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OPTIMIZATION OF OSPF COMPUTER NETWORK CORE TOPOLOGY ON IMPLICIT LOAD BALANCING BASIS

Annotation. It is proposed to assign of implicit load balancing index ILBI dependent on relational intensity of information traffic in OSPF-network core channels. The cores with different numbers of ABR routers are studied. On this basis we performed modification of the core topology that allowed to realize a more uniform distribution of load in channels when much greater average movement velocity of packets in the core.
Keywords: core, OSPF – network, implicit load balancing.

Introduction. Computer networks constructed on the basis of interior gateway routing protocol OSPF at present occupy a leading position in the Internet. In OSPF specification recommended to construct a separate parts of autonomous system (AS) as areas in which all routers have identical topological information database and perform the same calculations detailed in the protocol [1]. This allows significantly increase networks scalable.

Region 0 of autonomous system called as reference region and can be considered as AS core. With reference area must connect all other AS areas. An important for information traffic in the core of AS routing is the organization of interfaces of core boundary routers (ABR), each of which is located in the connection place of one region to another and has interfaces belonging to different areas. Due to the high intensity of traffic in zero region is very urgent task of routes load balancing.

Problem statement. The aim is to study, using an implicit load balancing index, core topology focused primarily on the implementation of tunneling between regions AS, and core topology optimization to extend its versatility and increase the degree of load balancing.

Main part. Implicit load balancing index (ILBI) λ is determined by the ratio of the communication channels used for transmission of information traffic to total number of existing channels [2]. Implicit load balancing (ILB) shows how routes with different metrics distribute network traffic in the process of work actually using all sources and destinations. Load balancing offers several advantages, including the

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increase of reliability of information transmission [3], a more rapid recovery [4] tolerate to significant fluctuations in the intensity of traffic [5].

Consider the topology of the core (zero region), in which the boundary routers ABR A1 and A2 respective areas connected of trunk lines with band of 10 Gbps. The same applies to routers B1 and B2, C1 and C2 and so on. These main routes used at least one intermediate router, respectively a, b, c .... . That is transfer between A1 and A2 is effected through a, and between B1 and B2 - through b, between C1 and C2 - through c and so on. To combine all core routers in a network and implement reservation of all the main channels introduced channels with less broad bands 1 Gbps (according Ethernet), as shown in Figure 1 for the number of ABR N = 10.

