Design Methods of Network Cabling With Concentrators

Lukyanov Victor Sergeevich ,PhD[1]   **Al-hadsha Fares Ali Hussein[2]**

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[1] **Computers and Computer Systems department, College of Electronics and Computer Science, Volgograd State Technical University-Russia E-Mail: lukvs@mail.ru**

[2] **Computers and Computer Systems department, College of Electronics and Computer Science , Volgograd State Technical University-Russia, E-Mail: alhadsha@mail.ru**

Abstract

In connection with mass distribution of grid computing systems a problem of efficient usage of them became very urgent. One of these problems is constructing network topology. Construction must be done in a way that reduces the expense of materials required. This problem has been handling in many papers. A construction of hierarchical networks with concentrators which perform a multiplexing of different subscribers with a bulk of them is being under consideration in this article. Here we deal with concentrators' method (addition and deletion algorithms) and hierarchical method. We demonstrate a new automated tool for designing network topology.

Keywords: network topology, network construction, hierarchical method, concentrators' method.

Introduction

A problem of communication networks topological design with an aim of reducing total cost of the network has been handling in many papers. At the beginning of 60`s of the past century A.Prim suggested a method of designing a network of a minimum value with a unified switching center by parallel coupling to this center of the nearest stations according to their distance [5]. Then there was a method by Ezhi-Williams issued from the connection to the switching center the most distant stations [1, 2, 4, 6].

A problem of communication networks design with a multiplexing of subscriber loops on separate concentrators for comparatively small sections of local networks has been considered in works mentioned above and also in [6].

Nowadays, a quantity of the subscribers per unit area and a quantity of the concentrators constructed within the assigned district or micro-district has dramatically increased. At the same time a lot of tracing restrictions arose both for subscribers` and multiplexed channels in view of the fact of tightening the apartment block and appearance of new enterprises and organization etc. A development of automated system of constructing regional sections of communication networks with concentrators, that'll take into consideration different cost and restrictions factors, became essential.

Ways of constructing networks with concentrators

There are two methods of constructing such networks:

1. Concentrators` method
2. Hierarchical method

1. Concentrators` method

There is a switch center (SC) and a set of subscribers. The subscribers can connect to the SC but not to each other. A connection is implemented with a cable of a certain cost. It is obvious that the most optimum alternative is to connect each subscriber to the nearest SC. But we have an opportunity to place concentrators in some spots of the network. These devices merge the traffic from several subscribers. The cost of installation of the concentrator includes the cost of the concentrator itself and the cost of the cable for connecting to the closest SC. We can convert the cost of the cable into the equivalent in value length of the cable. This is what we are going to do. According to the task, we can buy either a concentrator or some amount of cable for a certain sum of money. Mind that all the possible spots for installing the concentrator are already specified.

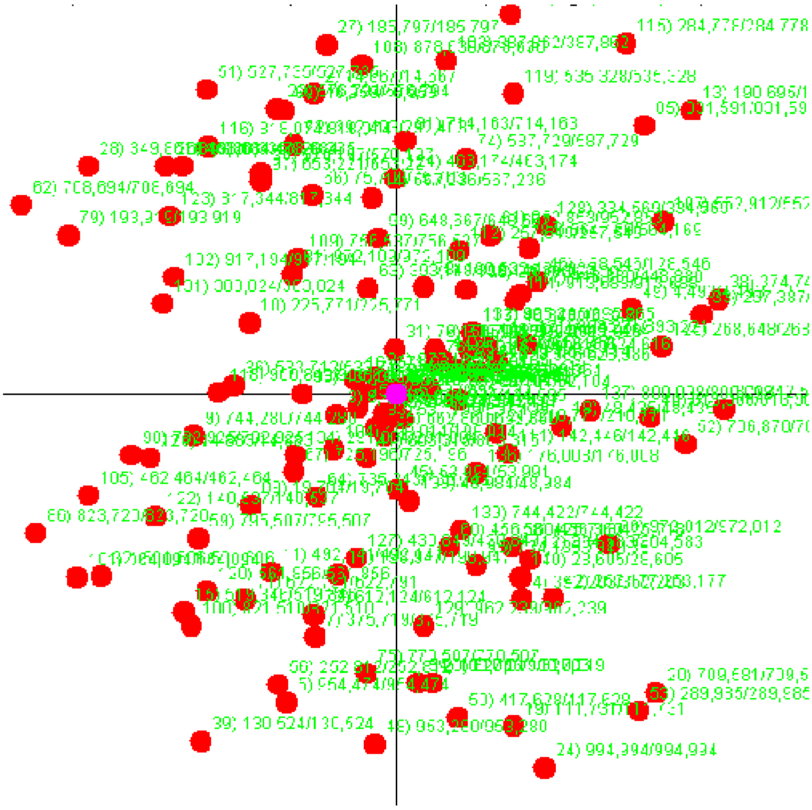
Exact solution requires a bulk of calculations. A heuristic approaches give a solution only close to the optimum [3, 4] which is not enough.

