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Performance Analysis of Interior Gateway Routing Protocols across Different AS

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Abstract: Routing is a vital part of today's communication networks and without it; data can never get past its originating subnet. It requires the implementation of a set of communication rules and guidelines called Routing Protocols. Each of these protocols has different features and performance capabilities, with different architectures and route processing algorithms. The data travels between local and wide area networks via different network topologies and is handled by different protocols within and outside different Autonomous Systems (AS). A secure and scalable communication platform relies on the selection of the right communication protocols. This plays an important role in the establishment and maintenance of successful communication grids, with the dynamic nature of the Internet connections and communication between different Autonomous Systems. This research paper presents a simulation as a comparative study of the Interior Gateway Routing Protocols (IGRP) in varying scenarios. Their performance was analysed and discussed by observing the generated traffic to identify the best combination of protocols for efficient data delivery. GNS3 network simulation software was used to create and implement the scenarios, and WireShark was used to capture the data packets.

Keywords: Interior Gateway Routing Protocols (IGRP), GNS3, WireShark.

1. Introduction

In today's era, communication networks are growing rapidly to accommodate the increasing needs for file transfer, print sharing, video streaming and video conferencing. With this rapid growth, technological inventors are tasked with the need for efficient solutions and applications for the network data forwarding issues. A network is a connection of multiple hosts, either with cables or wirelessly, so as to exchange information. To determine compatibility with other networks, the Open Systems Interconnection (OSI) reference model was created [1]. The model is divided into 7 layers, Application, Presentation, Session, Transport, Network, Data-Link and Physical. Routing protocols are implemented in the network layer. These protocols provide the rules for routers on how they intercommunicate to share information. Routing protocols are the electronic equivalent of the best way to send a parcel/postcard from one end of the world to another. A network router functions by reading the destination address marked in an incoming IP (Internet Protocol) packet, consulting its own internal information about the best outgoing link (or path) for this packet and finally forwarding the packet. Some routing protocols learn about destinations via Routing-by-Rumor, which means the interface cannot actually communicate directly with the rumored interface, but can find a neighboring router, who can do it [2].

Among the Interior Routing Protocols, OSPF and EIGRP are considered as the pre-eminent protocols for real-time applications. Intermediate System to Intermediate System (IS-IS) allows large scalability of networks and so is more popular with service providers. BGP is the only existing Exterior Gateway Routing Protocol and serves as the protocol that allows different Autonomous Systems (AS) to intercommunicate. An Autonomous System is simply a group of networks under the same administrative control. The whole internet today is comprised of multiple Autonomous Systems intercommunicating with each other.

Since each protocol has a unique set of features, the right choice of routing protocol depends on parameters unique to the network in which the protocol implemented. Related works [3] have shown EIGRP to be a better choice when dealing with real time applications within the network like instant-messaging and video-conferencing; whereas OSPF and IS-IS are better suited for scalable networks and service providers. Combining multiple protocols to get the best features, among all protocols has been a theoretical recommendation submitted by other researchers [4].

In this research paper, three scenarios running on different combinations of multiple routing protocols are implemented on GNS3 network simulation software. Wireshark is used to observe the data transmission traffic. The results observed provides a guideline of the best combination of the protocols for any given scenario with specific parameters.

2. Literature Review

Over the past two decades a lot of research has been submitted about Comparative Performances of the Interior Gateway Routing Protocols, each of them used different parameters for the comparison. Along with the interior protocols, there is an exterior gateway protocol known as Border Gateway Protocol (BGP) used to intercommunicate between multiple ASs. BGP is only advisable when there is the case of multi-homing to multiple ISP's (Internet Service Providers) or when it is tried to communicate with an alternate AS [5]. It is observed [6] that OSPF has the best detection mechanism but is practically more suitable for limited networks because of the higher possibility for packets to drop from different areas, while EIGRP is better suited for scalable networks. Another research [4] yielded results showing that EIGRP is more suitable for topologies with few routers, while IS-IS is ideal for complex topologies because of its higher scalability feature. In another study [7], varying sizes of topologies have been implemented. Upon the observed results and analysis, it was concluded that EIGRP is better suited for networks with critical delivery that cannot tolerate any form of errors, while OSPF is more suitable for networks with bandwidth constraints.

Furthermore, Stretch [8] suggested the implementation of multiple Interior Gateway Routing protocols within a single topology so as to be able to use the best protocols for higher throughput and lower bandwidth utilization as a more effective approach to gain higher throughput while minimizing bandwidth utilization. This paper implements the suggestions outlined by Stretch [8], which is, multiple protocols within a single topology. The suggestion [8] highlights the theoretical advantages of implementing multiple protocols, with the purpose of harnessing the best features of both at any given time. Multiple scenarios were created to implement the different combinations of the best pairings of the protocols from the results analysed.

