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IS IS NETWORK

CLASS: BSE V A

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ABSTRACT:

This research paper shows the terminology and algorithms used in IS-IS routing protocol. The purpose for the development of IS-IS is for routing the OSI traffic and it is capable of routing the protocols of internet traffic. The algorithm used in IS-IS is shortest path first in order to determine the routes. For designing the complex network topologies IS-IS is used. In IS-IS terminology the routers exchange the information of topology with their neighbors in the nearest. Finding the best path for each destination can be done with the help of IS-IS.

1. INTRODUCTION:

In late 1980s IS-IS protocol was developed by DEC. The abbreviation for DEC is Digital Equipment Corporation. In ISO/IEC 10589, IS-IS protocol was organized by ISO.

IS-IS protocol is considered as link state protocol and offers several different advantages which are not provided by the distance vector protocol such as provide support to larger internetworks; speed is faster and is less permitting to routing protocols. The algorithm used in IS-IS is shortest path first in order to determine the routes.

Topology changes are evaluated by IS-IS and determines that either there is a need to perform a complete SPF recalculation or a partial route calculation. The purpose for the development of IS-IS routing protocol is to route CLNP, which means Connectionless Network Protocol Packets. When there is a change in a network IS-IS uses hello packets which allow quickly occurrence of network convergence, same terminology is used by OSPF.

On data link layer IS-IS terminology is run called as layer 2 routing protocol, where as other routing protocols run on UDP,TCP,IP and considered as layer three and layer four protocols. On the top of Ethernet header IS-IS protocol can be run by using its own format of header.IS-IS protocol does not allow the encapsulation in an IP packet.

1.1 IS-IS TERMINOLOGY:

- Network topology is described with the help of packets; those packets are referred as link state protocol.
- Link state protocols have information of all the IP routes, data, checksum and other information.

2. LITERATURE REVIEW:

To configure a routing protocol is considered as one of the basic part of designing the network. In **reference paper [1],** there is a comparison of IS-IS, EIGRP and OSPF protocols of routing. Comparative analysis is performed between all of them by creating a network for voice and video conferencing. The results obtained from this comparative analysis is that, if we want to increase the

efficiency and performance of networks combination of three or two routing protocols is best and suggested.

In **reference paper [2**], there is a comparison of IS-IS and OSPF protocols of routing. Results show that they both are referred as routing algorithms of link state. Some similarities and some difference are shown in this comparative analysis. IS-IS routing protocol is referred in level 1 computing router and offers storage to minimize whereas OSPF offers routing to optimize.

In **reference paper [3],** it is discussed that IS-IS use can be related to ISP network development history. The scalability of IS-IS is larger than OSPF. Taking risk into account is not preferable that's why IS-IS is used for the establishment of the network backbone. For changing the protocol network cost is high.

In **reference paper [4]**, it is discussed that IS-IS protocol of routing uses information of IPv6 and is referred as router of intra-area, knows only about the local areas and creates a database link-state and tree of SPF for that area.

In **reference paper [5],** it is discussed that the IS-IS routing protocol provides the better performance as compared to the OSPF like:

- Duration of the convergence of network
- Activity of the convergence of network
- Duration of the convergence of router
- Activity of the convergence of router
- Throughput
- Queuing delay

All above mentioned features are provided by the IS-IS and provide better stabilization.

In the **reference study [6],** performance analyses of OSPFv3 and IS–IS are performed, evaluated, and contrasted on a simulation basis. In most instances, including the converging issue, IS-IS beats OSPFv3. To choose the best feasible way to move a packet to a specific destination, both these protocols use Dijkstra's shortest path first approach. OSPF only supports IP, whereas IS-IS enhance have both CLNS and IP. This explains that IS-IS routing protocol may be transferred between routers without the need for IP connectivity. There is also less LSP traffic since an IS-IS router corresponds to only one Level 2 region. Businesses that use networking apps and services are migrating from IPV4 to IPv6.

Reference paper [7] says that in all cases, EIGRP is the ideal option since it has a high convergence time and efficiently utilizes bandwidth. In regards of convergence time, IS-IS was the next best option, followed by OSFP. Due to its low performance, BGP is not ideal for big networks. Based on the data, there is a substantial difference in the performance of the protocols in regards of convergence time.

According to the **reference paper [8],** this study presents a method that enables IS-IS routing to transfer traffic away from a node-to-node or multi-access LAN connection rapidly and correctly during servicing or other operational events. This is performed by signaling IS-IS neighbors with a greater reversal metric, i.e. the IS-IS signaling direction.

