_{i,j}$” matrix, whose elements are ”$cu_{i,j}$”. figure(3) shows the generated matrix.

B. Service Utility Matrix ”SU”

1) Degradation of Utility matrix ”A”: Once the deployment of ”CSC” is a one off project, hence it is done once. It is essential to distribute the limited number of ”CSC” in such a way as to maximize the utility of services. In order to find Service Utility Matrix ”SU”, this study assumes that ”CSC” are homogeneous, in line with this, there exists only one matrix ”A”. Matrix ”A”: represents the degradation of ”CSC” utility as one moves away from its location) is predetermined and held constant for all machines. The rectilinear distance model is adopted as shown in figure (4).

2) Location Matrix ”L_n”: The matrix ”L_n” indicates the location of the nth ”CSC”. If this location is denoted by the coordinates (u_n,v_n), then all elements of ”L_n” are equal to zero except for coordinates (u_n,v_n) where they are equal to one as in the equation (7). Many ”L_n” matrices are generated by ”CSC-SA” algorithm, each”L_n” is a trial solution. The optimal solution is ”L_n” which maximize the fitness function ”PC”.

$$L_n = \begin{cases} 1 & \text{at } (u_n, v_n); \\ 0 & \text{elsewhere.} \end{cases} \quad (7)$$

The matrix ”SU” can be obtained from the convolving of two matrices ”A” and ”L_n”. The objective of the convolution here, is to surround the unique non-zero elements in ”L_n” with the service pattern matrix ”A”. Therefore, the convolution operation in this case can be performed very efficiently by simply centering the elements of the ”A” matrix at ”(u_n,v_n)”. For sake of more illustration, figure (5), explain the convolution process.

C. Gap Matrix ”G”

The optimization problem is organized in such a way, to realize market clearance, where there is no gap between supply and demand. In other words, the difference between Citizen Utility matrix ”CU” and Service Utility matrix ”SU” should be minimized. This difference can be expressed mathematically in equation (8):

$$G = SU - CU \geq \varnothing \quad (8)$$

Where ”G”: the Gap matrix of size (I×J) after assigning total number of ”CSC”, ”SU”: the Service Utility matrix of all ”CSC”, ”CU” : Citizen Utility matrix for the hall city of Damascus, $\varnothing$: the zeros matrix.

D. Fitness Function

This study aims to maximize citizen satisfaction by covering his demand, and the service utility should be maximized through effective deployment of ”CSC”, this will save the cost of providing additional ”CSC”. So this study defines the energy in terms of the Fitness function, equation (9) and (10):

$$PC = \frac{\sum_{i=1}^{I}\sum_{j=1}^{J}(\psi \times 100)}{I * J} \quad (9)$$

where ”ψ” is given in equation(10):

$$\psi = \begin{cases} 1 & \text{if } E(i,j) \geqslant 0 \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

where: ”PC”: is the Percentage Coverage computed as ratio of ” ψ”. (” ψ” equals to one in all points in gap matrix ”G” that have ”SU” greater than ”CU”) divided by the number of elements in ”G”.

XII. SIMULATED ANNEALING ALGORITHM FOR DEPLOYING CITIZEN SERVICE CENTERS IN DAMASCUS CITY ”CSC-SA”

In order to solve the problem of deploying ”CSC”, a simulated annealing algorithm has been modified and named ”CSC-SA”. The following topics describes that. Generic choices have been made for implementation of ”CSC-SA”:

1) Temperature schedule: The initial value of the temperature parameter ”T”, is chosen to be ”1000”. A temperature function, ”T_n”, is used to determine how the temperature will be lowered at each iteration over the course of the algorithm. It has a major impact on convergence rate and solution quality. On one hand, if the temperature is decreased quickly, then the algorithm converges fast, but final solutions will tend to get worse. On the other hand, slow cooling will make the algorithm slow but give better results. For this, slow cooling option has been chosen in this study, in order to obtain good solutions, the used rule is the geometric one as in equation (11):

$$T_{(n+1)} = \alpha \times T_n \quad (11)$$

Where: α = 0.99.

2) The number of iterations, ”NT ”: to be performed at each temperature, is taken to be ”100”.

3) Stopping criterion: ”CSC-SA” algorithm will be terminated after ”$(I \times J)^m$” iterations.

4) Acceptance criterion: The algorithm works iteratively keeping a single tentative solution at any time. In every iteration, a new solution is generated from the previous one, and either replaces it or not, depending on an acceptance criterion. The acceptance criterion works as follows: both the old and the new solutions have an associated quality value, determined by a fitness function ”PC”, if the new solution is better than the old one, then it will replace it. If it is worse, it replaces it with probability ”P”, given in equation (12).

$$P = e^{\frac{-\triangle PC}{T_k}} \quad (12)$$

This probability depends on, the difference between their quality values and a control parameter ”T”. This acceptance criterion provides a way of escaping from local minima. ”CSC-SA” algorithm is described in Algorithm(1).