The first variant is addition method. The essence of it is rather simple. At first we connect all the subscribers to the nearest SC; concentrators are not installed. The algorithm is iterative. On every iteration we alternately try to install each quiescent concentrator and to connect those subscribers re-connection of which will reduce total cost of the cable. Then we chose the concentrator which gives minimum cost of the network (including the cost of the concentrator). If the introduction of this concentrator reduces the cost of the network, then this configuration is taken as a new one and we move on to the next iteration. If not, a calculation is considered as complete and the topology derived in previous step as close to the optimum.

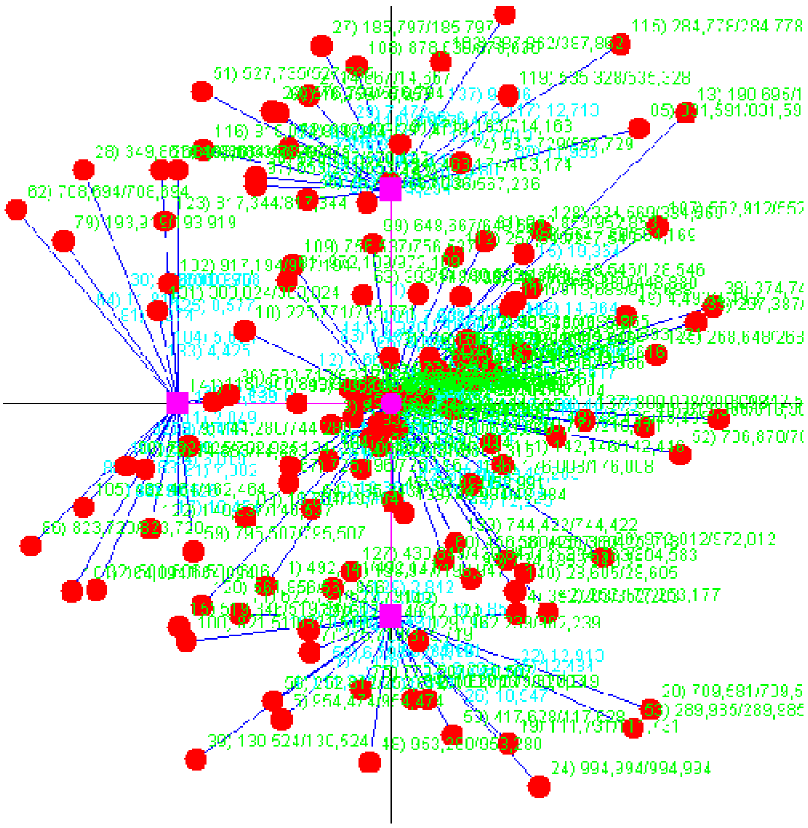
The second variant is deletion method. At first we install all the concentrators and connect the subscriber to the nearest point (either SC or the concentrator). The algorithm is iterative as well. On every iteration we try to remove each of the concentrators remained and to connect its` subscribers to the closest points. Among all configurations derived we chose the one of the minimum cost. If this cost is lower than in the previous step we take the topology as a current and move on to the next iteration. If not, a calculation is considered as complete and the topology derived in previous step as close to the optimum.

