Comparison the Performance of OSPF and IS-IS Protocols in Different Topologies

[1]Yahya Tareq Hussein

Department of Computer Techniques Engineering

Dijlah College University

Yahya.tareq@duc.edu.iq

ABSTRACT

This article compare between two deferentprotocols: OSPF (Open Shortest Path First) and IS-IS (Intermediate-System-to-Intermediate-System) and unveil the differences and similarities between them. A telecommunication network was designed to measure the traffic service of protocols. Discusses the terminology of protocols, contrast in network design.The coparission criteria are domain design, transport and volume of service traffic. The compared protocols generate different amounts of service traffic. With standard settings, the OSPF protocol generates several times less service data on a stable network than the IS-IS protocol. The small amount of OSPF overhead traffic allows you to deploy routing in large networks with a bottleneck problem without large loss of bandwidth. If this problem does not exist, using the IS-IS protocol will not damage the network.

Keywords: OSPF, IS-IS, topology, dynamic routing, network architecture, traffic, Dijkstra's algorithm.

INTRODUCTION

Currently, various dynamic routing protocols are widely used: BGP (Border Gateway Protocol), OSPF (Open Shortest Path First), IS-IS (Intermediate System to Intermediate System), and others. All of them are divided into two large groups: the external routing protocols EGP (Exterior Gateway Protocol) and internal routing IGP (Interior Gateway Protocol). The main task of dynamic routing protocols is the automatic search for the best route based on certain attributes for transmitting traffic over the network [1]. For example, dynamic routing protocols help efficiently use redundant communication channels, avoiding routing loops.The paper discusses several IGPs, such as OSPF and IS-IS, presents their comparative characteristics, and offers recommendations on the choice of protocol. Both protocols are based on channel state tracking technology and use the Dijkstra algorithm to find the shortest path.OSPF is a hierarchical protocol developed by the IETF (Internet Engineering Task Force). The development of the OSPF protocol began in 1987, today they use two versions:

OSPFv2: OSPF for IPv4 networks (RFC 1247 and RFC 2328) [2].

OSPFv3: OSPF for IPv6 networks (RFC 2740) [2].

The IS-IS hierarchical protocol was developed in 1978. ISO as a routing protocol for its own Connectionless Network Protocol (CLNP), which was part of the protocol stack designed to replace TCP / IP. The IS-IS protocol is described in ISO 10589. It has a two level hierarchical architecture.The compared protocols use different terminology (Table 1).

Table (1) Conformity of terms in protocols

#	OSPF	IS-IS
	Link	Circuit
	Host	End System (ES)
	Area	Sub domain (area)
	Link-State Advertisement	Link-State PDU (LSP)
	Router	Intermediate System (IS)
	Backup DR (BDR)	No equivalent, not used
	Packet	Protocol Data Unit (PDU)
	Designated router (DR)	Designated IS (DIS)
	Non-backbone area	Level-1 area
	Backbone area	Level-2 Sub domain (backbone)
	Hello packet	Hello PDU
	Autonomous System Boundary Router (ASBR)	Whatever IS
	Area Border Router (ABR)	L1L2 router

STUDY OF SIMILARITIES AND DIFFERENCES

Although OSPF and IS-IS are different protocols, they have some common features, for example:

• IGP, distribute routing information between routers only within one AS (Autonomous system);

• Dijkstra's algorithm was used to find the shortest path based on the state of the communication channels;

• Bidirectional Forwarding Detection (BFD) support and the ability to detect loss of communication with a neighbor for 50 ms depending on the hardware implementation of the equipment. The time of convergence of the protocols was studied in [3, 4];

• CIDR support (Classless Inter-Domain-Routing) - classless routing;

• VLSM support (Variable Subnet Length Masking) - variable length subnet masks;

• QoS (Quality of Service) support - quality of service;

• Authentication support.

DOMAIN DESIGN

First of all, it is worth considering the possibilities of domain design when creating a network. Properly built domain is one of the key points when choosing a network architecture, because it allows you to solve several possible problems in the future:

• Provide for scalability;

• Reduce the load on the router's hardware resources;

• Reduce network recovery time in case of an accident;

• Increase network resiliency in general.