3. Routing Protocols Overview

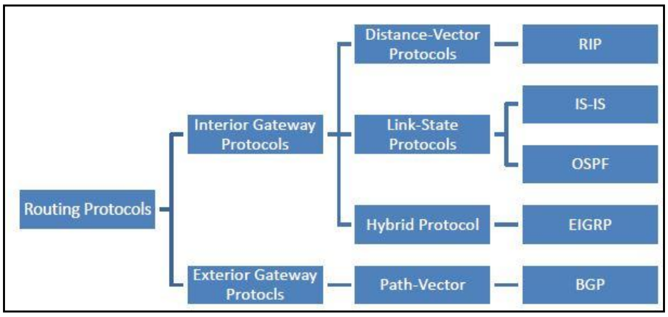


Figure 1. Classification of the Protocols

The Interior Gateway Routing Protocols have two broad classifications, Distance-Vector and Link State. The Distance-Vector Protocols use the Bellman-Ford algorithm which calculates the shortest path from a single node considering the negative edge weights. Data is forwarded using the best paths selected from the routing tables. These Protocols are further classified into RIP (version 1 - version 2) and EIGRP. The Link-State Routing Protocols on the other hand, calculate the best path from source to destination using the Djikstra algorithm, then present this information to all neighboring routers in the form of three routing tables. The Link-State Routing Protocols are further classified into OSPF and IS-IS and also have the added advantage of being able to segment a network into multiple administrative clusters, known as areas [9, 10, 11].

3.1 RIP version 1(V1) & version2 (V2)

Routing Information Protocol is among the earliest introduced routing protocols. V1 works by sending out a copy of its routing table to neighbors every 30 seconds. It also sends triggered updates whenever the metric of a route changes. V2 was introduced as an upgrade to V1. V2 is classless and supports VLSM (variable length subnet mask). It uses up all the unused fields available in the original protocol to support its enhancements. The Advantages and disadvantages of RIP are listed below [11, 12].

Table 1. RIP

Advantages	Disadvantages
Easy configuration	Lack of alternative routes
Loop-free	Limit to 15 hop count
Support load-balancing	Bandwidth Intensive
Supported by most of the routers	Support only equal cost load balancing

3.2 EIGRP

Enhanced Interior Gateway Routing Protocol is a hybrid of Link-State and Distance-Vector routing protocols. It comprises a few characteristics of both protocols. EIGRP uses Diffusion Update Algorithm (DUAL) for routing optimization and fast convergence. EIGRP was introduced as an upgrade to IGRP. Unlike other protocols, EIGRP only sends out updates when changes occur, thereby reducing traffic between routers. The EIGRP hop count is larger, at 224, which makes it compatible with larger networks [13].

Table 2. EIGRP

Advantages	Disadvantages
Fast convergence time	Cisco Proprietary
Consume less bandwidth	
Protocol independent	

3.3 OSPF

Open Shortest Path First was introduced as an improvement to RIP, offering faster convergence time and many configurable parameters. It works by the routers exchanging Hello packets, link state requests, updates and database descriptions. The Djikistra's algorithm is then used to determine the shortest path to the destination from each node. Updates are periodical, occurring only when there is a change, though the Link State Advertisement (LSA) table is refreshed every 30 minutes. OSPF implements hierarchical routing by bounding different networks into several areas. This enables better management of large internetwork routing. Unfortunately, OSPF does not scale well as more routers are added to the network, because more memory space and computing resources have to be used and routing loops could occur [9, 14].

Table 3. OSPF

Advantages	Disadvantages
Updates fast & finds loop-free route	Hard to configure
Low bandwidth utilization	Consume high memory
Good for large networks	

3.4 Intermediate System to Intermediate System (IS-IS)

Intermediate System to Intermediate System (IS-IS) is mostly used by service providers, because it is a good protocol for large internetworks due to its simplicity and stability. It has a better support for MPLS. This protocol is similar to OSPF, as it also uses areas to break down the routing domain into smaller regions. It also establishes adjacencies using Hello packets and exchange link state information using LSPs. IS-IS provides a multi-level hierarchy called area-routing, causing information about the topology within a defined area of the AS to be hidden from routers outside this area [15, 16].

Level 1 occurs within the IS-IS area. All devices in this level have a single area address, and routing is done by looking at the locally significant address portion and choosing the lowest-cost path.