Performance of numerous routing protocols was compared in a **reference study [9],** and it was revealed that EIGRP/IS-IS outperformed the others. EIGRP/IS-IS networks learn all network nodes significantly faster than IS-IS or OSPF/IS-IS networks. The IS-IS network, in particular, is slower to learn than the other two. The network that employs EIGRP/IS-IS has a quicker database response time than other networks that use OSPF, IS-IS, EIGRP, or OSPF/IS-IS. In a network that employs the OSPF/IS-IS combination, database response time is slower. As a result, database access is significantly faster in EIGRP/IS-IS networks than in OSPF/IS-IS networks. Other networks that use OSPF, EIGRP, IS-IS, OSPF/IS-IS, and OSPF/IS-IS have faster HTTP object response times and E-mail download response times than EIGRP/IS-IS networks. A network using the OSPF/IS-IS combination, on the other hand, has a delayed response in both cases. Therefore, EIGRP/IS-IS provides end users with faster access to HTTP applications OSPF, EIGRP, IS-IS, or OSPF/IS-IS networks. The performance of all connections is similar at the beginning of this study. However, the network that uses the OSPF/IS-IS combination beats all other systems in throughput after a few minutes.

In reference paper [10], they did a comparison analysis of selected protocols such as IS-IS, OSPFV3. The comparison analysis was conducted on the same network utilizing multiple protocols for real-world applications. A collection of variables was used to estimate performance to regulate the effects of routing methods. The IS-IS Protocol beats other two in specific terms of video end-to-end latency, according to the simulated data in the paper. In Jitter, OSPFV3 trumps the other two. In voice end-to-end delay, IS-IS OSPFV3 performs better.

Reference paper [11] confirms that IS-IS protocol surpasses the OSPF and EIGRP routing protocols in a comparison of several routing protocols. However, EIGRP's proprietary features and cost might be a hindrance at times. In large networks, OSPF surpasses competing protocols because to its hierarchical nature, which enhances scalability. Both big and medium networks benefit from IS-IS. The redistribution command shows how to use a variety of routing protocols. These conclusions are based on a performance examination of selected inner access point such as EIGRP, IS-IS, and OSPF, as well as an evaluation of numerous performance problems.

Using Riverbed Modeler, **reference paper [12]** investigated the performance of main routing algorithms: RIP, OSPF, EIGRP, and IS-IS. Here mesh topology and tree topologies have been developed, and each routing protocol had been simulated in each of the three topologies. Initially, the three routing methods were deployed in a tiny tree network and assessed. To assess the differences in their performance, we used convergence activity, convergence time, and traffic transmitted (bytes/sec). The three protocols were then implemented in large mesh and big tree topologies, and the results were reviewed. Three variables IS-IS is the quickest of the four. In comparison to RIP, EIGRP, and BGP, OSPF takes longer to initialize. IS-IS, In comparison to EIGRP and IS-IS, both RIP and OSPF have a longer initiation time.

3. FEATURES OF IS-IS:

The features of IS-IS routing protocol includes:

- Arrangement of routers in hierarchical manner
- Detecting classless behavior
- New information flooding rapidly
- Fast concurrence

- Very extensible
- Timer tuning is flexible
- Multi-area routing implementation(CISCO IOS)
- Route-leaking implementation(CISCO IOS)
- Overload-bit implementation(CISCO IOS)

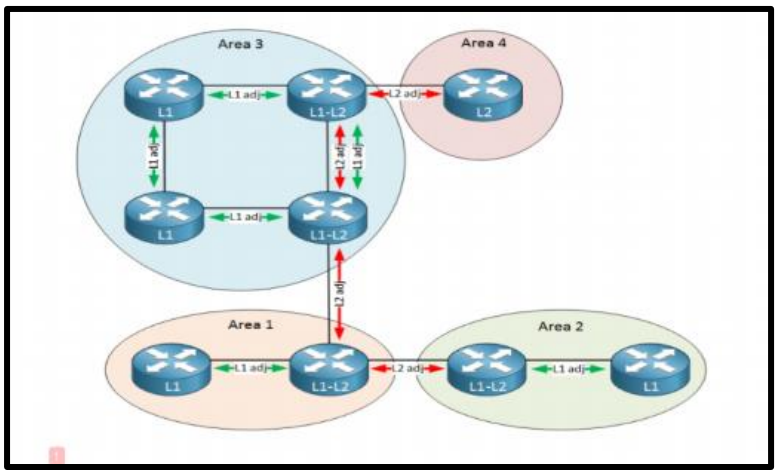
ROLES OF ROUTER AND AREAS:

Different areas are used in IS-IS and no backbone area is found. For backbone string of routers are used which involve routers of three types such that:

SYSTEM OF 1-LEVEL: System of 1-level is referred as router of intra-area, knows only about the local areas and creates a database link-state and tree of SPF for that area in 1-level.