The OSPF and IS-IS protocols ideologically relate differently to the issue of domain design.

OSPF is a hierarchical protocol, this means that the entire domain routing protocol OSPF can be divided into separate areas (area). The division into areas should not be arbitrary. If the topology is really divided into areas, the area with the number 0 (the so-called zero area) must be present, and all other areas are connected to the zero area using the ABR (Area Border Router) routers. Any interaction between the peripheral areas will be provided through the zero area [5]. That is, the OSPF protocol collects the "star" topology with a zero zone in its center. This construction of network logic provides protection against routing loops at the network level. The core of the network is usually allocated to the null region, and the periphery falls into the other regions. At the same time, the boundary between the regions passes inside the router, that is, in fact, the area does not belong to the entire router, but its separate interface, and the areas are delimited within the router. In Figure 1 shows the classic domain structure of the OSPF protocol.

The IS-IS protocol is also a hierarchical protocol with the possibility of dividing the topology into regions. But the principles of this separation are completely different:

• IS-IS-domain routers belong entirely to any one zone, i.e., the border between the regions passes through the communication channel between the routers, and not inside the router;

• There is no special zone number (as a zero zone in the OSPF protocol). That is, the areas into which the topology is divided can have arbitrary numbers and merge together in an arbitrary way.

The hierarchy of the protocol is based on the levels of interaction between routers with each other. A pair of IS-IS routers connected to each other can form two levels of interaction: Level 1 and Level 2 (L1 and L2). At the same time, a level 1 (L1) neighborhood is formed only between routers of the same area, and a level 2 (L2) neighborhood can be formed between routers of the same or different areas [6]. There are also L1 / L2 routers for interaction between routers of different levels, usually they are located on the border of a region [7]. An example of the formation of the design of the IS-IS protocol topology is shown in Fig. 2. In this case, the routers in zone 50.01 will own the full amount of routing information in the network, and routers in zone 50.02 and zone 50.03 will not know anything about each other, all duties on routing between them will be assumed by zone 50.01. This scheme is very similar to the OSPF protocol topology, and zone 50.01 is analogous to the null region, thus the core of the network is usually isolated and the interaction of the zones between themselves is delimited.

TRANSPORT

OSPF protocol was initially focused on IP networks, so it encapsulates its packets into IP packets. The IS-IS protocol encapsulates service packets directly into the link layer frames, thereby supporting several network layer protocols (for example, IP, IPX and AppleTalk) [8]. In addition, it provides additional protection against attacks at the network level aimed at this protocol, which is undoubtedly a big plus in its favor.

SERVICE TRAFFIC, TOPOLOGY MODELING, AND TESTING

Another criterion for comparison is the volume of service traffic generated by the protocols, since this affects the overall throughput of the communication channel. Within the framework of the article a test stand was assembled with the topology of four routers, shown in Fig. 3. The software product GNS3 was used as a medium (a graphical network simulator that allows modelingcomplex networks [9]). The Cisco 2691 routers as used platforms