Level 2 learns the location of Level 1 routing areas and builds an inter-area routing tables. All ISs on this level use the destination area address to route traffic using the lowest-cost path.

Table 4. Summary of Protocols

	RIPV2	EIGRP	OSPF	IS-IS
Type	Distance Vector	Hybrid	Link-state	Link-state
Default Metric	Hop count	Bandwidth/ Delay	Cost	Cost
Administrative Distance	120	90 (internal) 170 (external)	110	115
Hop counts Limit	15	224 (100 default)	None	None
Convergence	Slow	Very Fast	Fast	Fast
Updates	Full Table	Only Changes	Only Changes	Only Changes

There are a number of differences that exist between OSPF and IS-IS, some of them are explained below [15, 16].

- Backbone Areas: In IS-IS, the backbone area is the most complete collection in level 2, level 1-2 routers and the paths between them.
- Area Boundaries: In IS-IS, the area boundary is on a link between routers while in OSPF, the ABR is the boundary
- Update Exchange: IS-IS is more scalable than OSPF in the sense that it sends out a combined number of updates in one single LSP, while OSPF sends out LSPs for every change that occurs in the routing table.
- Area Types: OSPF has more area types; examples are standard, stub and Not-so-stubby area (NSSA)
- Metrics: OSPF has a scaled metric. This means that based on the bandwidth of a link, the metric will be scaled. In IS-IS every link has a metric of 10 and you must manually change it to show the preference of a link.

4. Experiment Setup

In this case study three network scenario models were created to test the suggestion from the researchers stated by Stretch [8]. The simulated scenarios were designed to be as realistic as possible, so that actual implementation on the hardware would be more seamless. All the models were designed to be connected with a single internet service provider (ISP) in the form of a router. Hosts were used only to test connectivity from end to end, and to examine how long it takes to recalculate the routes in the event of a link failure. The simulation was done on GNS3software, with packet capture and network analyzer tool Wireshark.

The first scenario (Figure 2) was created to accommodate a simple topology, limited to 4 routers with 1 serving as an ISP, 3 switches connected to the remaining 3 routers, and a host from each network attached to each router to test the connectivity and to monitor the traffic from each end of the topology.

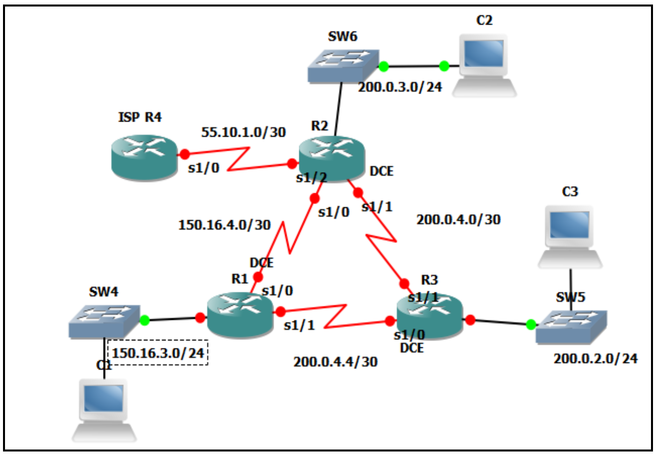


Figure 2. Scenario 1 (RIPv2 and EIGRP)

The second scenario (Figure 3) was similar to the first, the difference was the inclusion of 2 routers in the other cluster, each connected to the same ISP on different ends. The first cluster served as a backbone area for OSPF, which is implemented independently and is evaluated with EIGRP configured on the other cluster. The ISP was connected via the default route to both clusters.

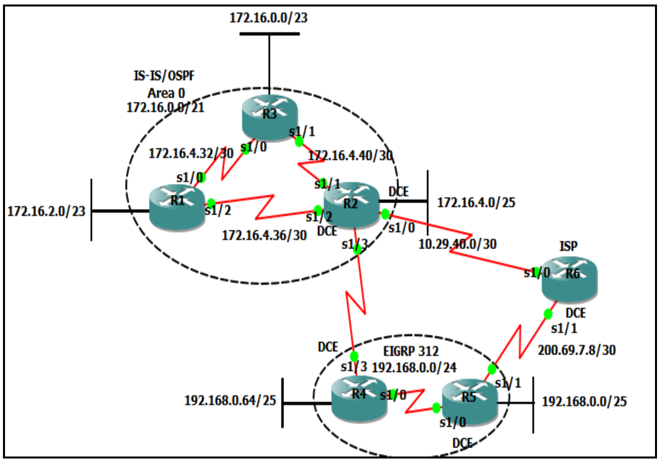


Figure 3. Scenario 2 (EIGRP and OSPF)

The third scenario (Figure 4) was more complex compared to the earlier scenarios, with 8 routers including one service provider. The connection was in the form of a tree topology, where 1 router is connected to the ISP, and the other two routers had separate branches that served as the stub areas. Only two protocols of IS-IS and OSPF are implemented in this scenario, because these two are more similar than the other routing protocols (RIP, RIPv2, and EIGRP) and they are tailor-made to communicate within and between the large regions with segmented areas.

