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Location-Allocation process for Network Analysis for Geographical Information System

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Abstract: Most of the infrastructures planning problems like facility location, allocation of resources, and path planning are based on the network topology created from maps with spatial and non-spatial attributes. The problem is where do you locate new facilities? In this example, the facility can be on any node i.e. at any road junction. It is also possible to locate a facility in the middle of the road segment but for the sake of simplicity in the optimizing process, the facilities are normally located at the roads. They can be then moved over the connected arcs for more refined facility location. However the optimization remains valid whether the location is made on node or on arc. The main areas of its application will be in planning of infrastructure at district level, state level, and province level. Some practical areas where this has good use are in location of facilities like hospital, health centers, schools etc. in an optimum way. The allocation of the facilities to the demand points is another infrastructure requirement, which has lot of potential uses. For example assigning certain facilities like schools to an area where there is certain demand based on certain constraints is the process of allocation. In real world scenario, there are numerous such applications where these types of software tools are very essential. In this research paper, a method is presenting to develop the location-allocation process for network analysis in Geographical Information System (GIS).

Keywords: Layered based approach, Location and Allocation processes, Global Regional Interchange Algorithm (GRIA).

I. INTRODUCTION

The method has been developed and implemented for placing facilities in infrastructures planning. In practical applications each location problem varies from the other. The constraints of location norms, demand and facility constraints vary a lot. So it is proposed to have a generic method to solve such problems as far as possible. So we have developed a generalized model, which can be used for most of the applications by properly mapping the physical entities to that of the model (network entities).

The process of location is done as under.

a) Place the facilities on one of the possible combination of candidate sites,
b) Allocate the demand nodes
c) Compute the total cost of travel (impedance) from all demand nodes to their respective facilities
d) Repeat the process till you complete all the possible combinations.
e) Result is the best combination, which gives the minimum cost.

Though the above problem looks to be simple, for practical applications, the complexity of the problem exponentially increases with the demand and facility nodes. It is impractical to solve the problem for all possible combinations on a computer within reasonable time. Several location algorithms have been developed successfully to solve this problem within reasonable time and get results to reasonable accuracy. One method is to judiciously reduce the possible candidates by taking all the constraints into consideration.

. Keeping in mind the above-mentioned requirement, we have been engaged in a number of activities involving study of GIS by using practical and theoretical analysis. Efforts have been made to understand the problem, and develop the corresponding high-level modules in Visual C++ version 6.0 tools and libraries

II. APPROACH FOR LOCATION AND ALLOCATION:

A. *Global Regional Interchange Algorithm:*

The GRIA is divided into two parts

(1) The global interchange set (2) The regional interchange set

Together these comprise a subset of all possible pair-wise interchanges that, when examined iteratively, will find a solution for which no pair-wise interchange will improve the objective function. The size of this subset of interchanges, as a proportion of all possible interchanges, varies with the size characteristics of problems.

The Global Exchange:

Global Exchange is done by using drop and add algorithm.

This process is as follows

- Find the best site to drop from the current solution and
- Second, identify the best substitute candidate.

By using single iterations of drop-and-add algorithms in combination, we can identify such substitutions very efficiently. To identify the site to drop, p candidates (the facility locations) are evaluated; this is equivalent to using the drop algorithm on the p sites in the solution.

The Regional Exchange:

The alternating algorithm to reduce the combinatorial search space of the problem uses the first and second properties of a solution to the p-median problem.

- The first step of this algorithm allocates each demand location to its closest facility and
- The second step relocates the facility at the medians of their service areas.

The alternating algorithm is used to ensure that all facilities are local medians for the demand points allocated to them and that all demand points are allocated to their closest facility. The location exchange accomplished at this stage is called the regional exchange

Algorithm for GRIA

Step 1: Select p candidates to be initial configuration of facility sited (the current solution) and calculate the value of the objective function.

Step 2:. For the global exchange subset,

a) Examine all the facilities in the current solution to determine which would least increase the objective function if it is removed (the “drop” sub step);
b) Substitute the (m-p) candidates not in the current solution for the candidate identified in (a) to determine which, if added to the current solution, will decrease the value of the objective function (the “add” sub step); and
c) If the decrease in the objective function for the candidate location identified in (b) is larger than the increase in the objective function for the facility identified in (a), swap the two locations, update the value of the objective function, and return to (a); otherwise go to step 3.