SYSTEM OF 2-LEVEL: Level-2 system is called as router of backbone because it contains the information of both inter-area router and the intra-area router. Create a database of link-state and tree of SPF for that backbone in 2-level.

SYSTEM OF 1-2 LEVEL: Both above roles are performed by this router such as it creates separate link state database for both level 1 and level 2 as well as it creates two SPF trees for each database. Neighbor adjacencies are performed by router having same level.



4. IS-IS OPERATIONS

Explaining IS-IS working:

- To find neighbors and generate adjacencies, routers transmit packets including hello messages out all IS-IS-active ports.
- If the hello packets from routers sharing a shared data connection contain information that fits the criterion for constructing an adjacency, they will become IS-IS neighbors. Depending on the type of media being utilized, the requirements varies somewhat (p2p or broadcast). Matching authentication, IS-type, and MTU size are the most important conditions.
- Routers can construct a (LSP) using their own interactions set for IS-IS also addresses learnt from other routes.

- In most cases, the routers send LSPs to every neighboring peers save one through which they got the LSP. However, we have several types of flooding, as well as variety of conditions under which the flooding activity may differ.
- Every router use these LSPs to build their link-state databases.
- Each IS calculates a shortest-path tree, and the routing table is generated from this SPT.

5. DATA-FLOW DIAGRAM OF IS-IS:

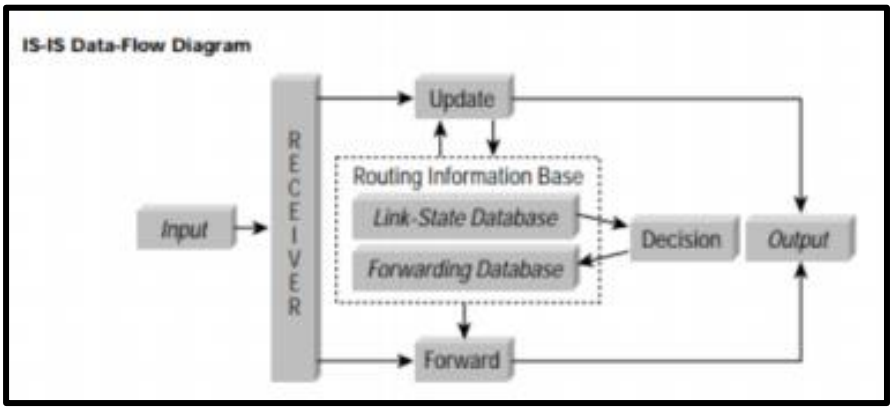
Point-to-point link is used in IS-IS in order to handle the adjacencies with other routers. Pseudo node LSP is generated within LAN environment. For the maintenance of synchronization and conducting flood over LAN, DIS is responsible for both of that.

Figure below shows the information flow mechanism in IS-IS routing protocol. The data flow diagram of IS-IS contains four processes which include:

- Receive
- Update
- Decision
- Forward

And a RIB is present in IS-IS which contains:

- Link-state database
- Forwarding database



The entry point of all data like user data, reports of error, information of routing and control of packets comes under the receive process. It pass data of user, reports of error to the process of forward and pass out the information of routing and packets control to the update process. Local link information is generated by update process which is flooded to routers that are adjacent as well as processes and forward the information that is received from adjacent routers.

Link-state databases of level 1 and level 2 are managed by this process as well as the floods that occur in level 1 and level 2 LSPs. Remaining lifetimes, sequence number and checksum is contained by each LSPs. The countdown of lifetime starts from 1200 to 0. Periodically this lifetime is preventing by LSPs originator in order to stop it from reaching to 0.

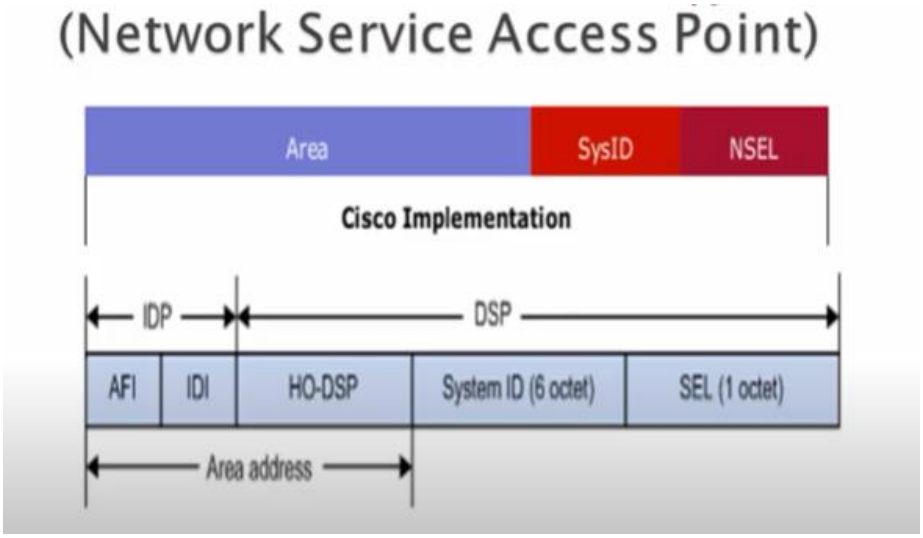
15 minutes is the refresh interval time, up to random 25 percent. LSP got expired if the remaining lifetime reaches to 0 but LSP will be stilled hold in the database for additional 60 seconds. If there is incorrect checksum of LSP received by router, then the router sets the remaining life time value to 0 by removing the body and router will reflood it.