Let`s look at the example. As an example we take a network where spots are scattered within a circle. Radius and the azimuth angle are distributed evenly. Thereby, closer to the center spots are situated more tightly. SC is in the center of the circle. Estimated places for concentrators are situated in semi-radius distance from the center, azimuth angles differ in 90 degrees. Let`s scatter 140 spots in a circle with radius of 20 units (pic.1) and connect them in two ways permitting to connect up to 20 subscribers. We suppose that the communicator is an equivalent of 120 units of the cable. Let`s look at the results of addition method (pic.2) and deletion method (pic.3). The first network costs 1258.82 (898.823 for cable, 360 – three concentrators), the second one costs 1339.15 (1099.15 for cable, 240 – two concentrators).

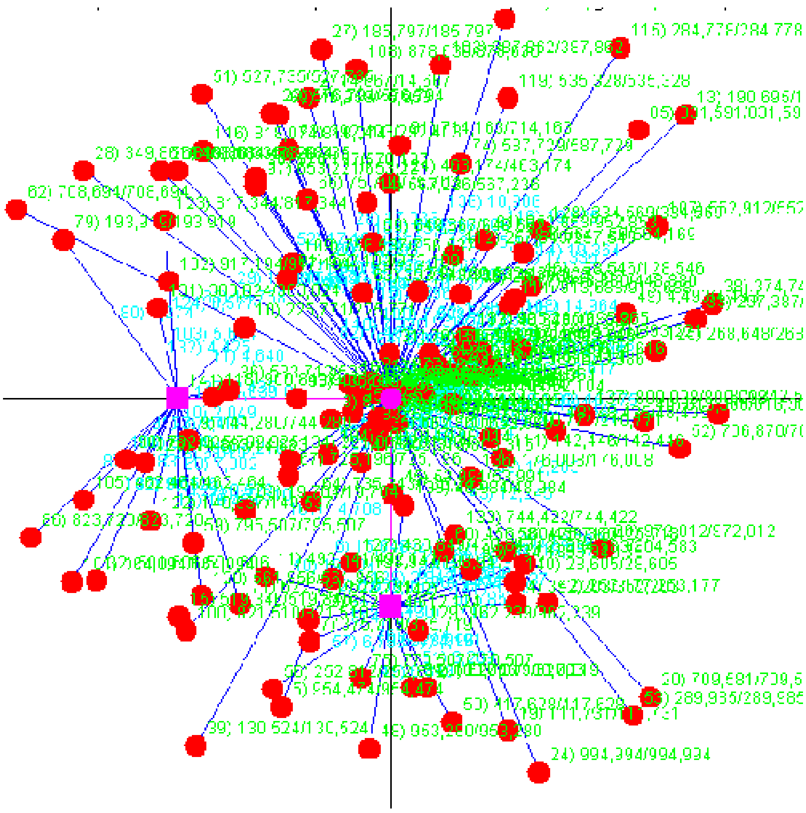
It is rather complicated to get a real time of completing the algorithm because all the calculations are done very quickly and a random component is commensurable with the time of the calculations. We have to increase a number of the spots to 10000. It is impossible to understand anything on the picture, that`s why we are not citing it here. Let`s tabulate all the data (Table 1). Hence it follows that deletion method gives worse results and takes more time.



Picture 1 – Spots without connection.



Picture 2 – Addition method.



Picture 3 – Deletion method.

Table 1. Comparison of the algorithms with a quantity of spots (10000 spots).

Algorithm	Networks cost	Cable cost	Number of concentrators	Concentrators cost	Time for calculations,msec
Addition	99643.8	99163.8	4	480	47
Deletion	99699.7	99219.7	4	480	4197

2. Hierarchical method

As communication networks providing a transmission of various information (phone, computer network data, facsimile, and multimedia) develop rapidly, an urgent necessity of building hierarchical systems appears. In these systems there is information, transmitted by shared channels from the local subscribers and concentrators, then it is compressed in concentrators of a higher rank and etc. till the commutation center of the highest rank.

The introduced variant of building a hierarchical network is based on the following principles [6]:

1. We connect n_i abonent stations to each of m local concentrators. Then we sort the assigned group of subscribers by distance from the subscriber to the concentrator of this group.

2. A computed sequence of certain distances from the subscriber to the concentrator is a sum of distances from any subscriber to the concentrator with a glance of distances closer to the concentrator. We create a chain of connections from subscribers to the

concentrator. For instance, for subscribers 3-5, 7-5, 8-6, where the first figure is subscriber`s number, and the second one is the distance to the concentrator we create a chain: 5(3), 10(3, 7), 16(3, 7, 8).

