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ANALYSIS AND MODELING OF DYNAMIC ROUTING NETWORK PROTOCOLS

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АНАЛІЗ І МОДЕЛЮВАННЯ ДИНАМІЧНОЇ МАРШРУТИЗАЦІЇ МЕРЕЖЕВИХ ПРОТОКОЛІВ

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This article analyzes the work of the OSPF routing protocol. Considered and justified the need for its use, identified the advantages and disadvantages. Analyzed the main features. A comparative analysis of the protocols OSPF and RIP. Based on the work done, conclusions formulated.
Keywords: *OSPF, RIP, metrics, interface cost, routing table, packet hops, Cisco Packet Tracer.*

Introduction. Network configuration is a complex and often multi-level process, the consequences of which have a huge impact on the future operation of the network. One of the main tasks that need to addressed when setting up a network is the choice of a routing protocol. A routing protocol is a network protocol used by routers to decide possible routes for results to flow through a composite computer network.

Dynamic routing is a type of routing in which the routing table is programmatically edited.

Dynamic routing protocols are usually divided by the type of algorithms used in them into:

- distance-vector;
- link-state;
- mixed type.

In fact, the protocols, taking into account the state of the channels, have replaced the distance vector protocols. The reasons for this transition were:

- The growth of channel capacity, accounting for which was absent in the distance-vector algorithm.
- The slowness of the distance-vector, which caused by so-called «count to infinity».

The following dynamic routing protocols exist RIP, OSPF, EIGRP, BGP, IS-IS.

Formulation of the problem. Many enterprises, firms, educational and government institutions have their own network in their structure. The properly chosen protocol can help to eliminate loops in the network, quickly identify and bypass its inaccessible areas and minimize the bandwidth used for routing.

The purpose of the article. The main goal of the work is to compare the routing protocols to identify their features and areas of use.

Theoretical information about the protocols.

A. OSPF protocol

One of the most commonly used communication protocols is OSPF.

OSPF (Open Shortest Path First) is a link-state technology routing protocol that has an open specification. To find the shortest path, this protocol uses Dijkstra's algorithm [1].

Among the advantages of OSPF could be distinguished [2]:

- Support VLSM (variable length subnet mask).
- High convergence time.
- Optimum bandwidth time.
- Fault tolerance, which provided by switching the exchange of information to another route for when of failure of one the routers.
- Reduced downtime risks.

B. RIP protocol

RIP (Routing Information Protocol) is an internal remote vector-type routing protocol. It is one of the easiest routing protocols. Based on its limitations, it is mainly used in small networks. Allows routers to update their routing information dynamically by getting it from their neighbor routers [3].

Comparative analysis of OSPF and RIP protocols by main criteria. Comparison of protocols carried out on the basis of key indicators, including security, load balancing, type of algorithm, and some others. The protocol metrics and the routing table configuration were considered in most detail. In addition, the issue was considered the issue of convergence.

Speaking about the comparison of the OSPF and RIP protocols, primarily, note that the OSPF protocol is intended for use in large and complex networks, while RIP is more often used for small networks. A more detailed analysis conducted in Table.

Table

Table of comparision

Indicator	OSPF	RIP
Security	Open password or key authentication MD5	Open password or key authentication MD5
Load balancing	Same metrics	-
Algorithm Type	Link-state	Distance vector
Combining routes	+	-
Variable-length subnet masks	+	+
Maximum number of routers in the network	65534	15
Accounting in the metric of various characteristics of the path	One main and three additional	One main
Update routing information	Only changes	Whole table
Availability of implementation	Open	Open
IPv6 support	+	-

A. Convergence

Network convergence is a necessary characteristic, without which the network is not fully operational. Convergence refers to the process of agreement between all routers on the best routes. Routing algorithms with poor convergence lead to creating routing loops or network failure.

This characteristic implies not only the joint but also the independent operation of devices. Despite fact is that routers communicate with each other, they need to independently find the impact of changes in topology on their own routes.

The following properties of convergence distinguished: the speed of propagation of routing data and calculate optimal paths. The propagation speed correlates with the time needed to send routing information from routers within a network.

Routing protocols are often evaluated by the convergence rate, which means that the faster the convergence performed, the more efficient the protocol is. OSPF, as a relatively new protocol, provides the fastest convergence, which makes it one of the most preferred.

One of the main principles of OSPF operation is that each router inside a zone stores the full topology of its zone. The time of bringing the network into this state is called convergence [4].

B. Protocol metrics

The metrics used by the routing protocols have a direct impact on creating the best route with the least number of hops. OSPF and RIP use different metrics, which described in more detail below.

