UDC 004.724.4

METHOD FOR ORGANIZING MULTIPATH ROUTING IN SDN NETWORKS

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In this work we propose a method for organizing multipath routing for SDN networks. It have two main parts. The fisrt one is a routing method based on modified wave algorithm for finding paths, and second one is load balancing method based on ECMP algorithm. Combination of these methods can optimize using of network resources and provide a more optimal load balancing of network. The basis of routing algorithm is the search and use partially-overlapping routes. The basis of load balancing algorithm is equal distribution network load between all found routes. A comparative analysis with an existing algorithms for routing and load balancing was conducted and the advantages of this development are presented.

Keywords: multipath routing, wave algorithm, partial-overlapping routes, SDN networks, load balancing.

аспірант, Калюжний О. О. Спосіб організації багатошляхової маршрутизації в програмно-конфігурованих мережах / Національний технічний університет України «Київський політехнічний інститут ім. Ігоря Сікорського», Україна, Київ.

У цій роботі ми пропонуємо метод організації багатошляхової маршрутизації для мереж SDN. Він має дві основні частини. Перша - це метод маршрутизації, оснований на модифікованому хвильовому алгоритмі пошуку шляхів, а другий - метод балансування навантаження, що базується на алгоритмі

ECMP. Поєднання цих методів дозволяє оптимізувати використання мережевих ресурсів та забезпечити більш оптимальне балансування навантажння у мережі. В основі алгоритму маршрутизації лежить пошук та використання маршрутів, що частково перетинаються. Основою алгоритму балансування навантаження є рівномірний розподіл навантаження між усіма знайденими маршрутами. Проведено порівняльний аналіз із існуючими алгоритмами маршрутизації та балансування навантаження та представлені переваги такої розробки.

Ключові слова: багатошляхова маршрутизація, хвильовий алгоритм, частково-пересічні маршрути, мережі SDN, балансування навантаження.

аспирант, Калюжный А. О. *Способ организации многопутевой маршрутизации в программно-конфигурируемых сетях /* *Национальный технический университет Украины «Киевский политехнический институт им. Игоря Сикорского», Украина, Киев.*

В этой работе мы предлагаем метод организации многопутевой маршрутизации для сетей SDN. У него есть две основные части. Первая - это метод маршрутизации, основанный на модифицированном волновом алгоритме для нахождения путей, а второй - метод балансировки нагрузки, основанный на алгоритме ECMP. Сочетание этих методов позволяет оптимизировать использование сетевых ресурсов и обеспечить более оптимальную балансировку нагрузки сети. Основой алгоритма маршрутизации является поиск и использование частично перекрывающихся маршрутов. Основой алгоритма балансировки нагрузки является равномерное распределение нагрузки между всеми найденными маршрутами. Был проведен сравнительный анализ с *существующими алгоритмами маршрутизации и балансировки нагрузки, и представлены преимущества этой разработки.*

Ключевые слова: многопутевая маршрутизация, волновой алгоритм, частично-пересекающиеся маршруты, сети SDN, балансировка нагрузки.

Introduction. One of the main tasks in SDN networks is to optimize the use of available network resources. This can be achieved by optimizing routing algorithms and load balancing within the network. The main task of routing is - how to transfer the data packet from sender to receiver? Basic routing schemes tend to focus on search one optimal path for routing with a specific metric desired. These indicators include jumps, distance, speed, delay, cost, etc. Accordingly, packets are always redirected in one way, which often leads to significant costs on network resources. An alternative approach is routing with multiple paths. This approach allows you to send packets in several "good" ways, rather than routing all packets in one "best" way.

Existing methods. Today, there are many algorithms for finding path and load balancing. However, not always a combination of the best solutions in each of the areas is the most effective.

Modern methods of forming a set of data transmission paths are based on search algorithms in depth, width or combinatorial methods. Most such routing methods [1, 2] are designed to search for non-overlapping routes, which in turn can not fully utilize all network resources.

In [3], the modification of the method of branches and boundaries adapted for multipath routing is also considered. With this algorithm, a tree of paths is constructed from the start to end node. The main disadvantage of this algorithm, like all other algorithms of wave algorithms and search algorithms in depth or width, is a fairly large area of search solutions.

However, quite often there are situations where in fairly large network we can only find one extraordinary route. All further paths will have cross sections with the given data.

One of the options for solving this problem is the choice of several partial-overlapping routes.

Finding all partial-overlapping routes in the graph is not the best option, although it is possible (for example, by modifying the search algorithm in depth), since it actually searches for all possible paths between the two nodes. In general, such a solution can be applied only in an attempt to maximally distribute and balance traffic within the network. However, this will result in very high costs for paths, data transmission delays and some other QoS criteria.