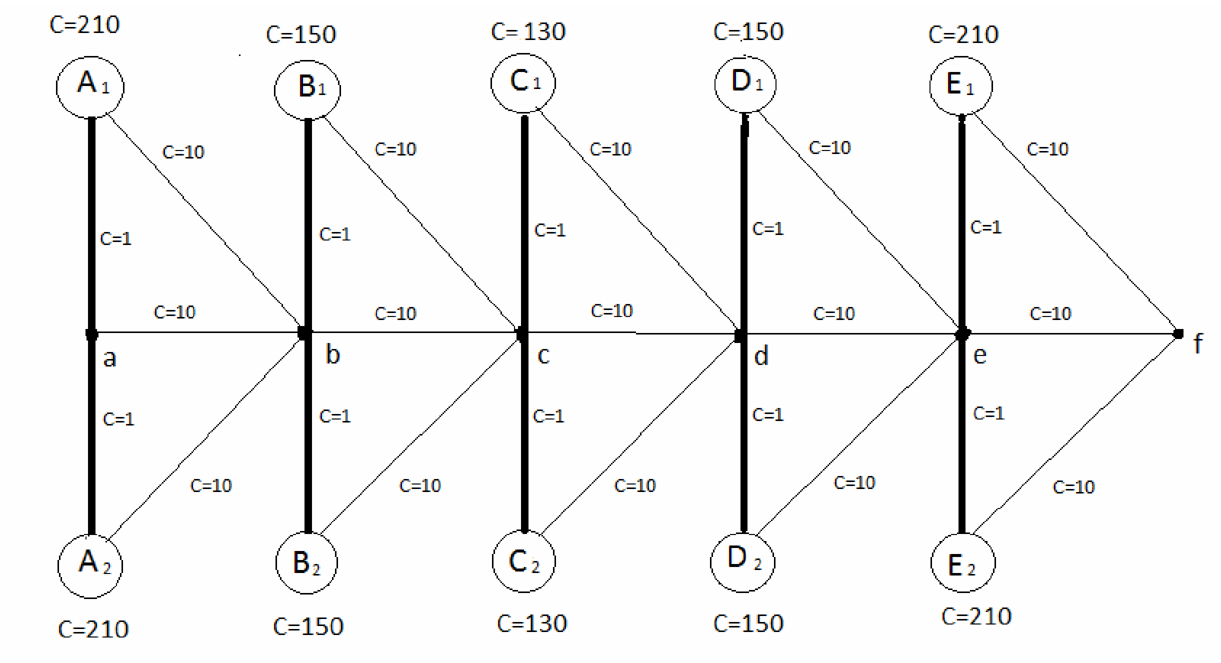

Fig.1. Primary core topology of autonomous system when N=10

On Figure 1 at each edge graph (link) shows its cost. Topologies of this type focused primarily on the implementation of tunneling between areas of autonomous systems connected to the same-named ABR routers A1, A2, B1, B2 and so on. However, it is appropriate, while maintaining this orientation, to realize more universal network in which high-speed exchange of information carried by all routers ABR of autonomous system core.

In determining the optimal route with the lowest metric (cost) protocol OSPF uses Dijkstra Shortest Path Algorithm (DSPA) [1]. Simulating network as a graph that has n vertices (nodes) and m arcs (ribs), DSPA starts at the root node and extends through the coating tree through a graph until all vertices are not connected with the root of the most short way possible. Most considered short path that has the lowest cost. In practical use of DSPA usually calculated inverse value to the basic bandwidth and the cost of the entire route is defined as the sum of the costs of its constituent channels (or connections).

Consider the exchange of information between all routers ABR (Figure 1). We assume that each one ABR sent information packages to all others. Calculate cost route for each information packet and number of packets that passed along every channel. Routes for packets to determine using the DSPA algorithm. For example, the route from A1 to E2 has a cost of 41. Figure 1 shows at each ABR total cost routes to it from all ABR core routers, such as C = 130 for router C1.

Let us change the number ABR routers in the core from 6 to 14. The corresponding values for the total cost routes for such cores are shown in the top row of Table 1.

Table 1

Total cost for all core routes

Total cost for all routers of ABR core	N=6	N=8	N=10	N=12	N=14
Primary topology	356	864	1700	2944	4676
Modified topology	76	152	294	472	716

Figure 2 shows a graph of changes of total cost routes for each ABR when moving in the direction A1 → B1 → C1 ... (or A2 → B2 → C2 ...) with the number 1 on the horizontal axis of Figure 2 corresponds to A1, figure 2 - B1, figure 3 - C1 and so on.

Define ILBI $\lambda 0$ for core with different N. For example, for the autonomous system core shown in Figure 1, the total number of channels is 22. Connections E1f, ef and E2f do not count, they are shown to illustrate that the network can be extended right. Channels, along which packages pass are 21 (the channel ab have not packages). So $\lambda 0 = 21/22 = 0.95$.

We propose to modify the index ILBI λ, defining it depending on the relative intensity of core traffic channels. Return to the core topology presented in Figure 1. Analysis of the number of packets that have passed through its channels, provided that each router ABR sent one information package to all others, showed that the maximum number of packets passed through the channel cd. This number is Imax = 32. Identify channels through which passes less than 10%, 20% and 30% of the maximum quantity of packages. For analyzed topology in Figure 1 we have 3, 7 and 13 such channels respectively.

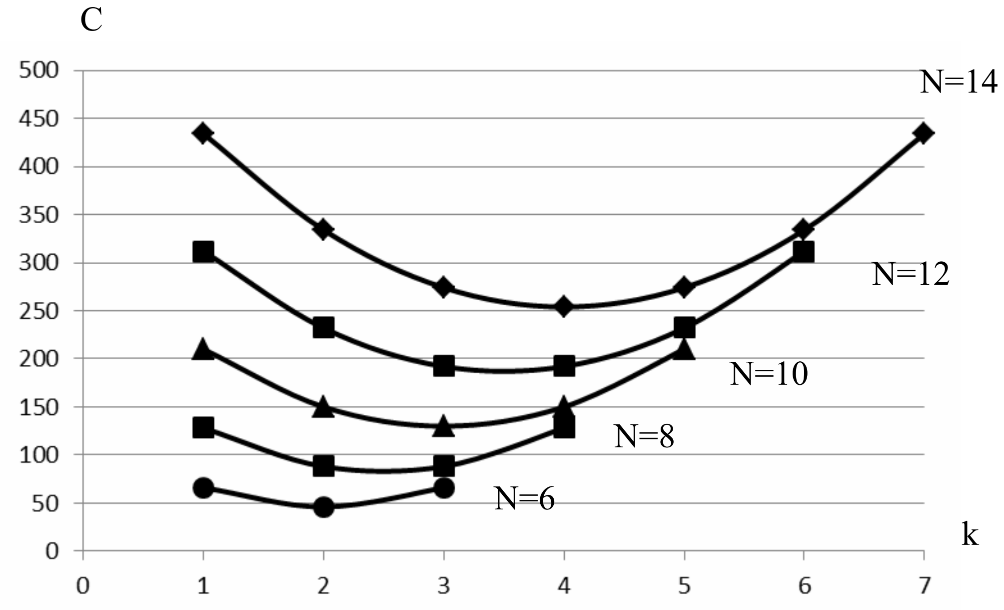

Fig.2. Changes in the total cost routes for each router ABR of primary core topology when moving in the direction A1 → B1 → C1... for cores with different number of ABR.