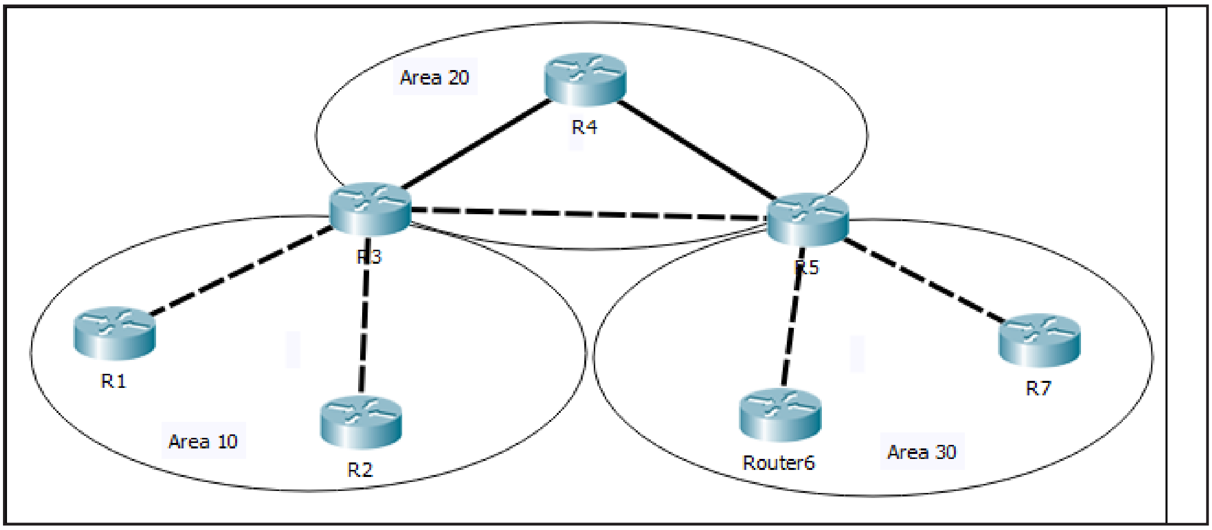

Fig. 1. OSPF Domain Design

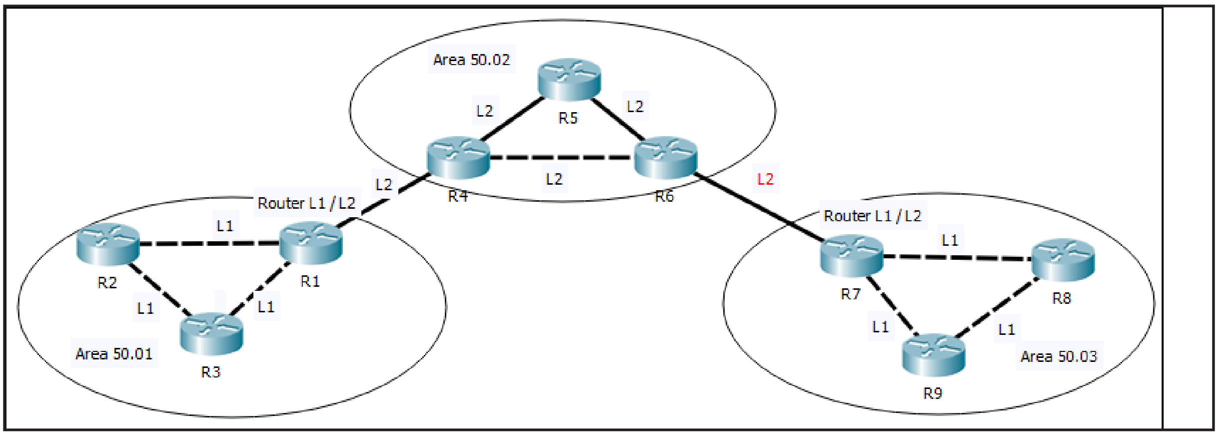

Fig. 2. Design of the IS-IS domain

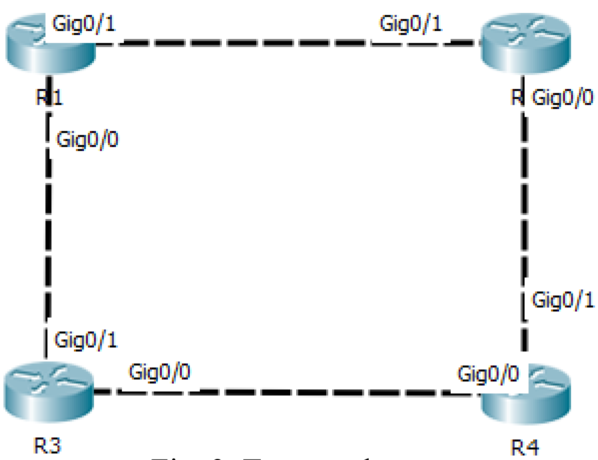

Fig. 3. Test topology

On each link between routers, an OSPF neighborhood in the null region is established, as well as an IS-IS L2 protocol adjacency with standard timers to emulate one domain with all the routing information distributed among all routers, which means the presence of all route data on each of the physical communication channels. The purpose of the experiment is to measure the volume of service traffic in a stable network; for this purpose, the WireShark utility is used — a traffic analyzer program for computer Ethernet networks and some others [10].