In the case of load balancing, there are several basic algorithms used, namely VLB[4] and ECMP[5]. When we must calculate network load, better to take ECMP in basis, because it distribute packets equally between all available routes.

Developed algorithms. In this work, we propose to use the wave algorithm developed in [6]. The feature of this solution is the ability to form a set of partial-overlapping routes using metric lengths and low time complexity.

How searching algorithm works:

1. Get Start(A) and End(B) nodes of routes.
2. Set A node as start of first wave.
3. For each node in current wave, use all links and form transmissions to next nodes and form a form temporary set of routes.
4. Remove routes that don`t have nodes for next wave.
5. Add end-point nodes from step 3 to next wave.

6. Delete all adjacent links between nodes in formed wave and remove backlinks.

7. If route reaches node B, save it.

8. Return to step 3 until we cant form next wave or length of current routes reaches [LengthOfShortestRoute + LengthOfShortestRoute/2].

As result, we have set of partially overlapping routes between A and B nodes of network.

In the next step, we must divide data flow between the received paths without overloading any network links.

For this task we can use modification of ECMP algorithm[7].

The main idea of this load balancing algorithm is redistribution load from overloaded paths to those that have free bandwidth.

How load balancing algorithm works:

1. Divide data flow to all found paths equally.

2. Find overloaded paths.

3. Calculate current path overload.

4. Split overload to all paths that have free bandwidth (free bandwidth calculates as the most loaded link of route).

5. Return to step 2 until we don`t have overload or reached maximum count of repeats (can set by developer, default is 3).

Testing. For experiment, a simulator program was developed that compares the number of elementary operations, number of used links performed by the developed algorithm in comparison with the Dejkstra algorithm, modified to search for partial-overlapping paths. For comparison, 100 startup algorithms were performed on randomly generated graphs of a given dimension. Fig. 1 and 2 shows the results of work.