In OSPF, when choosing the best route, a metric called cost used. It said that each link has a cost, respectively, if the route passes through several links, then their cost summed up. But the best route is the one whose cost is the lowest. The cost of an interface is inversely proportional to its bandwidth [2].

Cisco provides the following costing options:

- Cost calculated as the inverse of the link speed value.
- The cost for each link set by the user manually, based on personal ideas about the quality of this link.

The cost calculated by the formula (1):

$$p = a/b , \qquad (1)$$

where p is the cost, a is the specified bandwidth, and b is the bandwidth of interface.

RIP as a metric used packet jump - this is the number of routers through which a packet can pass along a given route. Each hop in the path from the source to the destination assigned a value of the number of hops, which is usually 1. When the router receives an update of the routing information that has a new or modified destination record, the router adds 1 to the metric value specified in the update and writes the network to routing table the sender's IP address is used as the next hop. A directly connected network to the router has a metric of zero; the inaccessible network has a metric 16 [4].

C. Configuring Routing

To configure dynamic routing, the following commands used: router and network. The router command that starts the routing process has the form:

Router(config)# *router protocol [keyword]*

where protocol is one of the routing protocols and keyword is an optional parameter.

The network command has the form:

Router (config-router)# *network network-number [keyword]*

where network-number is the identifier of the connected network and keyword is an optional parameter [5].

When using the OSPF protocol, when the router configured to work with the protocol, it begins to explore the environment through the following initialization stages [6]:

Use hello to find.

- The phase of first exchange between route bases.
- Sending route information with later confirmation.
- Compiling the routing table.
- Transition to full status.

When using the RIP protocol, the routing process connects the interfaces with the addresses that correspond to them and begins processing packets in specified networks.

Simulation and comparison. Conducting an experiment.

A. Cisco Packet Tracer Features

This simulator was developed by Cisco and recommended for use in the process of studying telecommunication networks and network equipment. But the

Cisco Packet Tracer features are suitable not only for training but also for setting up any network at the planning stage.

It includes the following features:

- Workspace, which used to create a network.
- Simulation, both in simulation mode and real-time.
- A graphical interface that used to interact with the user during the configuration process.
- Image of network equipment with the ability to move, add and remove components.

The software product allows you to design your own networks, create and send data packets. An important feature of the program is the ability to explore and use switches, routers, and workstations. Two simulation modes allow not only to see the result of packet transmission, but also to see their movement in the simulation model.

With the help of commands that entered into the command line of devices, you can display a variety of information about the network, including the routing table [7].

B. Network modeling

For a more detailed analysis of operating the OSPF protocol, a network modeled. Simulations performed using the Cisco Packet Tracer simulator. The network was configured in two ways: using OSPF and RIP. The network depicted in Fig. 1.

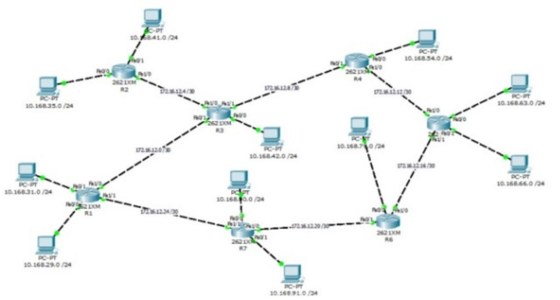

Fig. 1. Simulated network

Both of the resulting networks tested for performance by sending packets. An example of packet transmission shown in Fig. 2

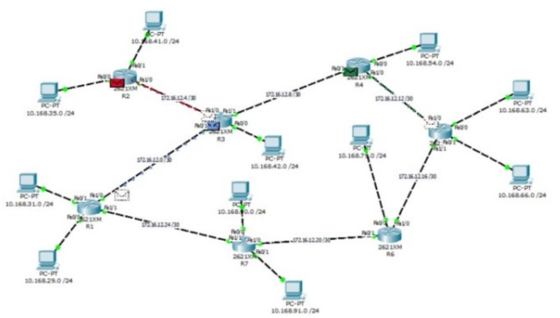

Fig. 2. Packet transmission

C. Routing Configuration Comparison

Configuring network routing using OSPF (3) and RIP (4) presented below. For example, the router R1 taken. Setup made in the command line.

```
R1>ena
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router ospf 1
R1(config-router)#network 10.168.29.0 0.0.0.255 area 0
R1(config-router)#network 10.168.31.0 0.0.0.255 area 0
R1(config-router)#network 172.16.12.1 0.0.0.3 area 0
R1(config-router)#network 172.16.12.26 0.0.0.3 area 0
```

Fig. 3. Network configuration setup (OSPF)

```
R1>ena
R1#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router rip
R1(config-router)#network 10.168.29.0
R1(config-router)#network 10.168.31.0
R1(config-router)#network 172.16.21.1
R1(config-router)#network 172.16.12.25
```

Fig. 4. Network configuration setup (RIP)

The difference in configuration setting is only in the advanced parameters — the inverse subnet mask and indication of the zone used in the OSPF protocol.