The traffic is always captured on the communication channel between the routers R1 and R2.

Test 1. Traffic is captured on the specified topology. The result of analysis is shown in Fig. 4. As can be seen from fig. 4, the IS-IS protocol sends 74.2% of all packets on this communication channel, but their volume occupies 96.1% of the total transmitted traffic, the share of the OSPF protocol accounts for only 1.6%. Analyzing the packet size statistics shown in Fig. 5, we can see that there are 583 packets with a volume of 1514 bytes. According to fig. 4, these are IS-IS Hello packets. Paying attention to the contents of the package, we will see that most of its volume is the Padding field, designed to detect problems with MTU in the communication channel before establishing a neighborhood.

Test 2. On all interfaces of routers where the IS-IS protocol process is running, the command 'no isis hello padding' is written. It proposes not to fill in the Padding field in the IS-IS Hello PDU for an already established neighborhood relationship. The result is shown in Fig. 6. The IS-IS protocol sends 74% of all packets, but now their total volume is 60.6%, the share of OSPF packets is only 16.4%. The ratio has changed 10 times. The traffic volume of the IS-IS protocol without taking into account transport overhead - 897 579 bytes in the first test and 56 838 bytes in the second test - decreased 15.8 times. The padding field in an IS-IS PDU significantly affects the amount of IS-IS protocol traffic

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s
Frame	100.0	1000	100.0	934377	5887
Ethernet	100.0	1000	1.5	14000	88
Logical-Link Control	74.2	742	96.3	899805	5669
ISO 10589 ISIS InTRA Domain Routeing Information Exchange Protocol	74.2	742	96.1	897579	5655
ISO 10589 ISIS Link State Protocol Data Unit	1.3	13	0.1	926	5
ISO 10589 ISIS Complete Sequence Numbers Protocol Data Unit	14.6	146	2.4	22630	142
ISIS HELLO	58.3	583	92.9	868087	5469
Internet Protocol Version 4	25.4	254	0.5	5080	32
Open Shortest Path First	25.4	254	1.6	15240	96
Data	0.4	4	0.0	252	1

Fig. 4. Results of traffic analysis

Topic / Item	Count	Average	Min val	Max val	Rate (ms)	Percent
Packet Lengths	1000	934.38	69	1514	0.0008	100%
0-19	0	-	-	-	0.0000	0.00%
20-39	0	-	-	-	0.0000	0.00%
40-79	11	71.91	69	77	0.0000	1.10%
80-159	260	94.78	94	138	0.0002	26.00%
160-319	146	180.00	180	180	0.0001	14.60%
320-639	0	-	-	-	0.0000	0.00%
640-1279	0	-	-	-	0.0000	0.00%
1280-2559	583	1514.00	1514	1514	0.0005	58.30%
2560-5119	0	-	-	-	0.0000	0.00%
5120 and greater	0	-	-	-	0.0000	0.00%

Fig. 5. Package size statistics

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s
Frame	100.0	1001	100.0	93807	588
Ethernet	100.0	1001	14.9	14014	87
Logical-Link Control	74.0	741	63.0	59061	370
ISO 10589 ISIS InTRA Domain Routeing Inform...	74.0	741	60.6	56838	356
ISO 10589 ISIS Link State Protocol Data Unit	1.1	11	0.8	724	4
ISO 10589 ISIS Complete Sequence Numb...	14.7	147	24.3	22785	142
ISIS HELLO	58.2	583	29.2	27401	171
Internet Protocol Version 4	25.6	256	5.5	5120	32
Open Shortest Path First	25.6	256	16.4	15360	96
Data	0.4	4	0.3	252	1

Fig. 6. Results of traffic analysis without Padding

Test 3. The network is doubled and now consists of 8 routers that build the topology, as shown in fig. 7. As before, on each communication channel, an OSPF and IS-IS adjacency relationship is established. Interface settings are the same as in the second test.