Step 3: For the regional exchange subset, for each facility in turn;

a) It the facility is not a fixed site, substitute it for all the candidate in its local service area;
b) Make the swap, if any, that will most reduce the value of the objective function. Repeat this step until P-1 facilities have been examined and no swaps have been made.

Step 4: If a pair of global and regional subsets has not resulted in a swap, stop.

The only pair-wise exchanges that may lead to an improvement in the objective function belong to the global or regional subsets.

III. FLOW CHART FOR GLOBAL REGIONAL INTERCHANGE HEURISTICS ALGORITHM

A flow chart of the location allocation program is given in figure 2.1. The first step is to read the initial solution. The allocation table is built by entering the identifiers of the closest and second closest facilities to each demand location, and their associated weighted distances, into the first four rows of the table. The initial value of the objective function is calculated by summing the second row of the allocation table (i.e., the weighted distances to the facility for each demand location).

Global Exchange Subset - The global exchange subset begins by deciding which facility location to remove from the current solution followed by following steps:

a. For every column of the allocation table, the difference between the weighted distances to the closest and second-closest facilities is calculated- this difference is the effect on the objective function of removing the closest facility.
b. This sum of these changes is calculated for each facility; the one with the smallest sum should be removed from the current solution.
c. The swapped step of the global exchange is to determine which candidate should be swapped for this facility site.
d. The candidate strings of the (m-p) candidate string not in the current solution are read into the fifth and six rows of the allocation table in turn.
e. After all these substitution have been evaluated, the best is selected, the facility location is moved to the candidate, and the allocation table is updated using both candidate and demand strings.
f. If this is not the first iteration, a check for termination is made: has a swap been made in either this global exchange subset or the last regional exchange subset? If no swap has been made, the process is terminated.

Regional Exchange Subset - The regional exchange subset involves moving each facility to the weighted spatial median of its service area, if it is not already there. The following sequence of steps is carried out for all facilities in turn, except the one identified in the global exchange and any fixed facilities.

a. First, the facility location’s demand string is read to find the list of candidates that can serve this facility location.
b. Then each of these candidates, in turn, is checked to verify that it is currently served by this facility. Examining the closest facility identifier in the allocation table does this.
c. If a candidate is served, its candidate string is read into the allocation table and the difference in the objective function for the substitution is calculated and recorded.
d. When all the candidates in the demand string that are served have been substituted, a check is made to see if any of the substitutions decreases the objective function. If so, the largest is found, the swap is made, and the allocation table is updated. Finally, a check for termination is made. If a swap has been made in either this regional exchange subset or the last global exchange subset, another global exchange subset is started; otherwise, the process is terminated.

IV. RESULTS

The location process is done for placing new facilities, for location the demand layer, which has demand table, candidate layer and number of facilities to be placed selecting demand, candidate layer and number of facilities for location. A location result is shown in figure 1 as a point layer for each facility and its demand nodes.

The results from the location-Allocation method (Exchange algorithm for location/allocation [1]) are shown blow for the Location-Allocation of facilities and demand nodes.

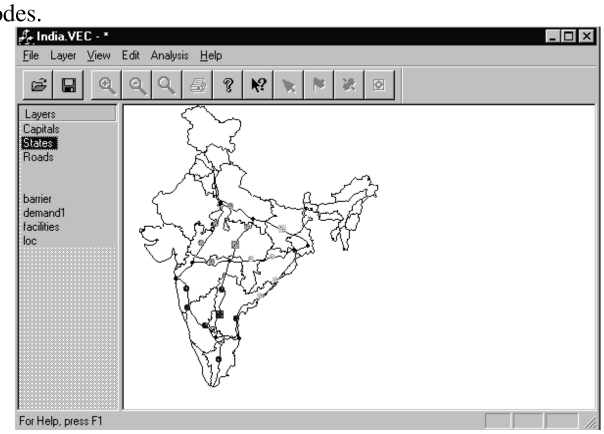

Figure1. shows the results of location process.