New LSP is send by the LSP generator. This behavior shows the difference between the OSPF and the IS-IS.LSPs having the incorrect checksum will not purged due to configured IS-IS, but the originator of LSP router will not knew about the LSP received or not.

On link-state database decision process runs SPF and forwarding database is created. Next-hop information is computed as well as adjacency sets are created for the purpose of balance loading. Up to six equal cost paths are used in cisco router in order to support load balancing. Receive process provide input to the forward process and then data packets are forwarded to their destination as well as reports of errors are also generated by that.

6. NSAP ADDRESSES

We will understand the addressing how it is done. We do not do normal addressing as if we do in OSPF. We will still use IPV4 and IPV6 addresses but IS-IS must be configured with NSAP addresses. ISO 8348/Ad2 defined the format and coding of NSAP address, which is network service access point. We have to configure this address in order to connect any device especially routers must be identified in the process of routing. Generally, cisco implementation have three portions area, sysID and N-selector (NET address). However, inside OSI we have AFI, IDI, HO-DSP in area id shown in the diagram.



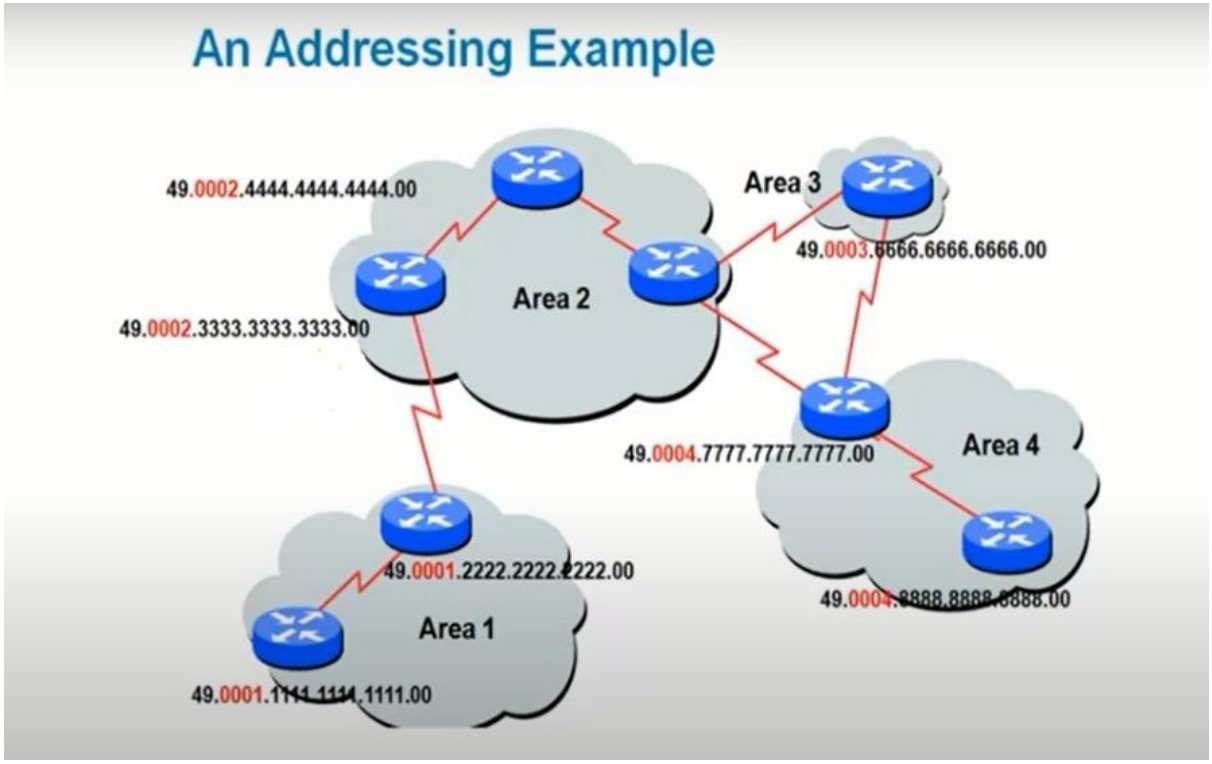
The simplest NSAP addresses format for different fields in NSAP are below.

