

Short Commucation

Characterization of Model on Zoning Process

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ABSTRACT

This paper represents the process by which a network is partitioned into smaller network each of which further delegated with a smaller network with a certain degree of autonomy in terms of resource allocation and operation. The term “Autonomy” implies that once the guiding policy is articulated and the resource allocation is decided upon, local management may enjoy some freedom in local, short-term decisions such as dispatching repositioning, budget planning and manning. The implications of zoning prevail over a long period, once a wide network is partitioned into sub network, each sub network will likely be treated as almost an independent network in terms of its “rights” to possess and to operate resources.

Keywords: Autonomy, delegated, network, partition, resources

ARTICLE INFO

Article history:

Received: 3 May 2018

Accepted: 21 June 2019

Published: 21 October 2019

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INTRODUCTION

One major advantage of zoning is that it facilitates the modeling and the solving of the local network policy problems. In most cases it consumes less time and effort than an attempt to use a global model. In the context of providing services, particularly in the public sector, the concept of equity asserts that the entire population of potential clients be treated as equally as possible in terms of the quality of service they get. Apply the equity criterion to a service network implies that the performance measures by which

the quality of service is evaluated be more or less equal in each sub zone (Ayeni, 1976). Practical realization of this criterion could be accomplished by partitioning the network into sub network that are more or less equal in the proportion of demand they generate. The sample network G exhibited in Figure 1.

Network G consists of 9 nodes and 16 links. The nodes have been numbered arbitrarily from 1 to 9. The Figure 1 near the links designates the length of the links. We will denote them $l(i, j)$, where i and j are node numbers. The fractions near the nodes indicate the proportions of the total demand generated in the particular nodes. These are denoted by $P_j, j = 1, \dots, 9$. Note that $\sum_{j=1}^9 P_j = 1$. We will certainly not recommend that node 2 and 9 constitute G while all the rest of the nodes are assigned to G since such partitioning will load 81% of the total demand G. Rather; we will try to mark nodes such that their accumulated demand will be close to 50%.

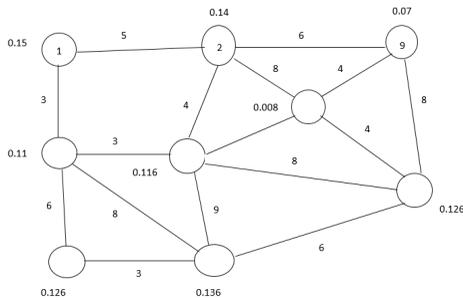


Figure 1. A sample network G

Contiguity

A basic principle in zoning is contiguity. A sub network is contiguous if it is possible to travel from every node in the sub network to every other node in it without crossing another sub network. In other words, there should be at least one path between any two nodes of a sub network such that a server is able to travel between the two nodes on that path without having to go through another sub network

(Dutta & Kumar, 2015). This is not to say that this path is necessarily the shortest one. It may very well be that the shortest path (Beckman, 1981) will be across another network, but there is at least one more path that is under the sovereignty of the said network, therefore contiguity is satisfied. The major reason is that it allows the sub network management to move its servers along the network without having to get permission or to coordinate the move with foreign authorities. Thus, dispatching, patrolling, and repositioning policies can be devised independently. One possible way to contiguity is by constructing a square matrix whose elements are binary, namely, zero or ones (Table 1). The rows and the columns correspond to the nodes of the network.

Compactness

An intuitive interpretation of the notion compactness is that the edges of a zone are not too remote from each other. In partitioning a planar area (rather than a network) compactness can be measured by any of three measurements:

- (a) Resemblance of the zone to a square.
- (b) Resemblance of the zone to a circle.
- (c) Reasonable” distance of the population from the center of the zone.

In network partitioning, managements related to a planar area topology do not adhere to the notion of a network.

A certain degree of proximity is maintained among the nodes of a zone. This can be obtained by imposing a length constraint on the shortest distance between any two nodes (Berman & Odoni, 1982) that are considered candidates for belonging to the same zone. Table 2 displays the shortest distance between any two nodes of network G. Based on Table 2 we can impose an arbitrary length beyond which two nodes cannot be part of the same zone. Suppose the arbitrary limit is 10. In Figure 1 we mark by 1 all the element in Table 2 that are less than or equal to 10, and by 0 all the elements that are greater than 10. Figure 1 constraints the zoning decision, namely, upon examining a node that is a candidate to be selected to a certain zone, we will observe with the compactness criterion. Such a table is called an exclusion matrix. The values of its element depend, of course, on the arbitrary value of the length constraint.