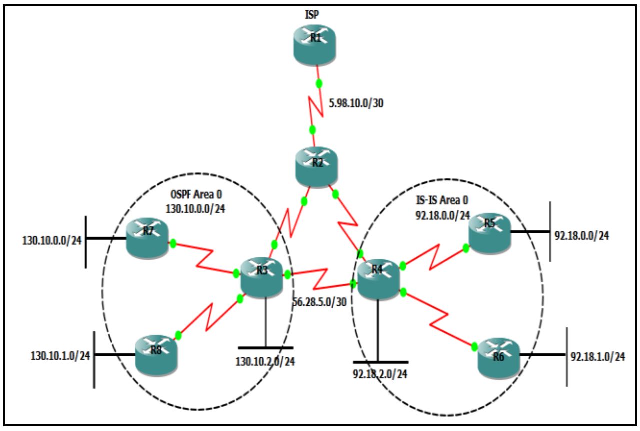
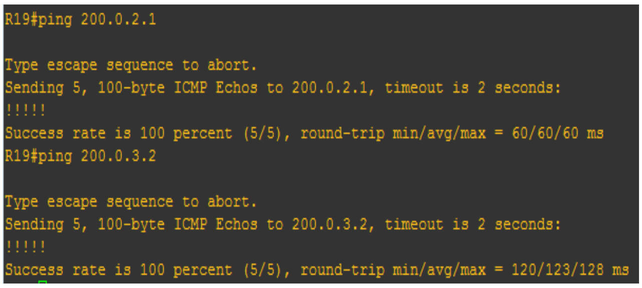


Figure 4. Scenario 3 (OSPF and IS-IS)

5. Experiment, Results and Discussions

5.1 Scenario 1

The scenario was first run on RIPv2 and then on EIGRP, and both situations were analysed separately. The timestamp of each frame and the total number of frames were recorded. After the separate analysis, the serial links between R1, R3, R2 and R4 were configured with RIPv2 and EIGRP respectively. The link between R1 and R2 was removed to check the effectiveness of the redundant link between R1 and R3. To allow the protocols to communicate with each other, the redistribution command was used. Each simulation was recorded for a period of 300 seconds. For further testing, after the result analysis, multiple hosts were added to each connected network to study the convergence time under a higher traffic load.



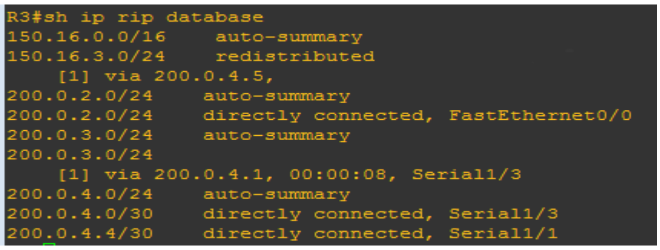
```
R19#ping 200.0.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 200.0.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 60/60/60 ms
R19#ping 200.0.3.2

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 200.0.3.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 120/123/128 ms
```

Figure 5. Successful ping test from R19(host) to Fast Ethernet port of R1

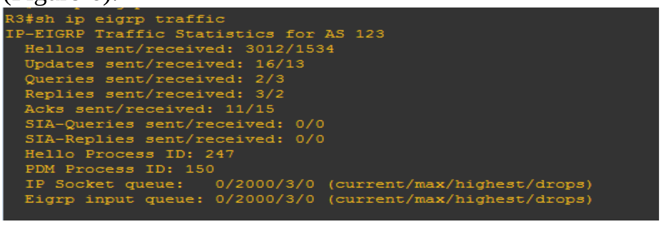
R19 served as an individual host used to test the connectivity after redistribution to monitor and record the generated traffic by both protocols (Figure 5).



```
R3#sh ip rip database
150.16.0.0/16    auto-summary
150.16.3.0/24    redistributed
    [1] via 200.0.4.5,
200.0.2.0/24    auto-summary
200.0.2.0/24    directly connected, FastEthernet0/0
200.0.3.0/24    auto-summary
200.0.3.0/24
    [1] via 200.0.4.1, 00:00:08, Serial1/3
200.0.4.0/24    auto-summary
200.0.4.0/30    directly connected, Serial1/3
200.0.4.4/30    directly connected, Serial1/1
```