Further on Fig. 5-6 shows the routing tables of two networks:

```
     10.0.0.0/24 is subnetted, 11 subnets
C       10.168.29.0 is directly connected, FastEthernet0/0
C       10.168.31.0 is directly connected, FastEthernet0/1
O       10.168.35.0 [110/3] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       10.168.41.0 [110/3] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       10.168.42.0 [110/2] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       10.168.54.0 [110/3] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       10.168.63.0 [110/4] via 172.16.12.2, 00:57:06, FastEthernet1/0
                    [110/4] via 172.16.12.25, 00:57:06, FastEthernet1/1
O       10.168.66.0 [110/4] via 172.16.12.2, 00:57:06, FastEthernet1/0
                    [110/4] via 172.16.12.25, 00:57:06, FastEthernet1/1
O       10.168.79.0 [110/3] via 172.16.12.25, 00:57:06, FastEthernet1/1
O       10.168.90.0 [110/2] via 172.16.12.25, 00:57:06, FastEthernet1/1
O       10.168.91.0 [110/2] via 172.16.12.25, 00:57:06, FastEthernet1/1
     172.16.0.0/30 is subnetted, 7 subnets
C       172.16.12.0 is directly connected, FastEthernet1/0
O       172.16.12.4 [110/2] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       172.16.12.8 [110/2] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       172.16.12.12 [110/3] via 172.16.12.2, 00:57:06, FastEthernet1/0
O       172.16.12.16 [110/3] via 172.16.12.25, 00:57:06, FastEthernet1/1
O       172.16.12.20 [110/2] via 172.16.12.25, 00:57:06, FastEthernet1/1
C       172.16.12.24 is directly connected, FastEthernet1/1
```

Fig. 5. Routing Table (OSPF)

```
     172.16.0.0/30 is subnetted, 7 subnets
C       172.16.12.0 is directly connected, FastEthernet1/0
R       172.16.12.4 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R       172.16.12.8 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R       172.16.12.12 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R       172.16.12.16 [120/2] via 172.16.12.25, 00:00:00, FastEthernet1/1
R       172.16.12.20 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
C       172.16.12.24 is directly connected, FastEthernet1/1
C    10.168.29.0/24 is directly connected, FastEthernet0/0
C    10.168.31.0/24 is directly connected, FastEthernet0/1
R    10.168.35.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.41.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.42.0/24 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.54.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.63.0/24 [120/3] via 172.16.12.25, 00:00:00, FastEthernet1/1
                    [120/3] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.66.0/24 [120/3] via 172.16.12.25, 00:00:00, FastEthernet1/1
                    [120/3] via 172.16.12.1, 00:00:06, FastEthernet1/0
R    10.168.79.0/24 [120/2] via 172.16.12.25, 00:00:00, FastEthernet1/1
R    10.168.90.0/24 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
R    10.168.91.0/24 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
```

Fig. 6. Routing Table (RIP)

Both routing tables show directly connected devices and the paths along which devices that at distance from the router are connected, as well as the ports used for this.

In addition, we can see the difference in the administrative distance, which is 110 for OSPF and 120 for RIP.

The designation O is the address formation by the OSPF protocol, and R is the address formation by the RIP protocol, respectively.

D. Comparing Metrics

An important difference between OSPF and RIP could be observed in the metrics that they use. These data could be viewed, and in some cases even changed, when you configure the network in Cisco Packet Tracer. In Fig. 7 marked packet hop for RIP:

```
      172.16.0.0/30 is subnetted, 7 subnets
C        172.16.12.0 is directly connected, FastEthernet1/0
R        172.16.12.4 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R        172.16.12.8 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R        172.16.12.12 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R        172.16.12.16 [120/2] via 172.16.12.25, 00:00:00, FastEthernet1/1
R        172.16.12.20 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
C        172.16.12.24 is directly connected, FastEthernet1/1
C     10.168.29.0/24 is directly connected, FastEthernet0/0
C     10.168.31.0/24 is directly connected, FastEthernet0/1
R     10.168.35.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.41.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.42.0/24 [120/1] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.54.0/24 [120/2] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.63.0/24 [120/3] via 172.16.12.25, 00:00:00, FastEthernet1/1
                     [120/3] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.66.0/24 [120/3] via 172.16.12.25, 00:00:00, FastEthernet1/1
                     [120/3] via 172.16.12.1, 00:00:06, FastEthernet1/0
R     10.168.79.0/24 [120/2] via 172.16.12.25, 00:00:00, FastEthernet1/1
R     10.168.90.0/24 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
R     10.168.91.0/24 [120/1] via 172.16.12.25, 00:00:00, FastEthernet1/1
```