The corresponding values ILBI we define as λ 0,1 = (22-3) / 22 = 0,86, λ 0,2 = (22-7) / 22 = = 0,68, λ 0,3 = (22-13) / 22 = 0.59. Similarly, the corresponding values of λ are defined for networks with N = 6, 8, 10, 12 and 14 [6]. Analyzing the obtained values, we can say that with increasing N they are steadily decreasing. The corresponding ranges are: λ 0,1 (N = 6) = 0,92 - λ 0,1 (N = 14) = 0.78; λ 0,2 (N = 6) = 0,92 - λ 0,2 (N = 14) = 0.53; λ 0,3 (N = 6) = 0,75 - λ 0,3 (N = 14) = 0.34. This indicates a significant irregularity in distribution of informational traffic in the core of autonomous system. If we consider only the channels through which information traffic passes, its average intensity with increasing N from 6 to 14 increased from 6.18 to 20.77, while the coefficient of dispersion has increased from 47% at N = 6 to 87% when N = 14.

Modification of the core network was aimed to reducing the uneven of distribution of information traffic and reduce the cost of the packages delivery that is actually to reducing their delays. Modification carried out using the coefficient λ 0,3 as follows: broadband channels (10Gbps) with intensity of traffic less than 30% of the maximum replaced the channels with a less wide bands (1Gbps), and such channels with intensity of traffic more than 30% of the maximum replaced the broadband channels. This topology with N = 10 is shown in Figure 3.