Figure 6. RIP database after redistribution

For RIP, the database was recorded to show the connectivity from one end of each branch to the other (Figure-6).



```
R3#sh ip eigrp traffic
IP-EIGRP Traffic Statistics for AS 123
  Hellos sent/received: 3012/1534
  Updates sent/received: 16/13
  Queries sent/received: 2/3
  Replies sent/received: 3/2
  Acks sent/received: 11/15
  SIA-Queries sent/received: 0/0
  SIA-Replies sent/received: 0/0
  Hello Process ID: 247
  PDM Process ID: 150
  IP Socket queue:     0/2000/3/0 (current/max/highest/drops)
  Eigrp input queue: 0/2000/3/0 (current/max/highest/drops)
```

Figure 7. EIGRP traffic after redistribution

For EIGRP, the traffic generated from initiation of the adjacent neighbor was recorded and monitored (Fig 7).

Table 5. Frame capture from scenario 1

RIP	
Total no. of frames	92
Total captured bytes	156 + 116)*11= 2992
EIGRP	
Total no. of frames	218
Total captured bytes	(109*64) = 6976 bytes where 109 = number of EIGRP frames
After Redistribution	
Total frames from the beginning of the simulation	1110
Total bytes	(44 + 56)100 = 10000 bytes where 100 = number of frames captured after convergence

The data recorded from the simulation time in Wireshark (table 5) was used to plot the graph of results displayed in (Figure 8).

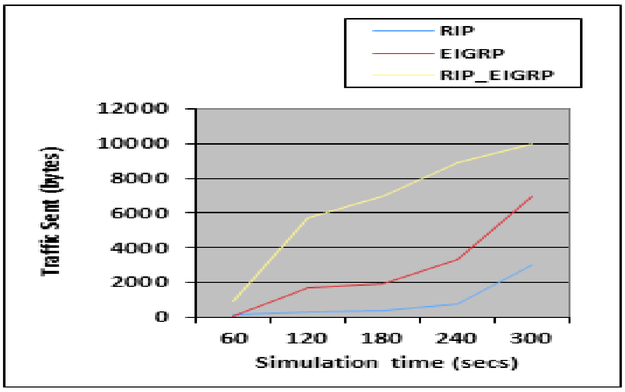


Figure 8. Result from Scenario 1

The captured results show that there is a better communication grid when RIP and EIGRP work together after redistribution of both than when only a single protocol is running on all three routers. This is likely because of the hybrid feature in EIGRP is working with the routing-by-rumor feature of RIP. RIP is observed to have much lower traffic as compared to EIGRP even when multiple hosts were added to the topology.

5.2 Scenario 2

As a result of segmentation into separate areas and the protocols running simultaneously, this scenario had a different approach than the first. Area 1 and area 2 were connected to the same ISP, but were also set to redistribute and intercommunicate. Results of connectivity within both areas were separately monitored, before the intercommunication link was configured.

Since each routing domain was already established and working separately, the amount of traffic from each end was monitored and recorded before redistributing to each domain.

```
R1#ping 192.168.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 52/60/68 ms
R7#ping 192.168.0.129

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.0.129, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/41/48 ms
```

Figure 9. Successful ping from R1 to R5

R1 was able to directly ping R5 of the adjacent cluster; showing successful communication between both domains (Figure 9).

```
R2#sh ip eigrp traffic
IP-EIGRP Traffic Statistics for AS 312
  Hellos sent/received: 711/711
  Updates sent/received: 5/7
  Queries sent/received: 0/0
  Replies sent/received: 0/0
  Acks sent/received: 4/3
  SIA-Queries sent/received: 0/0
  SIA-Replies sent/received: 0/0
  Hello Process ID: 247
  PDM Process ID: 150
  IP Socket queue:   0/2000/2/0 (current/max/highest/drops)
  Eigrp input queue: 0/2000/2/0 (current/max/highest/drops)
```