Set AFI permanently to 49. AFI is a value that is going to identify its authority format identifier, which is a 1-byte value. This provides the structure of different other files in area ID which are IDI and HO-DSP files respectively. Setting AFI to 49 means that we have these addresses reserved for private use. Structure of address will be 49.___. Example is 49.0001.0000.0000.0007.00. Here in this example, 49 represents private use. At least 1 byte

for area ID, 0001 represents the area ID, for example, two devices using the same area ID, these two routers are considered to be in same area. There is no specific length for area ID, we can write 16-bit, 32-bit, 48 –bit. 0000.0000.0007 divided in three portions 16-bit.16-bit.16-bit (48-bit address) represents the system ID. System ID that is a unique address and the length is exactly 48-bit, it is just like device host address to identify specific router. Lastly, 00 represents N-selector address which is always 00 it shows that we are implementing routing i.e. it will carry no transport layer information. N-sel address that is also called NET (network entity title) address. This is how generally the addressing is done.

If we want to run IS-IS on any specific router, the command will be **net 49.0001.0000.0000.0007.00 (just example).** Then router will be enabled with IS-IS. Router will be identified in the network with this NET address. We have to do some other commands too, but this is mandatory for NSAP addressing to enable IS-IS on any router.

To explain it further, here we have an addressing example



Here in this example, notice that we have same area ID in the particular area. The system ID is unique and the n-selector is always 00. Depending upon the area now, we have to define the levels also. Note that L1/L2 are default routers and works with every other router. Means it will communicate with internal routers as well as external routers. It is required to explicitly define all router types either L1, L2 or L1/L2. L1 and L2 cannot communicate with each other. So inside any area we must do same levels where we want communication, and for external communication L1/L2 is used.

7. PACKET TYPES AND ADJACENCIES

7.1 TYPES OF PACKETS:

There are four different sorts of packets, each of which may be classified as Level 1 or Level 2. These four types of packets are as follows:

1. The packet Intermediate System-to-Intermediate System Hello (IIH) are used by the routers to identify the nearest router and develop neighborhood. IIH is an IS-IS protocol. Moreover, ISH and ESH are also the protocols and are known as ES-IS (End system-to-Intermediate System).
2. There are four types of link state packets which are as follows:

   Level 1:

   - Pseudonode
   - nonpseudonode

   Level 2:

   - Pseudonode
   - nonpseudonode
3. Third packet is **CSNP** which stands for complete sequence number PDU. It includes a list of entire current database LSPs. CSNPs alerts other routers of link-state packets (LSPs) that are either obsolete or absent from their specific database which guarantees that all routers are synced and have the similar data. These packet are resembled with the OSPF data packets in appearance.
4. Fourth packet named Partial sequence number PDU (PSNP) requests and acknowledge the LSP receipt.

7.2 BUILDING ADJACENCY

On a point-to-point network, neighbors always become nearby unless they don't recognize each other in their hello PDUs and match on specific characteristics. Following are the conditions that must be followed so that the two router can become neighbors.

1. In level 1 the two routers that are sharing the segment of a common network must have organized interface in similar region.
2. If two routers sharing a common network segment are in separate locations and want to become neighbors, they must be configured as Level 2.
3. Authentication of IS-IS provides password for a specific link, a specific region, or an entire domain.

8. RELIABLE FLOODING AND THE LINK-STATE DATABASE

8.1 LINK-STATE DATABASE

All the LSPs that are accepted by the router are kept in the Link-state database. These link-state packets are used to define the area's topology. This link-state information is used by routers to generate their shortest-path tree.

8.2 RELIABLE FLOODING AND LSPS

Every router sends its Link-state packets to nearby routers in a flood, the packets are sent forward unmodified to nearby neighbors till they've reached every single router in the vicinity. The topology of an area is described by all of the Link-state packets that are received in level 1. The link state packets that are transferred among the routers are kept in link-state’s database.

Every router connected in the network has the same link-state database. When the topology changes, one or more of the LSPs must change as well. When a link goes up or down, the router that experienced it will resend its link-state packet to alert other routers that the change has occurred. When the Link-state packet is incremented by one then it means that the previous LSP is replaced by the new LSP. Initially, when the router firstly makes the link-state packet, then the sequence number of Link-state packet is1. When the state of Link-state packets rises, and reaches the supreme, then the procedure of IS-IS should be stopped for about 21 minutes. Flooding is an act of sending these new LSPs over the network to verify that all router databases are similar.