Algorithm 1 Simulated Annealing

Choose an initial chromosome $s \in S$ randomly
$i = 0$, $s^* = s$, $T_{initial} = 1000$, $best = pc(s)$
$t_i = T_{initial}$, $T_{stop} = 10$
repeat
  Generate randomly a chromosome $s^+ \in Neighbor(s)$
  if pc(s^+) > best **then**
    s^*=s^+
    best =pc(s^*)
  end if
  if random[0,1] < exp($\frac{pc(s^+)-pc(s)}{t_i}$) **then**
    $s = s^+$
  end if
  t_{i+1}=$t_i \times 0.95$;
until stop criterion ($t_{i+1} = T_{stop}$);

$$L_n = \begin{bmatrix} 0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&1&0&0&0 \\ 0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&0&0&0&1&0&0&1&0&0 \\ 0&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&0&1&0&0&0&0&0&0&0 \\ 0&0&0&0&0&0&0&1&0&0&0&0 \\ 0&0&0&0&0&0&0&0&0&0&1&0 \\ 0&0&1&0&0&1&0&0&0&0&0&0 \\ 0&0&0&0&0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&1&0&0&0&0&0&0 \\ 0&0&1&0&1&0&0&0&1&0&0&0 \\ 0&0&0&0&0&0&0&0&0&0&0&1 \\ 0&0&0&0&0&0&0&0&0&0&0&0 \\ 1&0&0&0&0&0&0&0&0&0&0&0 \\ 0&0&0&1&0&0&1&0&0&1&0&0 \end{bmatrix}.$$

Fig. 6. Theoretical Location Matrix of CSC proposed by CSC-SA

TABLE VIII
ADDING METHOD

N	20	21	22	23	24	25	26
PC_o	89.47	92.13	95.61	96.49	98.25	98.68	99.56

5) Adding Method : ”CSC-SA” algorithm is designed in such away, to generate an optimal solution with a predetermined number of ”CSC”. This study uses the same number of ”CSC” which exist in Damascus. But if this number is not sufficient to cover the demand on E-gov services provided in ”CSC”, Adding method could be suggested. The Counter starts with actual number of constructed ”CSC”, then adding more ”CSC” until ”PC” approaches ”100”, i.e. acceptable range of optimal ”PC ϵ [99-100]”, which is the terminal condition.

XIII. SIMULATION RESULTS

This section shows the experiments, that have been carried out in order to evaluate the proposed algorithm ”CSC-SA”, which are simulated in an operating environment given as follows:

CPU: Intel(R) Corei3 (M380) @ 2.53GHz; Memory: 4.00GB; Operation System: Windows 7, Ultimate, 32Bit; Compiler: Matlab

The calculation of the percentage coverage ”PC”, for ”CSC” actual location matrix ”Lr”, produces:

N = 19 and PC_r = 46.34

Simulation results shows, the actual deployment of ”CSC” in Damascus City, produces a weak percentage coverage ”PC”, thus, first hypotheses states that: *”The actual locations of Damascus’ ”CSC” are ideal, in term of citizen satisfaction, thus Citizens are satisfied from E-Gov services”,* should be refused. That means, there is a shortage of Citizen Service Centers ”CSC” in Damascus City, or the distribution of these centers is not ideal.

By Redeploying the same number of constructed ”CSC” in Damascus, which is ”N = 19”, ”CSC-SA” algorithm achieved this solution, which can be considered optimal, because of high Fitness function value ”PC”. Figure (6).

For a fixed and predetermined number of ”CSC”, equal to actual one, ”CSC-SA” algorithm achieve the highest ”PC” it could be: ”$PC_{Optimal}$= 88.16” . By comparing it with actual one ”PC_{real}=46.34”, it is obvious the great enhancement in this ratio, that leads to accept the second hypothesis states that: *”The theoretical Locations of Damascus’ ”CSC” proposed by ”CSC-SA” Algorithm, are better than reality, and well optimized in term of citizen satisfaction”.*

Using Adding method to find the optimal number of ”CSC”, which cover the demand, and satisfy market clearance condition ”PC ϵ [99-100]”. Table (VIII) describe this method.

From table (VIII), an important inference could be derived, that is: Damascus needs to construct seven more ”CSC”, in order to satisfy its citizen from E-Gov services. Lastly, all data collected for geographic variables, ”CSC” distribution in reality and Theoretical location proposed for ”CSC” by ”CSC-SA” Algorithm, are pointed in figure(7).