Fig. 7. Hop records (RIP)

For greater clarity, one route considered for both networks using the traceroute command. The results presented in Fig. 8-9:

```
R1#traceroute 10.168.54.0
Type escape sequence to abort.
Tracing the route to 10.168.54.0

  1   172.16.12.2     47 msec   31 msec   32 msec
  2   172.16.12.10    23 msec   62 msec   46 msec
```

Fig. 8. Traceroute (OSPF)

```
R1#traceroute  10.168.54.0
Type escape sequence to abort.
Tracing the route to 10.168.54.0

  1   172.16.12.1     32 msec   31 msec   31 msec
  2   172.16.12.10    47 msec   62 msec   62 msec
```

Fig. 9. Traceroute (RIP)

We can notice that there is no difference in the number of packet hops, but there are small differences in time in favor of the OSPF protocol.

In addition, on the network using OSPF it is possible to find out and change the cost of interface, as one of the main protocol metrics. To do this, use the command:

R1#*show ip ospf interface*

The results shown in Fig. 10:

```
R1#show ip ospf interface
FastEthernet0/0 is up, line protocol is up
  Internet address is 10.168.29.1/24, Area 0
  Process ID 1, Router ID 172.16.12.26, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1
  Designated Router (ID) 172.16.12.26, Interface address 10.168.29.1
  No backup designated router on this network
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    No Hellos (Passive interface)
  Index 1/1, flood queue length 0
  Next 0x0(0)/0x0(0)
  Last flood scan length is 1, maximum is 1
  Last flood scan time is 0 msec, maximum is 0 msec
  Neighbor Count is 0, Adjacent neighbor count is 0
  Suppress hello for 0 neighbor(s)
```

Fig. 10. Interface Cost (OSPF)

Changes in cost will make adjustments to the formation of routes.

The Cisco Packet Tracer simulator does not provide for such commands for the RIP protocol since the protocol has a completely different principle of route generation. Accordingly, introduction of changes by the user is also not provided.

At the same time, the software product allows you to consider most of the features of the protocols, which reflected in the work.

Conclusions. According to the results of the study, we can conclude that the OSPF protocol is one of the most popular in the modern world, but this, for the most part, concerns networks with a large number of nodes. Many factors contribute to this, in particular, the high time of network convergence. Best of all, the difference between the OSPF protocol and others can be seen in the example of comparison with other dynamic protocols, like the RIP protocol used in the work. It can be concluded that the results of the two protocols may be about the same, provided that the network being studied is small. In addition, the OSPF protocol has more functionality than the older RIP protocol. The analysis and comparison carried out in this paper allow us to draw conclusions about feasibility of using the OSPF protocol in certain conditions.

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Барбарук Л.В., Михайлова А.О., Бакитько Д.Е. Аналіз і моделювання динамічних протоколів мережі маршрутизації

У цій статті аналізується робота протоколу маршрутизації OSPF. Розглянуто та обґрунтовано необхідність його використання, виявлені переваги і недоліки. Проаналізовано основні особливості. Порівняльний аналіз протоколів OSPF і RIP. На підставі виконаної роботи зроблені висновки.

Ключові слова: *OSPF, RIP, метрики, вартість інтерфейсу, таблиця маршрутизації, стрибки пакетів, Cisco Packet Tracer.*

Барбарук Л.В., Михайлова А.А., Бакитько Д.Э. Анализ и моделирование динамических протоколов сети маршрутизации

В этой статье анализируется работа протокола маршрутизации OSPF. Рассмотрена и обоснована необходимость его использования, выявлены достоинства и недостатки. Проанализированы основные особенности. Сравнительный анализ протоколов OSPF и RIP. На основании проделанной работы сделаны выводы.

Ключевые слова: *OSPF, RIP, метрики, стоимость интерфейса, таблица маршрутизации, прыжки пакетов, Cisco Packet Tracer.*

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