9. SECURITY

An authentication mechanism is included in the Cisco IS-IS implementation to stop unauthorized routers from generating vicinities or neighborhood. Merely plain-text verification is currently provided, in which the set password is sent unencrypted in plain text inside the IS-IS PDUs. As a result, sniffing the packets might reveal the password.

10. NETWORK TYPES

IS-IS defines the following kinds of networks:

- Point-to-point networks
- Broadcast networks.

10.1 POINT-TO-POINT NETWORKS

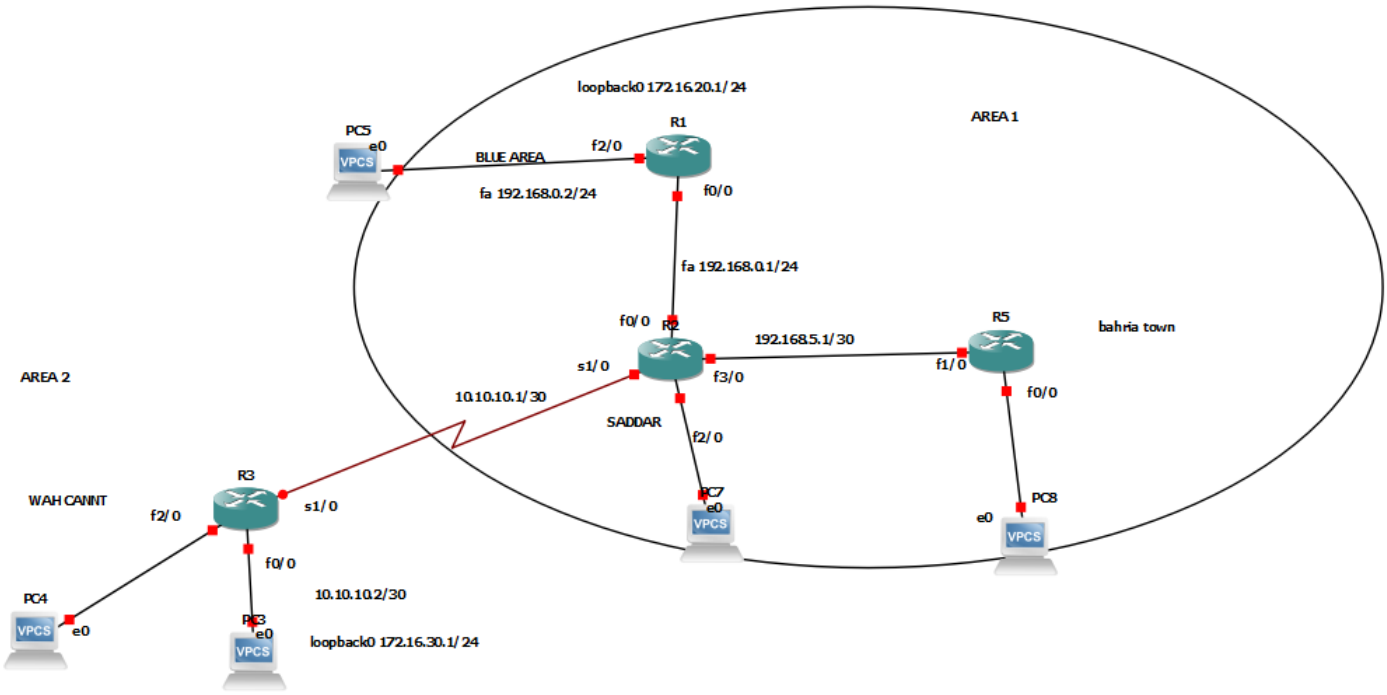
Point-to-point networks are used to provide the connection between the single pair of routers. The router that is connected in point-to-point interface will build an adjacency with an IS-IS router. On this sort of connection, a DIS is not selected. The essential process stated in the standard is that if a hello packet is received at one side in this network, then the other side is declared to be accessible.

10.2 BROADCAST NETWORKS

Broadcast networks provides a connection between two or more than two devices so that when one router sends a packets, then it's received by all of the other routers connected in a network. Example of broadcast networks are Ethernet, FDDI and Token Ring etc. In this broadcast networks, hello packets are transmitted to the MAC-layer broadcast addresses AllL1ISs or AllL2ISs. The Designated Intermediate System (DIS) is used to define the existing routers in a network. In this network, one IS will make itself the Designated Intermediate System (DIS) and flooding is caused by the DIS.