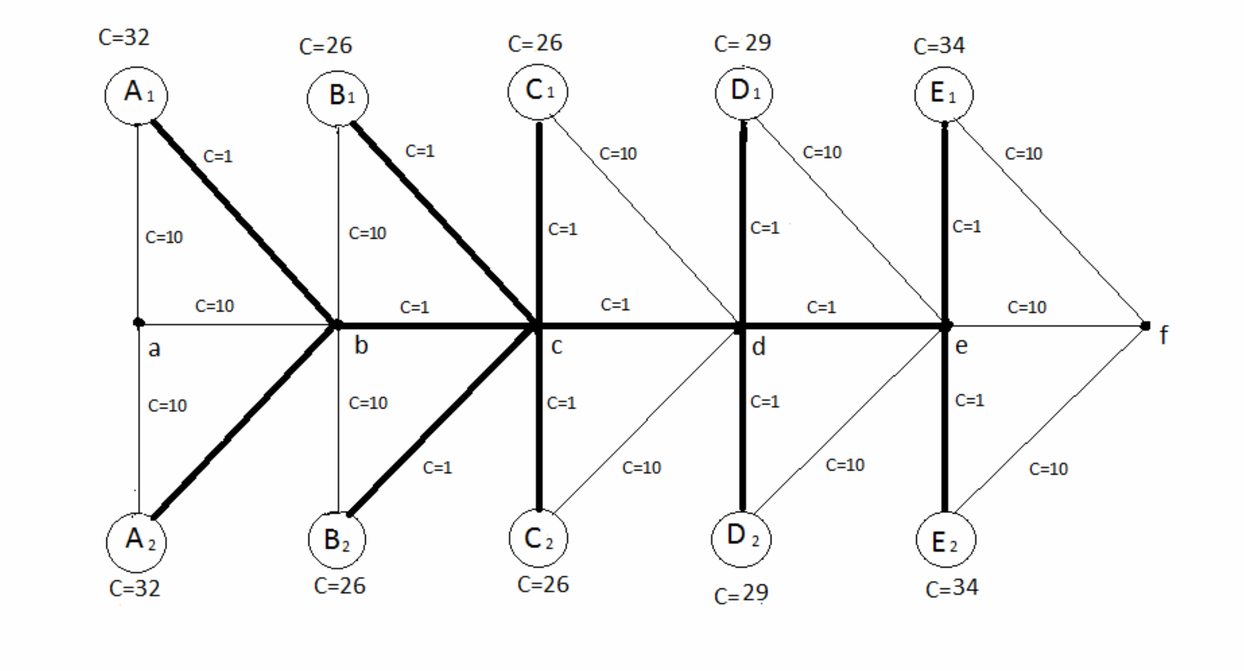

Fig.3. Modified topology of autonomous system core when N=10

The value of the total cost routes for all core at different N are in the second row of Table 1. Similar to Figure 2 graphics describing the topology of the modified cores are shown in Figure 4. It is seen that achieved a significant decrease in the cost of delivery of packages that is greatly enhanced speed of delivery. This relative decrease in cost as obtained from Table 1 is becoming more weighty with increasing N (from 4.68 when N = 6 to 6.53 when N = 14). Statistical results of modified cores of networks OSPF autonomous systems working collected in Table 2.

The average intensity of traffic γ of modified core much higher than the corresponding values for the primary topology (for N = 6 on 76%, for N = 8 by 78%, for N = 10 by 92%, for N = 12 by 81%, for N = 14 by 81%). Standard deviation σ and especially its relative values (coefficient of dispersion) is significantly less than for the previous topology (for N = 6 by 55%, for N = 8 by 51% for N = 10 by 35%, for N = 12 by 33%, for N = 14 by 31%). Note permanence implicit load balancing index when the change of traffic intensity - $\lambda 0 = \lambda 0{,}1 = \lambda 0{,}2 = \lambda 0{,}3 = 0{,}59$, while the value is independent of the number N router ABR, i.e. the size of the core of autonomous system. In the last column of Table 2 is shown the percentage increasing of the number of broadband channels ξ when we transfer to a modified topology. It is seen that the increasing is moderate. Channels with less bandwidth exclusively perform backup functions.

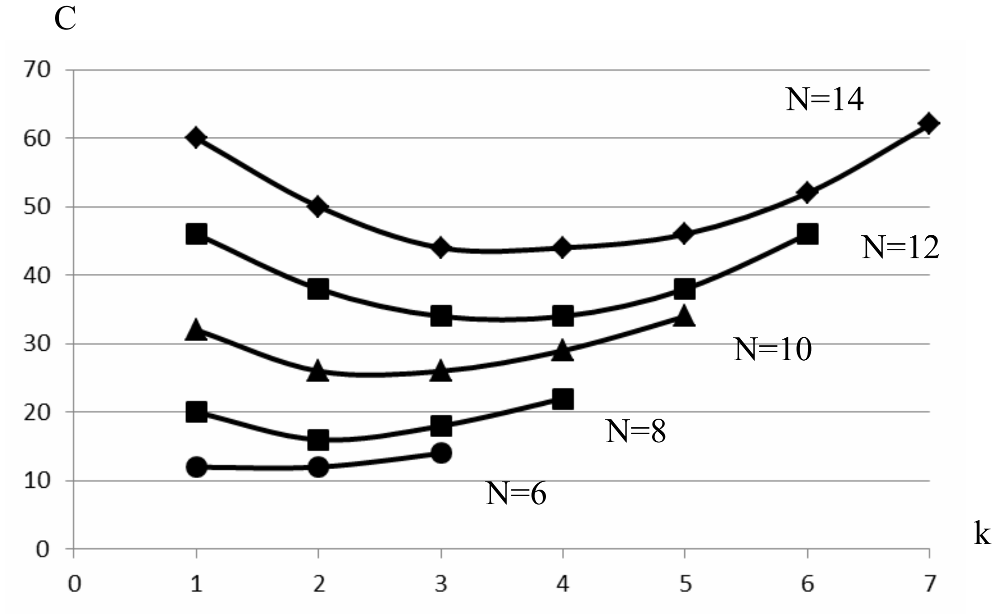

Fig.4. Changes in the total cost routes for each router ABR of modified core topology when moving in the direction A1 → B1 → C1... for cores with different number of ABR.

Table 2

Statistical properties of modified cores

N	γ	σ	α,%	ξ,%
6	10,86	2,27	21	17
8	16,0	4,22	26	25
10	22,46	9,28	41	33
12	29,5	14,78	50	33
14	37,68	22,49	60	36

Conclusions

1. Using implicit load balancing index ILBI it is studied the topology of core of network OSPF autonomous system oriented to implementation of tunnels between regions of autonomous systems connected to the corresponding ABR routers.

2. We propose the modification of ILBI, defining it based on the relative intensity of information traffic in core channels. It is studied the cores with different numbers of ABR routers. On this basis, core topology modification was performed that allowed to

realize more even distribution of the load between the communication channels at much greater average velocity of package moving in core.

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