Figure 10. EIGRP traffic through R2 after redistribution

As R2 is the router that connected each branch of the separate protocols, redistribution was done from this node; then the generated traffic was recorded (Figure 10, 11).

```
R2#sh ip ospf traffic

OSPF statistics:
  Rcvd: 707 total, 0 checksum errors
        676 hello, 8 database desc, 2 link state req
        11 link state updates, 10 link state acks

  Sent: 1049 total
        1017 hello, 6 database desc, 0 link state req
        20 link state updates, 6 link state acks


            OSPF Router with ID (172.16.4.10) (Process ID 1)

OSPF queue statistics for process ID 1:

                   InputQ     UpdateQ    OutputQ
  Limit            0          200        0
  Drops            0          0          0
  Max delay [msec] 12         4          4
  Max size         2          2          1
    Invalid        0          0          0
    Hello          1          0          1
    DB des         1          1          0
    LS req         0          1          0
    LS upd         0          0          0
    LS ack         0          0          0
  Current size     0          0          0
    Invalid        0          0          0
    Hello          0          0          0
    DB des         0          0          0
    LS req         0          0          0
    LS upd         0          0          0
    LS ack         0          0          0
```

Figure 11. OSPF traffic through R2 after redistribution

It was observed that even when multiple hosts were added to the topology to generate heavy traffic, the size of the frames remained relatively the same, and the simulation and observation time also remained similar.

The data recorded from the simulation in Wireshark (table 6) was used to plot the graph of results displayed in Figure 12.

Table 6. Frame capture for Scenario 2

EIGRP	
Total no. of frames	216
Total captured bytes	216*64 = 13824
Total observation time	315s
OSPF	
Total no. of frames	142
Total captured bytes	84*142 = 11928
Total observation time	320s
After Redistribution	
Total captured frames	225
Total captured bytes	148*64 = 9472
Total observation time	320s

The results indicate that OSPF and EIGRP also work better in a network topology when communicating with each other than when only a single protocol is being run. The traffic remained constant even when multiple hosts were included.

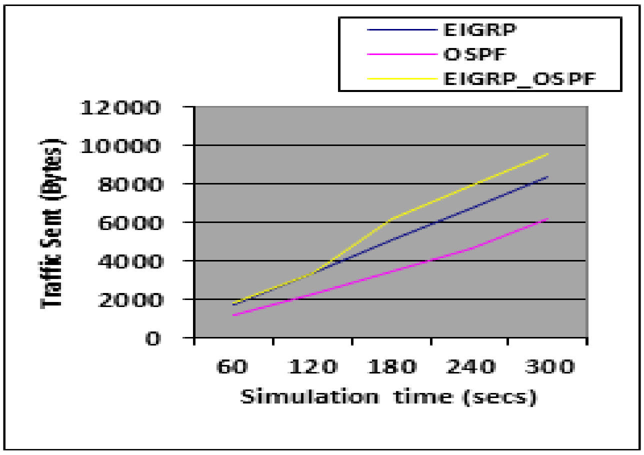


Figure 12. Result for Scenario 2

5.3 Scenario 3

This scenario had the same basic approach as the second, in that different branches were specifically assigned to a particular protocol. The areas were configured and monitored separately before the intercommunication grid was configured. Each seperated domain was also monitored in this scenario before implementing and monitoring the redistribution node.

For this scenario, R2 was the redistributing node for it had interfaces running both protocols. A redundant link was included between R3 and R4, but was not configured so as to avoid routing loops.

```
R2#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

     92.0.0.0/30 is subnetted, 3 subnets
i L1    92.18.2.72 [115/20] via 92.18.2.66, Serial1/3
i L1    92.18.2.68 [115/20] via 92.18.2.66, Serial1/3
C       92.18.2.64 is directly connected, Serial1/3
     130.10.0.0/16 is variably subnetted, 5 subnets, 3 masks
O       130.10.1.0/24 [110/138] via 130.10.2.65, 01:19:13, Serial1/2
O       130.10.2.0/26 [110/74] via 130.10.2.65, 01:19:13, Serial1/2
O       130.10.2.72/30 [110/128] via 130.10.2.65, 01:19:13, Serial1/2
C       130.10.2.64/30 is directly connected, Serial1/2
O       130.10.2.68/30 [110/128] via 130.10.2.65, 01:19:15, Serial1/2
```

Figure 13. R2 Routing table showing successful configuration

```
R7#ping 92.18.2.70

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 92.18.2.70, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 64/73/84 ms
R15#ping 92.18.2.74

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 92.18.2.74, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 68/72/80 ms
```

Figure 14. Successful ping test from the OSPF area (R7) to IS-IS area (R5)