The result is shown in Fig. 8. The percentage of packets transmitting is the same. The percentage of transmitted traffic has changed: the percentage of IS-IS increased from 60.6% to 68.7%, while the percentage of OSPF conversely decreased from 16.4% to 12.9%. 252 OSPF packets with a total complexity of 15,120 bytes were transmitted, in other words, the traffic volume did not change as compared with the previous test. The IS-IS protocol now accounts for 80,342 bytes,up from 56,838 bytes, with overhead data growth of 41%. This is due to the fact that with a stable network, OSPF protocol only exchanges Hello-packets.The amount of data in the IS-IS protocol increases.Based on the statistics, it can be seen that compared with the second test, the total volume of IS-IS CSNP packets (Complete Sequence Number PDU) increased by 2 times compared to the same number. Using these PDUs, IS-IS routers synchronize their topology information known to them, PDUs contain a list of all LSPs (Link-State PDUs).Thereforethe volume of the IS-IS CSNP packet directly depends on the number of routers in the network and on its connectivity, which implies a direct dependence of the volume of IS-IS service traffic from the IS-IS CSNP packet size

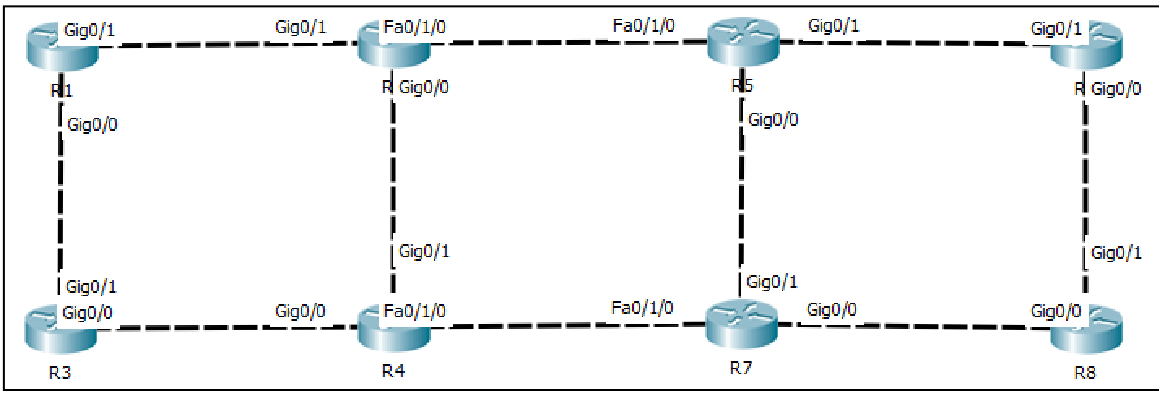

Fig. 7. Extended Test Topology

Protocol	Percent Packets	Packets	Percent Bytes	Bytes	Bits/s
Frame	100.0	1000	100.0	116986	742
Ethernet	100.0	1000	12.0	14000	88
Logical-Link Control	74.4	744	70.6	82574	523
ISO 10589 ISIS InTRA Domain Routeing Information Exchange Protocol	74.4	744	68.7	80342	509
ISO 10589 ISIS Link State Protocol Data Unit	2.1	21	1.3	1529	9
ISO 10589 ISIS Complete Sequence Numbers Protocol Data Unit	14.4	144	39.0	45648	289
ISIS HELLO	57.9	579	23.3	27213	172
Internet Protocol Version 4	25.2	252	4.3	5040	31
Open Shortest Path First	25.2	252	12.9	15120	95
Data	0.4	4	0.2	252	1