The process of assigning the demand nodes to the facility nodes is called allocation. In allocation process the facilities are fixed and known. The demand layer and facility layer is added through dialog box. Allocation result is shown below as a point layer for each facility and its demand nodes.

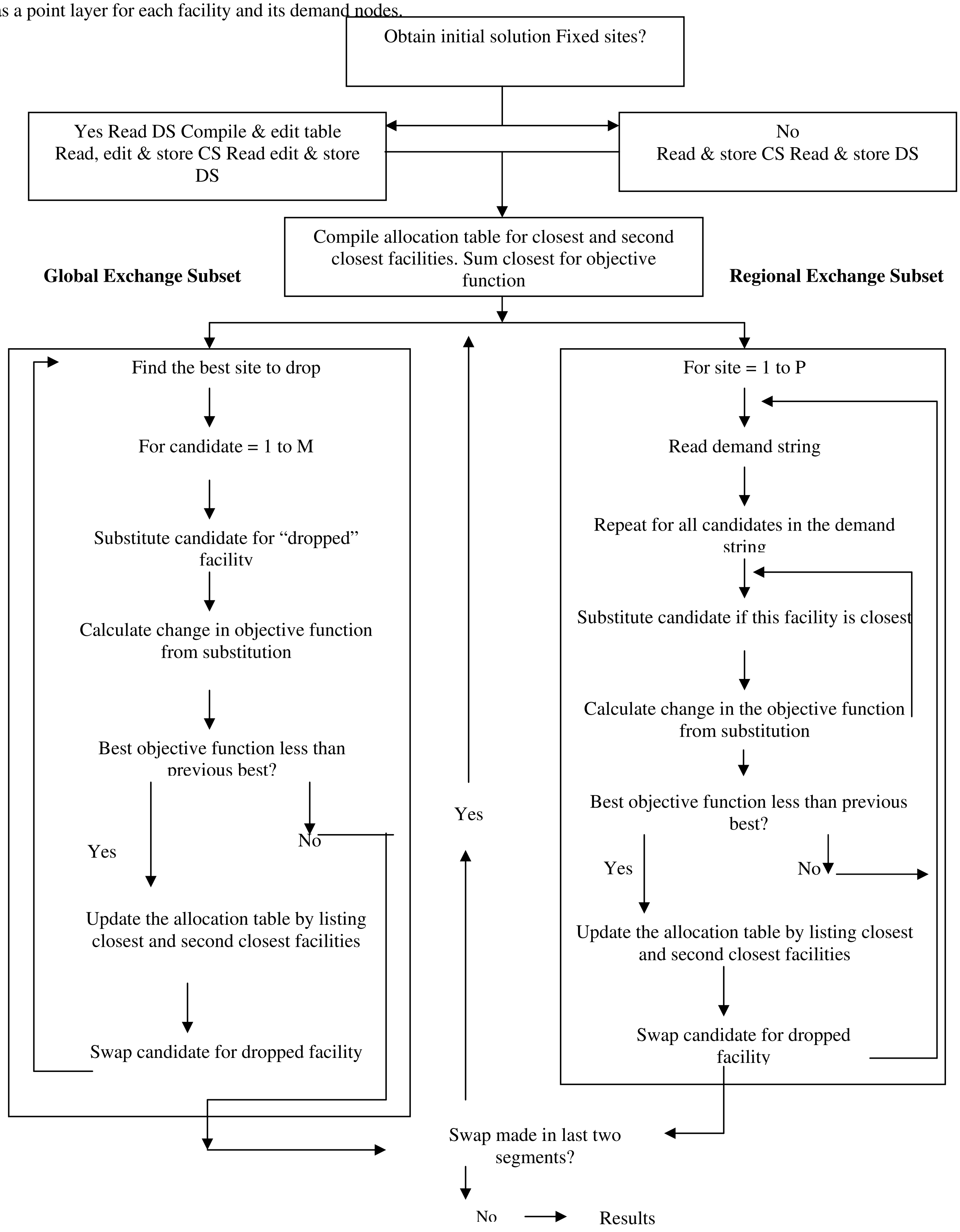

Figure 2 Flow Chart for the Global/Regional Interchange Algorithm

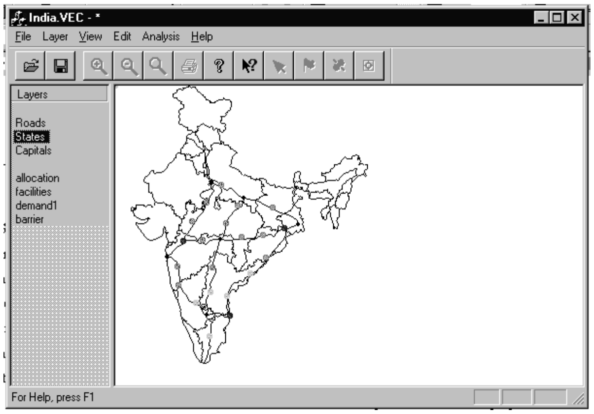

Figure 3 Output of a allocation process

The results of the location and Allocation by using from the GRIA algorithm are:

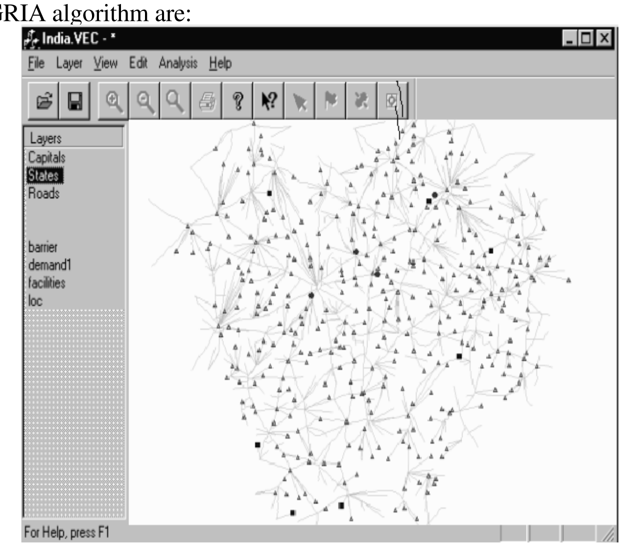

Figure 4 shows the results of location process

The Figure 5 shows the results of allocation process.

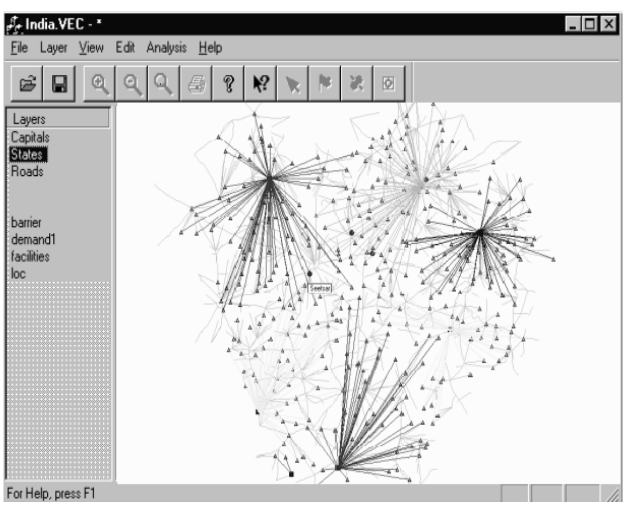

Figure 5 Output of a allocation process

V. CONCLUSION:

The infrastructure of the modern world forms the network like structure. Most of the infrastructures planning problems like facility location, allocation of resources, and path planning are based on such network topology created from maps with spatial and non-spatial attributes. The main areas of its application will be in planning of infrastructure at district level, state level, and province level. Some practical areas where this has good use are in location of facilities like hospital, health centers, schools etc. in an optimum way. Similarly to find the optimal route from one place to another place is another example. In real world scenario, there are numerous such applications where these types of software tools are very essential. As process is a complex optimization problem and computationally intensive. We are focusing here on some applications for rural planning rather than urban planning. In this research paper instead of using the Exchange algorithm for location-allocation [1], we used the GRIA algorithm. As seen from the results of both the algorithms (Exchange algorithm for location/allocation [1] and GRIA algorithm), the results are more accurate of GRIA algorithm than the other method.

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