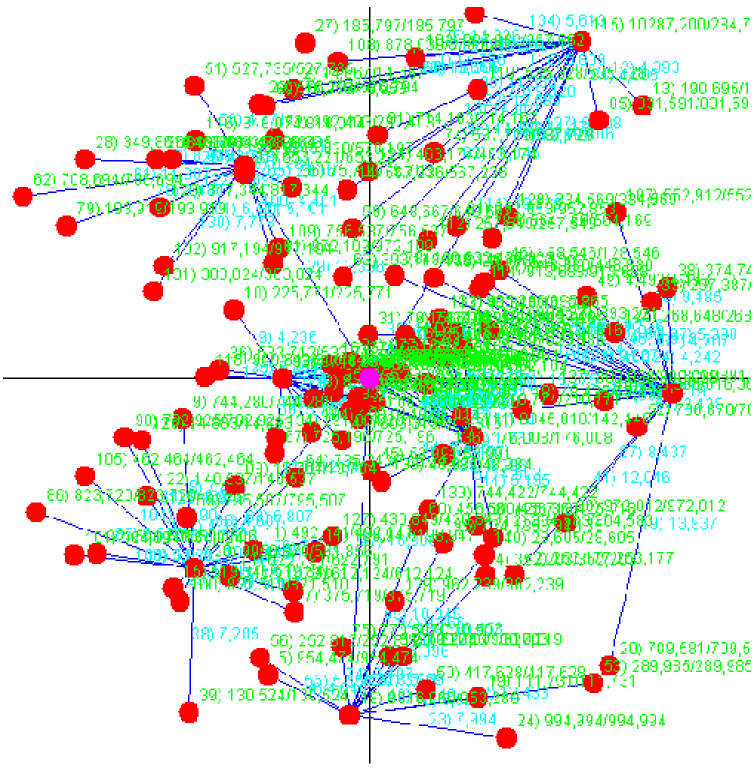
3. By this chain we define the closest to the corresponding concentrator subscribers groups $n_{зад}$, where $n_{зад}$ is an assigned permissible number of subscribers connected to the concentrator.

4. We sort out a group of the lowest cost then unite the subscribers of this group into a separate sub network. Determine the next sub network, etc.

The algorithm is iterative. After coalescing nodes into groups the centers of these groups became new nods, which by-turn will be also grouped. Continue till all the nods are coalesced.

Now we take the same example (pic.1). A workload of each subscriber we define as a random evenly distributed figure from 0 to 1000. We get a following topology (pic.4). The cost of the connection is 942.24.

This calculation takes <50 msec. Then we compare the execution time and the number of subscribers for processing (table 2). One can notice that hierarchical method has a cubic complexity (chain calculation has a cubic complexity and is done certain amount of times. This amount is approximately proportional to the amount of the subscribers).



Picture 4 – A hierarchy.

From picture 4 we see that distance from separate concentrators to the common switch center (SC is defined on the latest iteration of the algorithm) may be greater than the distance from separate stations to the SC. It can be explained by the fact that in the beginning of constructing the network a position of the SC is still undefined. We can avoid such situations by a minor adjustment of the algorithm if we know at least an approximate position of the SC.

Table 2. Time calculation and cost dependence on spots number.

Number of spots	Cost	Time calculation, sec
500	1698.26	0.39
1000	2656.07	2.948
1500	3324.59	10.389
2000	3979.46	24.211
10000	8738.66	5010.56

You should mention that in case with 10000 spots the time exceeds the cubic time: it should be about 3200 sec. It happens because of lack of main memory and evinced in frequent swapping.

Conclusion

Thereby, there are heuristic algorithms for designing networks with active and passive concentrators. As a result we`ve got a tool for building up hierarchical networks which can be used for multiplexing in concentrators.

We can combine both methods: at first coalesce nods with one method and then connect the centers with the other.

These algorithms can be applied to various types of the concentrators, which multiplex not only by unifying the subscribers` channels into main one, but also by frequency division and time-division multiplexing, replacement of the wire cable by optical fiber cables.

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