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Performance Evaluation of Routing Protocols in University Network

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ABSTRACT

In an enterprise network, multiple dynamic routing protocols are used for forwarding packets with the best routes. Therefore, performance of the network is based on routing protocols and the route redistribution is an important issue in an enterprise network that has been configured by multiple different routing protocols in its routers. So, aim of the system is to analyze the performance and comparison of different Interior Gateway routing protocols. Routing is depended on many parameters critical such as network convergence time, Ethernet delay, throughput, end-to-end delay, jitter, packet delivery, security and bandwidth, etc. In this paper, the analysis of characteristics and the performance of the different routing protocols as Routing Information Protocol (RIP), Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP) are evaluated in a university network. The performance evaluation are based on end to end packet delay, network convergence time, packet delay variation and administrative distance, etc. The analysis focuses on the performance of the routing protocols with its routing table in a simulator. The Simulation software can be used to evaluate and compare the performance of the routing protocols. The simulator return the routing table for each node or router in the university network which would contain the best path to reach the remote destination on the metric chosen based on the routing protocol implemented. The simulation software give results used to evaluate the performance of routing protocols, the performance of different routing protocols will be compared, and to analyze the convergence time and administrative distance of routing protocols.

***KEYWORDS:** dynamic routing protocol, RIP, OSPF, EIGRP*

I. INTRODUCTION

For a packet to travel from source to destination it has to pass through multiple paths or sometimes a single path. So when a packet finds multiple paths to reach the destination, it has no judging methods available to right path. The routing algorithms can be used by routing protocols. Routing algorithms are responsible for selecting the best path for the communication a border way, a routing protocol is the language a router speaks with other routers in order to share information about the reach ability and status of network. A routing protocol is a protocol that specifies how routers communicate with each other, disseminating information that enable them to select routes between any two nodes on a computer network. The working of router is controlled by using routing protocols. Routing is often contrasted with bridging. The primary difference between both of them are the layer in which they are working. Metrics such as path bandwidth, reliability, delay, current load on that path etc. are used by routing algorithms to determine the optimal path to a destination. The routing is proceeding in such a way that first it shares information with its immediate neighbors, then thorough out the entire network. The routing is established by the configuration of routing tables in the routers. There are two different way to configure routing tables in router. They are *static routing and dynamic routing.* Static routing is simply the process of manually entering routes into the routing table of a device using it's a configuration file that is loaded when the routing devices starts up. In static routing, all the changes in the logical network layout need to be manually done by the system administrator. However, dynamic routing allows routers to select the best path when there is a real time logical network layout change. Static routing is easy to implement in small networks. They are very safe and predictable as the route to the destination is always the remains same. Any require routing algorithm or update mechanisms does not required.

But dynamic routing protocols work well and suitable in all topologies where multiples routers are required. They are scalable and automatically determine better routes if there is a dynamic routing the better choice for medium, large and very large inter network. The dynamic routing protocol is further classified into distance vector routing protocol and link state routing protocol. Distance vector protocol uses simple algorithms to calculate cumulative distance value between routers based on hop count. But link state routing protocols uses sophisticated algorithm that maintain complex data base of inter network topology.

II. RELATED WORK

Sandeep Kumar Sahoo has analyzed the performance of routing protocols using OPNET and GNS3 simulators. The work focuses on the analysis of the routing protocols in a simulator and analysis of the routing table. The work also is to design a simulator that can find the best path to a given topology. The simulators returned the routing table for each node or router in the network which would contain the best path to reach the remote destination on the metric chosen based on the routing protocol implemented. The analysis of routing protocols is done on these two simulators. This paper is the result of the thorough understanding of the use of the two simulators and the routing protocols [4].

Archival Sebial and Chris Jordan performed on corroborating the simulated performances of the RIP, EIGRP and OSPF routing protocols to actual operations. Simulation was employed with the use of a packet tracer and authenticated to real time situation with the use of hyper terminal emulator. Sub netting was also utilized to address and relieve network congestion and security in both environments. In the conduct of the study, results on performances in both simulation and real time situation have been the same. Both yielded same performance results as long as parameters are set consistently. The simulation process had been validated by the actual setup. Based from the results, the author concludes that simulation is consistent with the real time scenario. Results in simulation are generally accurate, time effort and cost efficient [1].