11. IMPLEMENTATION:

IS-IS network is created on cisco packet tracer. In this network four routers have been taken. These routers are given different names of Islamabad and Rawalpindi in Pakistan to show different areas. Router R1 is given blue area, R2 is Saddar, R3 is wah cantt and R5 is Bahria town.



ROUTER R1: BLUE AREA:

```
!
interface Loopback0
 ip address 172.16.20.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 192.168.0.2 255.255.255.0
 ip router isis
 duplex full
!
interface Serial1/0
 no ip address
 shutdown
 serial restart-delay 0
!
interface Serial1/1
 no ip address
 shutdown
 serial restart-delay 0
!
interface Serial1/2
 no ip address
 shutdown
 serial restart-delay 0
!
interface Serial1/3
 no ip address
 shutdown
 serial restart-delay 0
!
```

```
interface FastEthernet2/0
 ip address 10.50.1.1 255.255.255.0
 duplex full
!
router isis
 net 49.0001.2222.2222.2222.00
 is-type level-2-only
 redistribute connected
!
ip forward-protocol nd
!
!
no ip http server
no ip http secure-server
!
```

ROUTER R2: SADDAR:

```
!
interface Loopback0
 ip address 172.16.10.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 192.168.0.1 255.255.255.0
 ip router isis
 duplex full
!
interface Serial1/0
 ip address 10.10.10.1 255.255.255.252
 ip router isis
 serial restart-delay 0
 clock rate 56000
!
interface Serial1/1
 no ip address
 shutdown
 serial restart-delay 0
 clock rate 56000
!
interface Serial1/2
 no ip address
 shutdown
 serial restart-delay 0
!

interface Serial1/3
 no ip address
 shutdown
 serial restart-delay 0
!
```

```
interface FastEthernet2/0
 ip address 10.50.2.1 255.255.255.0
 duplex full
!
interface FastEthernet3/0
 ip address 192.168.5.1 255.255.255.0
 ip router isis
 duplex full
!
router isis
 net 40.0001.1111.1111.1111.00
 redistribute connected
!
```

ROUTER R3: WAH CANTT:

```
!
interface Loopback0
 ip address 172.16.30.1 255.255.255.0
 ip router isis
!
interface FastEthernet0/0
 ip address 10.50.3.1 255.255.255.0
 duplex full
!
interface Serial1/0
 ip address 10.10.10.2 255.255.255.0
 ip router isis
 serial restart-delay 0
 clock rate 56000
!
interface Serial1/1
 no ip address
 shutdown
 serial restart-delay 0
!
interface Serial1/2
 no ip address
 shutdown
 serial restart-delay 0
!
interface Serial1/3
 no ip address
 shutdown
 serial restart-delay 0
!
```

```
interface FastEthernet2/0
 ip address 10.50.33.1 255.255.255.0
 duplex full
!
router isis
 net 49.0002.3333.3333.3333.00
 is-type level-2-only
 redistribute connected
!
```

ROUTER R5: BAHRIA TOWN:

```
!
!
interface Loopback0
 ip address 172.16.40.1 255.255.255.0
!
interface FastEthernet0/0
 ip address 10.50.4.1 255.255.255.0
 duplex full
!
interface FastEthernet1/0
 ip address 192.168.5.2 255.255.255.0
 ip router isis
 duplex full
!
interface FastEthernet2/0
 no ip address
 shutdown
 duplex full
!
router isis
 net 49.0001.5555.5555.5555.00
 is-type level-2-only
 redistribute connected
!
ip forward-protocol nd
!
!
no ip http server
no ip http secure-server
!
!
!
!
control-plane
!
```

```
R3#show isis topology


IS-IS TID 0 paths to level-2 routers
System Id            Metric     Next-Hop             Interface   SNPA
saddar               10         saddar               Se1/0       *HDLC*
bluearea             20         saddar               Se1/0       *HDLC*
R3                   --
Bahria_Town-Rwp      20         saddar               Se1/0       *HDLC*
R3#
```

```
PC3> ping 10.50.4.2
10.50.4.2 icmp_seq=1 timeout
10.50.4.2 icmp_seq=2 timeout
84 bytes from 10.50.4.2 icmp_seq=3 ttl=61 time=51.981 ms
84 bytes from 10.50.4.2 icmp_seq=4 ttl=61 time=54.974 ms
84 bytes from 10.50.4.2 icmp_seq=5 ttl=61 time=37.959 ms

PC3> show ip

NAME        : PC3[1]
IP/MASK     : 10.50.3.2/24
GATEWAY     : 10.50.3.1
DNS         :
MAC         : 00:50:79:66:68:05
LPORT       : 10020
RHOST:PORT  : 127.0.0.1:10021
MTU:        : 1500

PC3> ping 10.50.1.2
10.50.1.2 icmp_seq=1 timeout
10.50.1.2 icmp_seq=2 timeout
84 bytes from 10.50.1.2 icmp_seq=3 ttl=61 time=49.005 ms
84 bytes from 10.50.1.2 icmp_seq=4 ttl=61 time=51.000 ms
84 bytes from 10.50.1.2 icmp_seq=5 ttl=61 time=51.070 ms

PC3> ping 10.50.2.2
10.50.2.2 icmp_seq=1 timeout
10.50.2.2 icmp_seq=2 timeout
84 bytes from 10.50.2.2 icmp_seq=3 ttl=62 time=34.007 ms
84 bytes from 10.50.2.2 icmp_seq=4 ttl=62 time=26.932 ms
84 bytes from 10.50.2.2 icmp_seq=5 ttl=62 time=30.910 ms

PC3>
```