For testing purposes, the furthest node in the OSPF area was used to ping the furthest node in the IS-IS area. The test was successful, as seen in Figure 14.

```
R2#sh ip ospf traffic

OSPF statistics:
  Rcvd: 724 total, 0 checksum errors
        706 hello, 3 database desc, 0 link state req
        11 link state updates, 4 link state acks

  Sent: 728 total
        708 hello, 4 database desc, 1 link state req
        6 link state updates, 9 link state acks


            OSPF Router with ID (130.10.2.66) (Process ID 3)

OSPF queue statistics for process ID 3:

                      InputQ    UpdateQ    OutputQ
  Limit               0         200        0
  Drops               0         0          0
  Max delay [msec]    12        4          4
  Max size            1         1          2
    Invalid           0         0          0
    Hello             1         0          1
    DB des            0         1          1
    LS req            0         0          0
    LS upd            0         0          0
    LS ack            0         0          0
  Current size        0         0          0
    Invalid           0         0          0
    Hello             0         0          0
    DB des            0         0          0
    LS req            0         0          0
    LS upd            0         0          0
    LS ack            0         0          0
```

Figure 15. Summary of OSPF traffic through R2

```
Summary traffic statistics for process ID 3:

OSPF packets received/sent

  Type              Packets                 Bytes
  RX Invalid        0                       0
  RX Hello          708                     33984
  RX DB des         3                       156
  RX LS req         0                       0
  RX LS upd         11                      1268
  RX LS ack         4                       216
  RX Total          726                     35624

  TX Failed         0                       0
  TX Hello          722                     57756
  TX DB des         4                       256
  TX LS req         1                       80
  TX LS upd         6                       552
  TX LS ack         9                       656
  TX Total          742                     59300
```

Figure 16. Summary of traffic statistics of R2

```
IS-IS: Time since last clear: never
IS-IS: Level-1 Hellos (sent/rcvd): 0/0
IS-IS: Level-2 Hellos (sent/rcvd): 0/0
IS-IS: PTP Hellos     (sent/rcvd): 512/490
IS-IS: Level-1 LSPs sourced (new/refresh): 11/5
IS-IS: Level-2 LSPs sourced (new/refresh): 8/4
IS-IS: Level-1 LSPs flooded (sent/rcvd): 10/25
IS-IS: Level-2 LSPs flooded (sent/rcvd): 10/28
IS-IS: LSP Retransmissions: 0
IS-IS: Level-1 CSNPs (sent/rcvd): 1/1
IS-IS: Level-2 CSNPs (sent/rcvd): 1/1
IS-IS: Level-1 PSNPs (sent/rcvd): 23/9
IS-IS: Level-2 PSNPs (sent/rcvd): 22/10
IS-IS: Level-1 DR Elections: 0
IS-IS: Level-2 DR Elections: 0
IS-IS: Level-1 SPF Calculations: 14
IS-IS: Level-2 SPF Calculations: 13
IS-IS: Level-1 Partial Route Calculations: 0
IS-IS: Level-2 Partial Route Calculations: 4
IS-IS: LSP checksum errors received: 0
IS-IS: Update process queue depth: 0/200
IS-IS: Update process packets dropped: 0
```

Figure 17. Summary of IS-IS traffic through R2

After the successful connectivity, the traffic generated by both protocols was monitored and recorded (Figure 15, 16, 17). There is a slight variation in the data recorded from Wireshark because while the data capture times were being monitored, the router simulation time was not monitored.

Table 7. Frame capture for Scenario 3

OSPF	
Total no. of frames	142
Total captured bytes	72*84 = 6048
Total observation time	317s
IS-IS	
Total no. of frames	75
Total captured bytes	75*74 = 5550
Total observation time	318s
After Redistribution	
Total captured frames	74
Total captured bytes	74*85 = 6290
Total observation time	318s

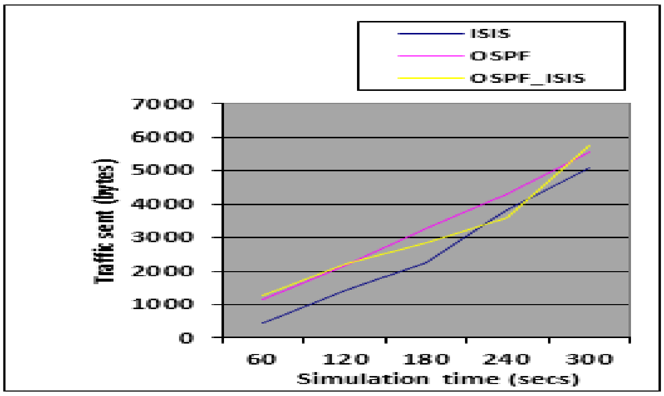


Figure 18. Result from Scenario 3

The results analysis showed that OSPF communicates better. This is an unexpected result, as IS-IS is theoretically and practically known to have the fastest convergence. When both protocols were able to communicate, the result showed that after convergence, the protocols communicated better with the added destinations to the routing tables. The initial decline followed by the exponential increase in the performance of the intercommunicating protocols could be attributed to the recalculation of routes because of the increased number of LSP’s with the new information coming from the routing tables of both protocols.