Fig. 8. Results of traffic analysis for the topology of 8 routers

Table 2. Test results

Test number	Taking time	Number of Packages,	Number of links	Number of routers	Protocol	Traffic volume, byte	Occupied, bps
1	1240	1000 4	4		OSPF	15240	5655
					IS-IS	897579 9	6
2	1235	1001 4	4		OSPF	15360	356
					IS-IS	56838 9	6
3	1260	1000 1	0	8	OSPF	15120	509
					IS-IS	80342 9	5

Also here the rule of transitivity applies, the volume of service traffic directly depends on the number of routers in the network and on its connectivity.In table 2 summarizes the test results.The OSPF protocol shows obvious stability regardless of the number of routers and the connections between them.The volume of service traffic of the IS-IS protocol varies depending on the presence of the Padding field in protocol packets, and is directly dependent on the number of routers and the connections between them.Even after optimization (disabling the Padding field in the Hello PDU for an established neighborhood), this protocol generates a greater amount of service traffic.

CONCLUSIONS

The compared protocols are somewhat similar:

1- IGPs use the same algorithm for calculating the shortest path, together with the BFD protocol, they show almost the same convergence time.

2- The compared protocols differ in design approach. The OSPF protocol builds a star-type topology with a null region in the center and does not allow all other regions to interact with each other bypassing the null region, which, in turn, is an excellent protective mechanism against routing loops. Currently, this approach is practiced in most networks of various sizes. IS-IS protocol domain design architecture is different. The areas inside the AS can be connected in any order, which makes it difficult for a person to understand topology with a network of large sizes and creates additional opportunities for the appearance of loops, and the probability of human error during configuration also increases. On the other hand, the IS-IS protocol has a flexible two-tier architecture and allows you to createan analogue of the zero domain of the OSPF protocol with proper domain design, but this causes additional work.

3- The compared protocols use transport for their packets at different levels on the OSI model. OSPF packets use the network layer and encapsulate their data in IP packets. The ISIS protocol transmits service data at the data link layer, this release the protocol from possible attacks at the network level, which speaks in favor of this protocol.

4- The compared protocols generate different amounts of service traffic. With standard settings, the OSPF protocol generates several times less service data on a stable network than the IS-IS protocol. From tab. 2 that the increase in the amount of IS-IS protocol traffic is directly proportional to the number of nodes in the network and the connections between them. The small amount of OSPF overhead traffic allows you to deploy routing in large networks with a bottleneck problem (the problem of slow information exchange due to the low bandwidth of one of the communication channels in the network) without large loss of bandwidth. If this problem does not exist, using the IS-IS protocol will not damage the network. With modern data transfer rates, the overhead information generated by the protocol is negligible and does not affect the performance of the channel.

REFERENCES

[1]. Oliver V. G., Oliver N. A. Computer Networks. Principles, Technologies, Protocols: Textbook for high schools 4th ed. St. Petersburg, Piter, 2010, 944 p.

[2]. Makarenko S. I. The Convergence Time of Routing Protocols in Case of Network Failures [Vremjashodimostiprotokolovmarshrutizaciipriotkazah v seti] Sistemyupravlenija, svjazi I bezopasnosti, 2015, no. 2, pp. 45-98.

[3]. Tsegaye Y., Geberehana T. OSPF Convergence Times. Master of Science Thesis in the Programme Networks and Distributed Systems. Göteborg (Sweden), Chalmers Univ. Technol., 2012, 77 p. Available

[4]. Odom W., Hogg S. CCNA Routing and Switching ICND2 200-105 Official Cert Guide. Indianapolis, Cisco Press, 2016, 2557 p.

[5]. Cisco Systems (2017). Available at: http://cisco.com (accessed 19 March 2017).

[6]. Martey A. IS-IS Network Design Solutions. Indianapolis, Cisco Press, 2002, 405 p.

[7]. Tanenbaum A., Wetherall D. Computer Networks. 5th ed. St. Petersburg, Piter, 2012, 960 p.

[8]. GNS3 documentation (2017). Available at: http://docs. gns3.com (accessed 23 March 2017).

[9]. Wireshark documentation (2017). Available at: https://www.wireshark.org/docs (accessed 23 March 2017).