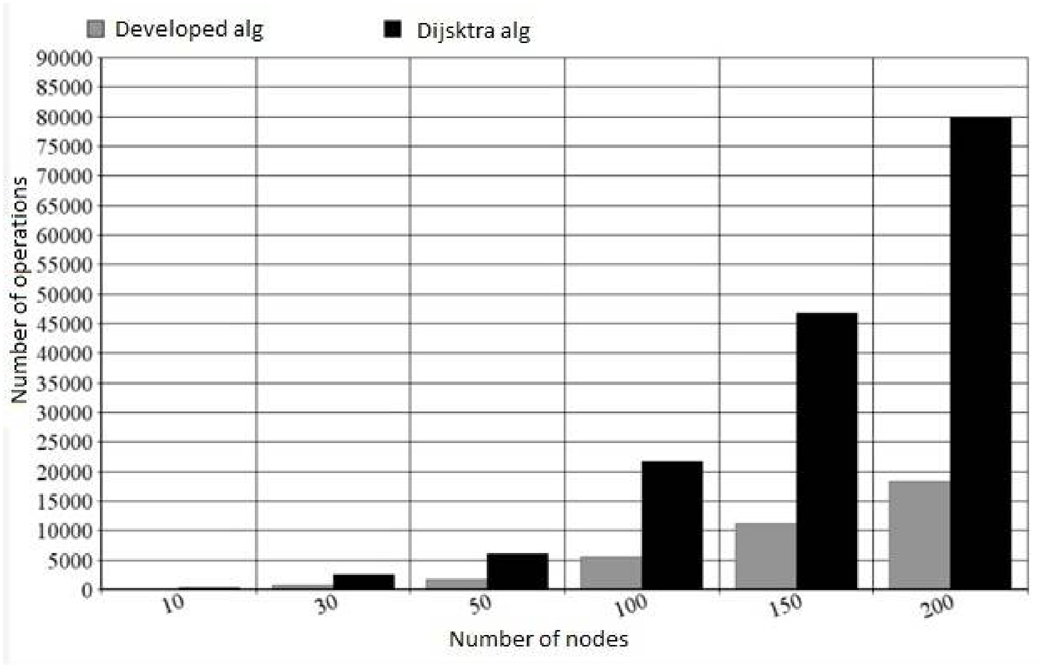

Fig. 1. Number of performed operations

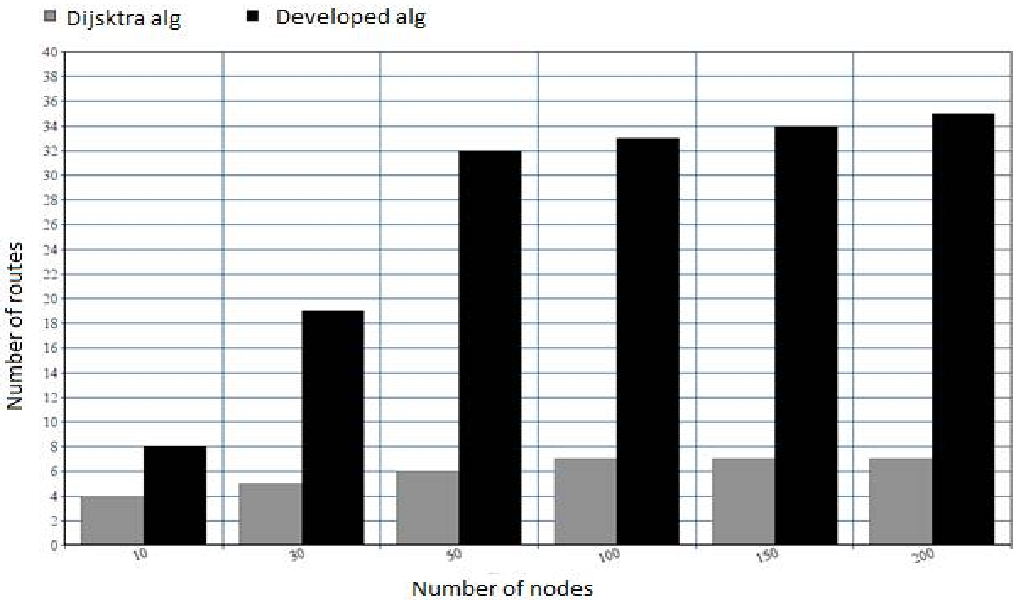

Fig. 2. Number of found routes

As we can see, developed algorithm has better results than Dijkstra algorithm. It perform lower number of operations and find more routes. So we can say that it use more network links and we can split load between that links.

For testing the developed method with load balance, we use network on Fig. 3

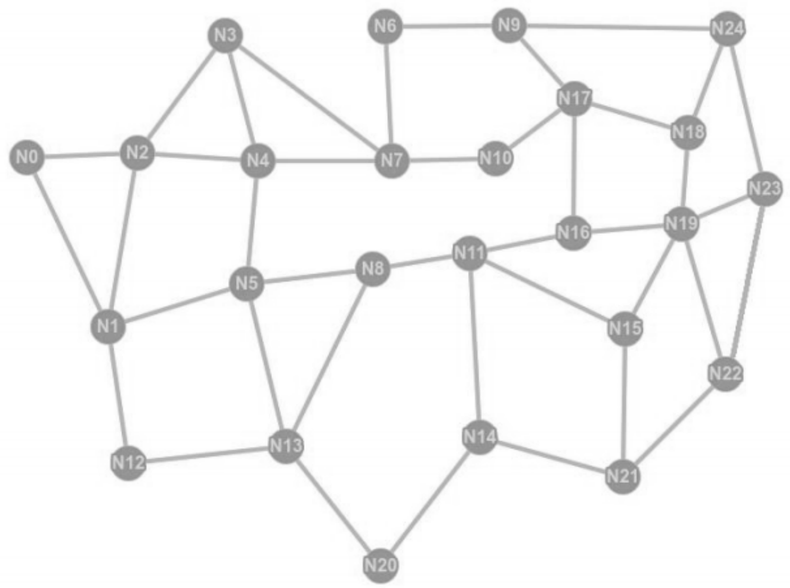

Fig. 3. Testing network

Network link bandwidth – 50 mb/s, pairs of nodes for which the algorithms would be simulated are: (0, 22), (12, 24), (3, 21), (9, 14), size of the input data flow is 40 mb/s.

The main idea of this test, is comparison developed method with existed algorithms. On Fig. 4 we can see comparison of developed algorithm with Dijkstra algorithm using classic ECMP for load balancing. As we can see, both algorithms have overloaded links but Dijkstra have more.

On Fig. 5 we can see comparison of developed routing method and Dijkstra algorithm with using developed load balancing method. In result we don`t have any overloaded links with developed routing algorithm but have more with Dijkstra. In comparison with previous test, we can say that developed routing algorithm + developed load balancing algorithm have better results than other combinations.