XIV. RECOMMENDATIONS

Based on study results, some recommendations are presented to be helpful tools to decision maker:

1) Syrian government should conduct a sufficient investigations before construct an additional ”CSC”, taking in account geographic and economic considerations.
2) All ”CSC” should be at the same level of development, i.e. they should employ a sufficient number of qualified servants, and supply a same set of services.
3) Syrian governmental agencies at all levels, should automate their processes, and collaborate with each other, in order to reach the same level of E-Readiness, and provide its services through ”CSC”. If that happened, one could say that, Syria pass a long way in its E-Gov project and reach the level of horizontal integration.
4) A diffusion of sufficient number of ”CSC” should be taken, in other Syrian cities.

XV. CONCLUSION

This study shaded a light on a problem of distribution Citizen service Centers ”CSC” in Damascus, the capital city of Syria. For that, tries made to design an effective search tool, using one method of artificial intelligence called Simulated Annealing ”CSC-SA”, this algorithm was found to be scalable, highly effective and feasible. The experimental results have demonstrated. First: The misallocation of actual constructed ”CSC”. Second: the optimal deployment strategy to redistribute the actual ”CSC”. Lastly, The feasibility of ”CSC-SA” to work with, ”CSC” deployment problem by using Adding method, to determine the best number of ”CSC” to be constructed in Damascus. One possible direction of the future work would be, the consideration of both demand side represented by citizens’ utility from ”CSC” service, and supply side represented by the cost of providing this service, in order to find an optimization model, takes into account, all possible considerations.

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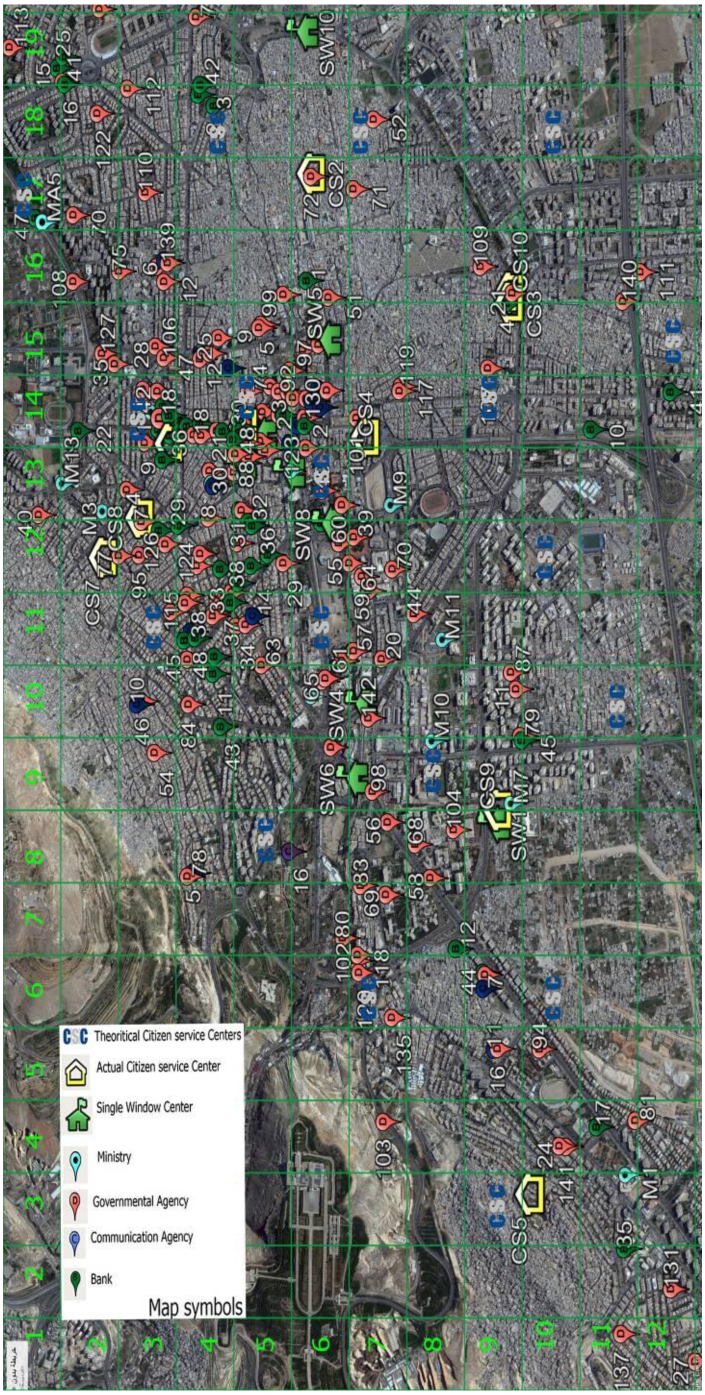

Fig. 7. Damascus Map