6. Conclusions

Based on the simulation results detailed above, it can be concluded that EIGRP and OSPF are the best combination of protocols for a given network with about 1000 hosts. However, a combination of EIGRP and RIPv2 would be better suited for a smaller network because of the absence of segmented areas. IS-IS has been known to be the best protocol for ISP’s and really large enterprises because of its scalability, fast convergence and added advantage of not needing IP connectivity to communicate with neighbors.The results also show that IS-IS communicates well with OSPF, as a result of attribution to the OSPF similarities. So a combination of the two protocols would be better than configuring only 1 of them for a scenario with complex parameters.

7. Future Work

The one varying parameter in this analysis is the size of the topology. Improvements in future work can include metrics on the interfaces, like bandwidth, distance, Bit Error Rate (BER) and the delay. Since Link-State Routing Protocols are very complex and unpredictable, more time could be spent analysing the value of parameters that need to be set. Simulation of very large data volume will help us verify the performance.

Implementation can be done on the equipment so as to gain a more realistic level of traffic from each end of the topologies and their actual performances. Another improvement can be made by introducing BGP as the external protocol of choice. Packet capture can be done from one AS to another for a more realistic comparison of the respective protocol performance.

References

[1] J. F. Kurose, K. W. Ross, “Computer Networking: A Top-Down Approach”, *Boston, Pearson Education Inc*, 2010.

[2] R. Graziani, J. Allan, “Routing protocols, and Concepts: CCNA exploration companion guide”, *Cisco Press USA*, 2008.

[3] S. Farhangi, A. Rostami, S. Golmohammadi, “Performance Comparison of Mixed Protocols Based on EIGRP, IS-IS and OSPF for Real-time Applications”, *Middle Eastern Journal of Scientific Research*, vol. 12, no.11, pp. 1502-1508, 2012.

[4] T. M. Jaafar, D. Blair, “Simulation-Based Routing Protocol Performance Analysis: A Case Study”, *Proceedings of the 38th conference on Winter Simulation. Winter Simulation Conference, 2006*.

[5] Cisco System, Inc., "IP Routing: BGP Configuration Guide, Cisco IOS Release 12.4T", *Cisco Press USA*, 2011.

[6] K. Mirzahossein, N. Michae, E. Sarah, “Analysis of RIP, OSPF, and EIGRP Routing Protocols using OPNET”, *Simon Fraser University, School of Engineering Science*, 2013.

[7] W. Aslam, “An Empirical Study to Observe Route Recoverability Performance of Routing Protocols in Real-Time Communication”, *Master Desertation, Halmstad University, Sweden*, 2009.

[8] S. Sendra, P. A. Fernández, M. A. Quilez, J. Lloret, “Study and Performance of Interior Gateway IP Routing Protocols”, *Network Protocols and Algorithms* 2.4, 2011.

[9] P. J. Conlan, “Cisco Network Professional's Advanced Internetworking Guide”, *Wiley Publishing, Inc.,Indiana*, 2009.

[10] R. Malhotra “IP Routing: O' Reilly Online”, *O’Reilly & Associates, Inc., Sebastopol, CA*, 2002.

[11] A. Bruno, J. Kim, “CCDA Self-Study: RIP, IGRP, and EIGRP Characteristics and Design”, *Cisco Press, USA*, 2005.

[12] G. Malkin, "RIP Version 2 Carrying Additional Information", *RFC 1723, Xylogics, Inc.*, 1994.

[13] L. Eric, "EIGRP: Packets & Neighborships", Retrieved URL:http://ericleahy.com/index.php/eigrp-packets-neighborships/, Accessed on: 25 Sep2013.

[14] HN Computing, "Network Infrastrcutre 2: OSPF Features", Retrieved URL: http://www.sqa.org.uk/e-learning/NetInf203CD/page_10.htm, Accessed on: 25 Sep2013.

[15] Cisco System, Inc., “IP Routing: IS-IS Protocol – Overview”, *Cisco Press USA*.

[16] T. Li, S. Henk, “IS-IS extensions for Traffic Engineering”, *RFC 5305*, Oct. 2008.