Table 1

A contiguity matrix

Node \ Node	1	2	3	4	5	6	7	8	9
1	-	1	0	0	0	0	0	0	0
2	1	-	0	1	1	0	0	0	1
3	1	0	-	1	0	1	1	0	0
4	0	1	1	-	1	0	1	1	0
5	0	1	0	1	-	0	0	1	1
6	0	0	1	0	0	-	1	0	0
7	0	0	1	1	0	1	-	1	0
8	0	0	0	1	1	0	1	-	1
9	0	1	0	0	1	0	0	0	-

Table 2

Shortest distance in G

From	To								
	1	2	3	4	5	6	7	8	9
1	0	5	3	6	10	9	11	14	11
2	5	0	7	4	8	13	13	12	6
3	3	7	0	3	7	6	8	11	11
4	6	4	3	0	4	9	9	8	8
5	10	8	7	4	0	13	10	4	4
6	9	13	6	9	13	0	3	9	17
7	11	13	8	9	10	3	0	6	14
8	14	12	11	8	4	9	6	0	8
9	11	6	11	8	4	17	14	8	0

Enclaves

During the process of zoning we have to make sure that we do not create enclave (Sarkar et al., 2015). An enclave is a node, or a subset of nodes that cannot constitute an independent zone because of the equity criterion. On the other hand, the node cannot be connected to other “free” nodes for no contiguity reasons. Thus, they might remain “Orphans” if the zoning process proceeds without being interrupted.

ADDITIONAL CRITERIA

There could be some additional terms that a network planner would be required to accede to under certain circumstances. Take for instance administrative boundaries. Another criterion is related to the characteristics of the region being partitioned. It is therefore recommended to account for the characteristics (Conway et al., 1996) of the region before a “mechanical” zoning process is executed. When these or similar criteria are being examined, one has to distinguish between mandatory requirements and optimal requirement. A mandatory requirement possesses a constraint that must be followed. In a way, a mandatory requirement can sometimes facilitate the computational complexity of a zoning algorithm because it usually splits the problem into a number of smaller problems, each of which can handled more easily. An optional requirement is unlikely to facilitate the solving process-it is more likely to complicate it (Mishra & Tripathy, 2012). The planner has to solve the constrained model as well as the unconstrained one in order to provide the decision maker with the “cost” of the additional requirement, cost in this respect is a decrease in performance. Nonetheless, with the fast advance of computing technology, running an algorithm for a number of times under varied constraints is usually not infeasible. We turn now to introducing a zoning selection algorithm.

An Algorithm for Zoning Selection

Zoning selection process has been applied mostly for area districting. An elaborate algorithm for such cases was provided by Garfinkel and Nemhauser (1970). When network zoning is considered, however, some of the guiding criteria have to be modified (Eilon et al., 1971). For the notion of compactness is expressed in distance measurement rather than in area topology, the notion of contiguity is expressed by connectivity of nodes rather than by having common borders.

Let us try to partition network G into four zones. We impose the following constraints:

- (a) Equity: The ‘ideal’ demand generated in each zone would be 25% however, we allow for 2.5% deviation, namely, an acceptable zone may generate demand ranging from 22.5% to 27.5% of the total demand.
- (b) Contiguity: Contiguity must be maintained for each zone.

Compactness

The shortest distance between any two nodes in a zone should not exceed 10 units of time. Here enclaves must be avoided during the application of the algorithm. Suppose these are the only restrictions imposed on the zoning process. The partitioning process consists of two major phases (EI-Shaieb, 1973). Phase I, determines all the possible zones that comply with the requirement listed above. Since this phase identifies all the possible zones, upon completion of Phase I, we may very well face redundancy in node coverage, that is, a certain node might belong to more than one candidate zone. Phase II, given the required number of zones, determines the node partitioning according to a suitable objective function (Hallpern & Maimon, 2011). It therefore eliminates some of the possible zones in order to obtain not only an exhaustive but also a mutually exclusive partitioning. The way Phase I works is by selecting an arbitrary node and trying to form all the feasible zones that include that node while watching not to violate any constraint.

