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METHOD OF SDN CLUSTERING USING CONNECTIONS DENSITY DISTRIBUTION

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СПОСІБ КЛАСТЕРИЗАЦІЇ МЕРЕЖІ SDN З УРАХУВАННЯМ РОЗПОДІЛУ ЩІЛЬНОСТІ ЗВ'ЯЗКІВ

The paper proposes method of SDN clustering using connections density distribution that solves the problem of controller load balancing.

Key words: SDN, network clustering, controller placement problem.
Fig.: 2. Tabl.: 1. Bibl.: 3.

У роботі запропоновано спосіб кластеризації мережі SDN з урахуванням розподілу щільності зв’язків, що вирішує проблему рівномірного навантаження контролерів.

Ключові слова: SDN, кластеризація мережі, задача розташування контролера.
Рис.: 2. Табл.: 1. Бібл.: 3.

Relevance of research topic. The efficient SDN management is a pending problem because of the wide spread of such networks and their increase in scale during recent years. To solve this problem we need to define network structure efficiently, that is, to split the network in to a number of subnetworks and to place a controller at the optimal position in each of them.

Formulation of the problem. As SDN separates control and data planes, the problem of controller placement arises, that is, how many controllers should be in a network and how exactly they should be placed. In this paper we propose a method of controller placement based on connections density distribution.

Analysis of recent research and publications. Some works have proposed heuristic algorithms to solve the controller placement problem and defined this as multi-objective combinatory optimization task. However, for a large-scale network such algorithms demonstrate an unreasonably high solution time [1].

On the other hand, there exists an approach in which controller placement is determined by certain defined metrics.

One such method is density based controller placement (DBCP), which uses nodes

clustering algorithm based on density distribution. These nodes have higher quantity of connectivity inside the cluster and lower quantity of connectivity with nodes from other networks, thus there is one and only one controller in each subnetwork [2].

Selection of unexplored parts of the general problem. In a real life network when performing clustering the task of controller load balancing arises. This task has not been solved in the original DBCP algorithm.

Target setting. We proposed a modification of DBCP algorightm so as to ensure the balanced controller load.

The statement of basic materials.

The density based clustering algorithm three main steps: density analysis, density based clustering and controller placement. The metrics that is introduced in the modified algorithm for the choice of controller's position is the index of proximity to the cluster's margin.

In general, the clustering network algorithm based on density distribution consists of three main steps:

1) analyze the distribution local density distribution throughout network of routers;

2) according to the found values of density and distance from the current node to the node with a higher density, divide the network routers in clusters;

3) solve the task of selecting a placement for one controller in each subnetwork according to the given criterion.

During the first stage, the topology of the network is analyzed for the presence of higher connected groups of routers. For each router, the density of the local connections d and the distance r to the router with the higher value of the local density is calculated.

The metric that is additionally introduced in the modified algorithm is the index of proximity to the boundary of the cluster s_{zp} to distinguish vertices with similar local densities of nodes. Let the router V have a local density d. For each router V_i we define the set of neighboring routers $N(Vi)$, each of them has a greater or equal local density. Then, according to the formulas of the information entropy theory [3], the index of proximity to the cluster boundary can be calculated by the following formula:

$$s_{\text{гр}\,i} = \sum_{j}^{N(Vi)} \frac{d\,j}{D} \log \frac{d\,j}{D}, \text{ де } D = \sum_{j}^{N(Vi)} d\,j$$

Then, during the second stage of clustering, the cluster assignment procedure for the current node needs to be corrected. As the firstly allocated cluster was defined as closest to the current vertex, then we will sort the vertices by increasing the proximity index to the cluster boundary in modified algorithm.

For all vertices included in the $N(Vi)$ set, we sort by the local density value in descending order, and we try to attach a vertex to a cluster that contains a router with a higher local density value and contains the ability to expand.

Figure 1 examines the example of the network, while the simulation has set the limit of 6 vertices to the size of the cluster. The simulation results are reproduced in Figure 2 and in Table 1.