CONCLUSION:

This research paper has briefly explained the IS-IS network and its terminology. There are various different advantages that IS-IS network provided over distance network protocol and OSPF network. IS-IS network is comparatively faster, supports larger internetworks and is less permitting to routing protocols. A list of features of IS-IS network is also mentioned in

section 3 of this paper. Three levels of system are discussed (level 1, level 2, level 1-2) in which level 1 is referred as intra-area and level 2 contains both intra-area and inter-area. Level 1-2 creates separate link state database for both level 1 and level 2. This paper has explained the complete working and operations of IS-IS network in section 4. The three types of NSAP addresses which are Area id, System id and N-selector are explained in detail. The types and portions of Area, system id and N-selector are also discussed in section 6(NSAP addresses). The data flow diagram of IS-IS contains four processes which include Receive, Update, Decision and Forward which is explained in section 5. This research paper has also discussed four types of packets and their levels. The conditions which are necessary required so that two routers can become neighbors are in the form of level 1, level 2 and the authentication phase. These conditions are briefly discussed in building agency section.

The two phases of IS-IS network Link-state database and reliable flooding are explained in section 8. Link state database stores all the LSPs that are accepted by the router. Flooding is an act of sending these new LSPs over the network to verify that all router databases are similar. Security of the software Cisco Packet Tracer in which the IS-IS network is created is also defined. There are two types of networks used which are point to point and broadcast network. Moreover, in this research paper the IS-IS network is also implemented in cisco packet tracer.

REFERENCES:

1. Farhangi, S., A. Rostami, and S. Golmohammadi. "Performance Comparison of mixed protocols based on EIGRP, IS-IS and OSPF for real-time applications." *Middle-East Journal of Scientific Research* 12.11 (2012): 1502-1508.
2. Perlman, Radia. "A comparison between two routing protocols: OSPF and IS-IS." *Ieee Network* 5.5 (1991): 18-24.
3. Martey, Abe, and Scott Sturgess. *IS-IS network design solutions*. Cisco Press, 2002.
4. Hopps, C. "Routing IPv6 with IS-IS." *work in progress* (2005).
5. Thorenoor, Sheela Ganesh. "Communication Service Provider's Choice between OSPF and IS-IS Dynamic Routing Protocols and Implementation Criteria Using OPNET." *2010 Second International Conference on Computer and Network Technology*. IEEE, 2010.
6. Jaafar, ANH Ahmad, et al. "Performance evaluation of OSPFv3 and IS-IS routing protocol on ipv6 network." *2017 International Conference on Engineering Technology and Technopreneurship (ICE2T)*. IEEE, 2017.
7. Asabere, Eunice Domfeh, Joseph Kobina Panford, and James Ben Hayfron-Acquah. "Comparative Analysis Of Convergence Times Between OSPF, EIGRP, IS-IS and BGP Routing Protocols in a Network." *International Journal of Computer Science and Information Security (IJCSIS)* 15.12 (2017): 225-227.
8. Valadas, Rui. *OSpF and IS-IS: from link state routing principles to technologies*. CRC Press, 2019.
9. Pandey, Nisha, Dinesh Kumar, and Haryana Palwal. "Simulation Based Comparative Study on EIGRP/IS-IS and OSPF/IS-IS." *International Journal of Engineering Research and General Science* 3.2 (2015): 204-214.
10. Kaur, Jagmeet, and P. Singh. "Comparative study of OSPFv 3 IS-IS and OSPFv3_IS-IS protocols using OPNET." *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)* 3.8 (2014): 2656-2662.

11. Sudha, R., and R. Derick Macedo. "Distribution of Dynamic Routing Protocols (Is-Is, EIGRP, OSPF) in IPv6 Network and Their Performance Analysis."
12. Wandile, Suraj, et al. "Comparison of routing algorithms using riverbed modeler." *Int. J. Adv. Res. Comput. Commun. Eng* 6.6 (2017): 428-432.