The nodes are selected in an ascending order according to their arbitrary numbers from 1 to 9. In this manner we make sure that nodes are not being overlooked; also, when a certain node is selected, the process has to examine only subsequent nodes (in terms of their serial numbers) because it is guaranteed that preceding nodes have been examined previously (Garfinkel and Nemhauser, 1970). Let us start, then, with node 1. It is linked to node 2, together they accumulate 27% of the total demand. They do not violate compactness, nor do they enclave any node, thus {1, 2} constitute a feasible zone (Hall, 2009). We cannot add any more node [1, 2} since any additional node that is linked either to 1 or to 2 will push the demand beyond the tolerated limit, which is 27.5%. By similar arguments, nodes {1, 3} form a feasible zone that cannot be further augmented. Let us turn now to node 2. We do not have to examine the combination of 2 and 1 because this has already been covered. New feasible zones are, therefore, {2, 4} and {2, 5, 9}.

Table 3 summarizes (Goldman, 1971) the final results of phase I, the set of feasible zones. In column (a) we have numbered the zone and column (b) designates the number of the zone and column (c) displays the total demand of a zone. And column (d) calculates the amount of deviation of the demand relative to maximum tolerated deviation (2.5%).

$$\frac{|29 - 25.2|}{2.5} = \frac{3.8}{2.5} = 1.52$$

Column (e) displays the largest shortest distance, namely, the shortest distance between the most remote nodes within a zone. The table is divided into sections. Each section is associated with another “root node”, namely, a node from the search for feasible zones begins. The “root node” determines the section number in column (f).

Table 3

List of feasible zones

Zone No.(a)	Nodes (b)	Demand(%),(c)	Relative deviation (d)	Largest shortest distance (e)	Section list (f)
1	1,2	29	0.8	5	1
2	1,3	26	0.4	3	-
3	2,4	25.6	0.2	4	2
4	2,5,9	29	0.4	8	-
5	3,6	23.6	1.0	6	3
6	4,5,9	26.6	0.2	8	4
7	4,7	25.2	00	9	-
8	4,8	24.2	0.4	8	-
9	5,8,9	27.6	0.2	8	5
10	6,7	26.2	0.4	3	6
11	7,8	26.2	0.4	6	7

CONCLUSION

Eventually, both optimizations of equity and compactness have provided the same partitioning. This, however, is not necessarily the case a more complex problem is encountered. Generally speaking, by comparing the results of a number of optimization processes, one can learn the “price” paid in one criterion in order to optimize another one. The zoning process that is presented above was performed mainly by observation.

ACKNOWLEDGEMENT

The authors would like to thank the anonymous reviewers for their critical comments and valuable suggestions. The general and the technical remarks of the editor and reviewers were of great help for improving the quality and presentation of the paper.

REFERENCES

- Ayeni, M. A. O. (1976). A predictive model of urban stock and activity: 2. Empirical development. *Environment and Planning A*, 8(1), 59-77.
- Beckman, M. J. (1981). Continuous Model of transportation and location. *International Journal of Network System*, 4(5), 619-630.
- Berman, O., & Odoni, A. R. (1982). Locating mobile servers on a network with Markovian properties. *Networks*, 12(1), 73-86.

- Conway, R. W., Maxwell, W. O., & Miller, L.W. (1996). Theory of scheduling. *International Journal of Network System*, 4(5), 312-325.
- Dutta, D., & Kumar, P. (2015). A partial backlogging inventory model for deteriorating items with time varying demand and holding cost. *International Journal of Mathematics in Operational Research*, 7(3), 281-296.
- Eilon, S., Watson-Gandy, C. D. T., & Christofides, N. (1971). *Distribution Management: Mathematical Modeling and Practical analysis*. London: Griffin.
- El-Shaieb, A. M. (1973). A new algorithm for locating sources among destinations. *Management Science*, 20(2), 221-231.
- Garfinkel, R. S., & Nemhauser, G. L. (1970). Optimal political districting by implicit enumeration techniques. *Management Science* 16(8), 495- 508.
- Goldman, A. J. (1971). Optimal centre location in simple networks. *Transportation Science*, 5(2), 212-221.
- Hall, R. W. (2009). Direct versus Terminal Freight routing on a network with concave costs. *International Journal of Network System*, 4(5), 287- 298.
- Hallpern, J., & Maimon, O. (2011). Algorithms for the m-centre problems a survey. *European Journal of Operation Research*, 10(3), 195-203.
- Mishra, U., & Tripathy, C. K. (2012). An EOQ model for time dependent Weibull deterioration with linear demand and shortages. *Scientific Journal of Logistics*, 8(2), 123-136.
- Sarkar, B., Saren, S., & Cardenas-Barron, L. E. (2015). An inventory model with trade credit policy and variable deterioration for fixed lifetime products. *Annals of Operations Research*, 229(1), 677-702.