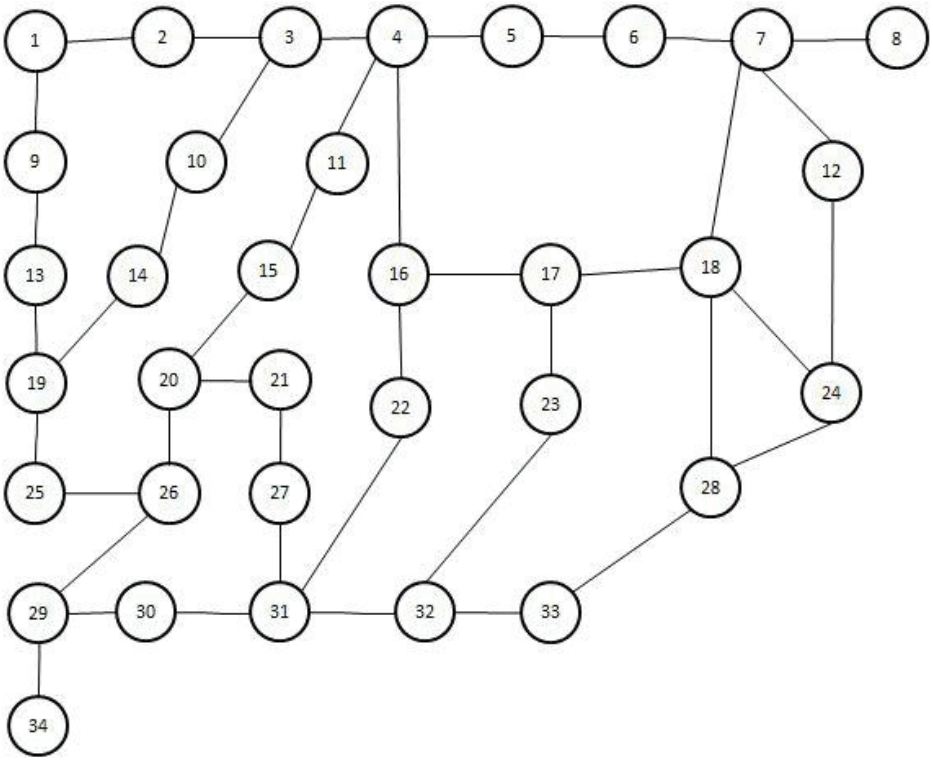

Fig. 1. Initial network graph

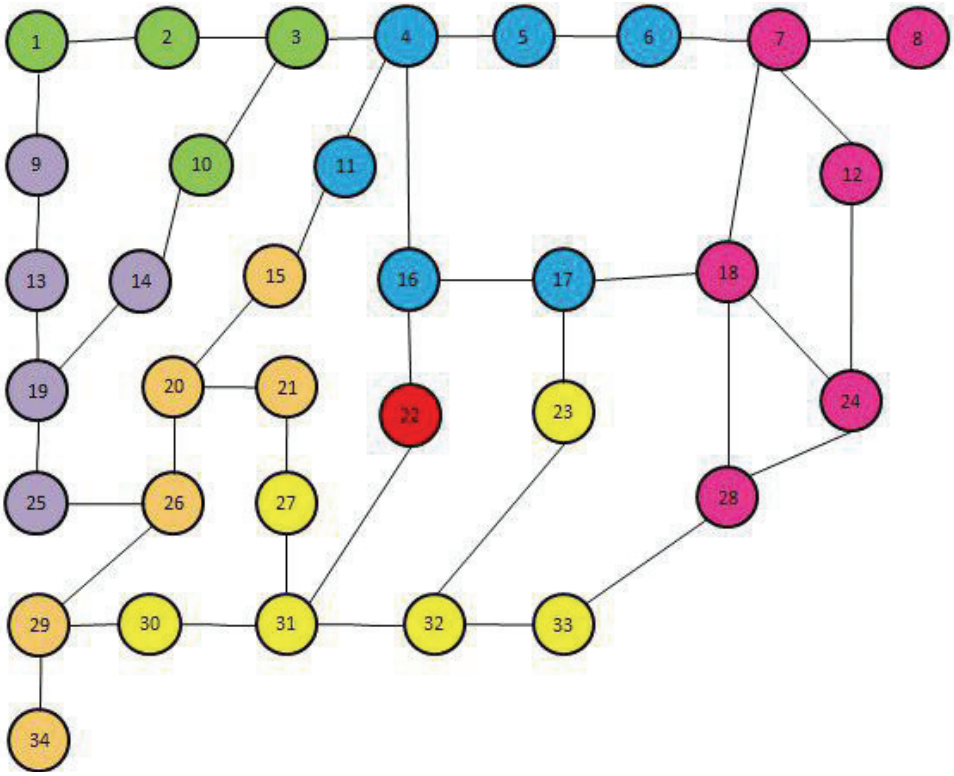

Fig. 2. Clustering algorithms' results considering maximum load limitation

Table 1

Clustering algorithms' results considering maximum load limitation

Node Id	***d***	***r***	s_{zp}	***Node Id***	***d***	***r***	s_{zp}
1	4	1	0.91	18	9	3	0.0
2	8	1	0.0	19	6	2	0.0
3	8	1	0.99	20	7	1	0.0
4	10	3	0.0	21	5	1	0.99
5	6	1	0.95	22	7	1	1.0
6	6	1	0.98	23	6	1	1.0
7	8	1	0.0	24	6	1	0.98
8	4	1	0.0	25	6	1	0.98
9	4	1	0.99	26	8	3	0.0
10	5	1	0.96	27	6	1	0.0
11	6	1	0.0	28	7	1	0.0
12	6	1	0.98	29	6	1	0.99
13	5	1	0.0	30	7	1	0.0
14	5	1	0.99	31	9	3	0.0
15	5	1	0.99	32	8	1	0.0
16	9	1	0.0	33	6	1	0.99
17	8	1	1.0	34	3	1	0.0

Conclusion. In our paper we have proposed an algorithm of network clustering using connections density distribution. An example of the algorithm's work has been demonstrated. The use of the proposed algorithm will allow to increase network clustering efficiency taking into account controller load.

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EXTENDED ABSTRACT

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