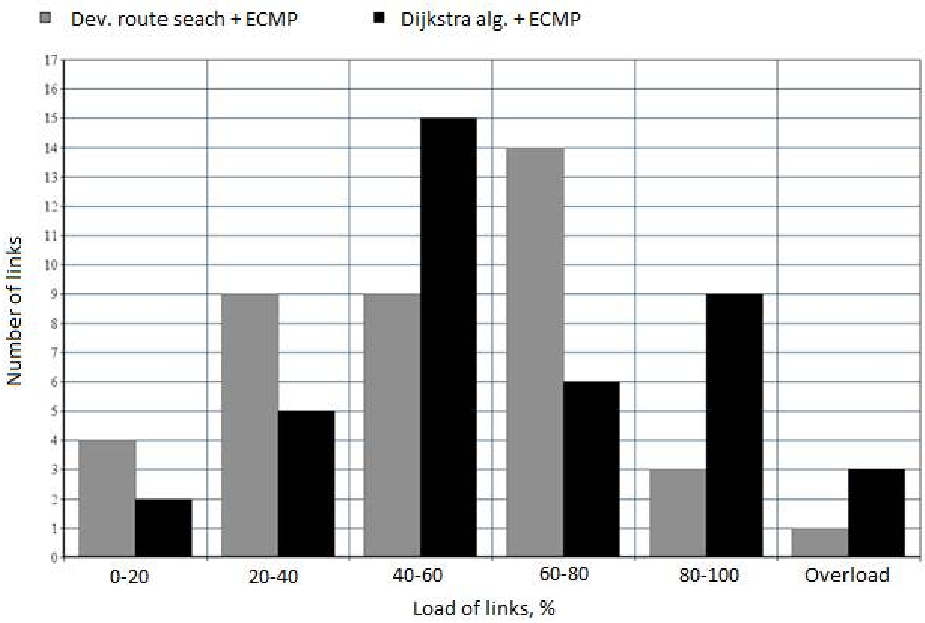

Fig. 4. Comparison of developed method with Dijkstra algorithm using ECMP

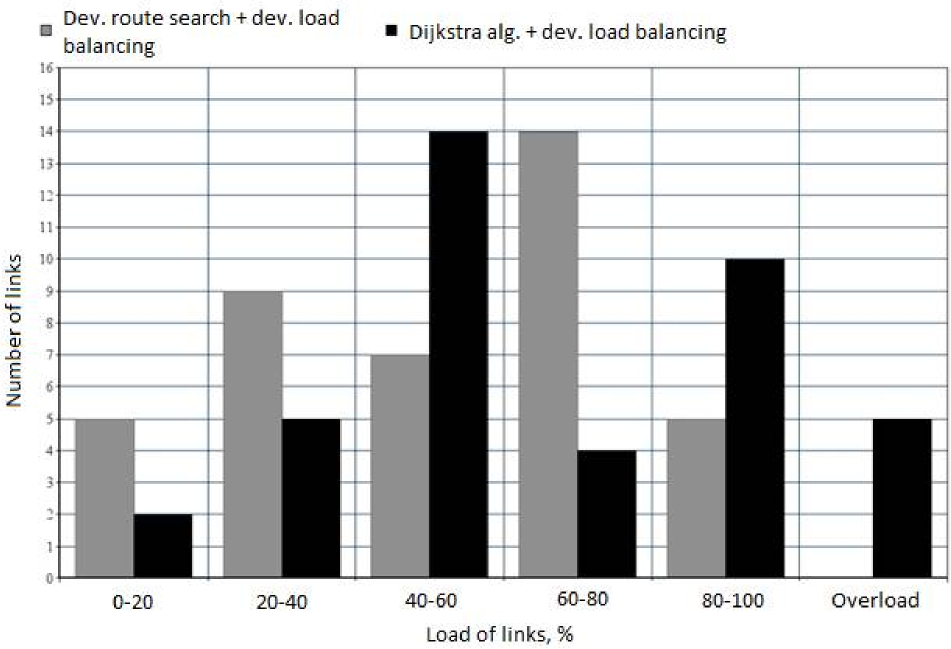

Fig. 5. Comparison of developed method with Dijkstra algorithm in load balancing

Conclusion. This paper presents a method of organizing multipath routing in software-configured networks. The main task of the modification was to increase the number of found routes by finding partially intersecting data paths. This made it possible to create a rather optimal algorithm, which can involve most of the network links and allows more optimally distribute load in network. A modification of the classic ECMP algorithm for load balancing was also presented in this work. This algorithm was developed to optimally balance network load when using partially-intersecting data transmission routes.

The simulation results showed that the solution developed in this work fulfills the tasks and can compete with other routing algorithms used in SDN networks. The simulation results also showed that the developed algorithms at work allow to optimally distribute the load on the network, which reduces the potential loss of packets and allows more efficient use of available resources.

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