III. ROUTING PROTOCOLS

Routing protocols specifies how routers communicate with each other. A routing protocol shares this information first among immediate neighbor and then throughout the network. The specific characteristics of routing protocols include the manner in which they avoid routing loops, the manner in which they select preferred routes, using information about hop costs, the time that require to reach routing convergence, scalability and other factors [2].

A. Classification of Dynamic Routing Protocols

The classification of routing protocol is shown in figure 1.

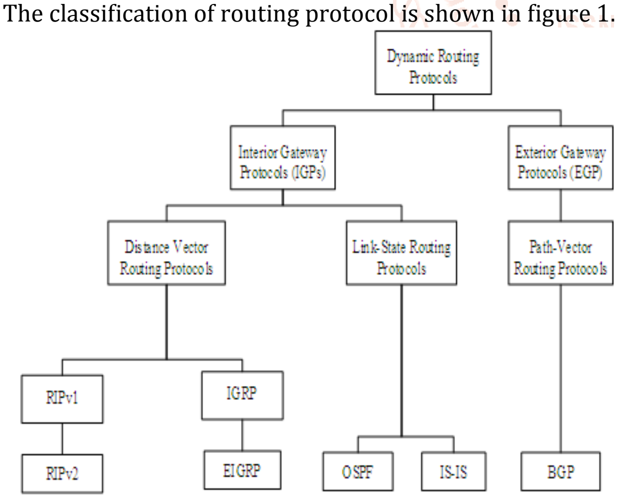


Figure1. Classification of Dynamic Routing Protocols

B. Routing Algorithms

Routing Algorithm is a method for determine the routing of packets in a node. For each node of a network, the algorithm determines a routing table, which in each destination, matches an output line. The algorithms should lead to a consistent routing, that is to say without loop. This means that should not route a packet a node to another node that could send back the package. In dynamic routing protocols, most of the routing algorithms are possible to be classified like one of two basic algorithms such as Distance Vector and Link State.

C. Distance Vector characteristics

1. The routing by distance vector collects data of the information of the routing table of its neighbors.
2. The routing by distance vector determines the best route adding the metric value that receives as the routing information happens from router to another one.
3. With most of the protocols of routing by distance vector, the updates for the change of topology consist of periodic updates of the tables. The information happens from router to another one, giving generally like result one more a slower convergence.
   RIP and EIGRP are examples of distance vector routing protocols [5].

D. Link State characteristics

1. In the link state routing, each router works independently to calculate its own shorter route towards the networks destiny.
2. With the protocols of routing of connection state, the updates are caused generally by changes in the topology.
3. The relatively small LSA that have gone to all the others routers generally give like result faster times of convergence with any change of topology of the internetwork.
   OSPF is an example of link state routing protocol [5].

E. Routing Information Protocol (RIP)

RIP, a distant vector routing protocol, is one of the most commonly used routing protocols for small homogeneous networks. As a distance-vector routing protocol, RIP is used by routers to exchange topology information periodically by sending out routing table details to neighboring routers every 30 seconds. These neighboring routers in turn forward the information to other routers until they reach network convergence. RIP uses the hop count metric with the maximum limit of 15 hops anything beyond that is unreachable. Because of this RIP is not suitable for large, complex networks [3].

F. Open Shortest Path First (OSPF)

OSPF, a link - state routing protocol, is used in large organizations for Autonomous System (AS) networks. OSPF gathers link state information from available routers and determines the routing table information to forward packets to base on the destination IP address. This occurs by creating a topology map for the network. Any change in the link is immediately detected and the information is forwarded to all other routers, meaning they also have the same routing table information. Unlike RIP, OSPF only multicasts routing information when there is a change in the network. OSPF is used in complex networks that are subdivided to ease network administration and optimize traffic. It quickly calculates the shortest path if topology changes, using minimum network traffic. OSPF allows network admin to assign cost metrics for a particular router so that some paths are given higher preference. OSPF also provides an additional level of routing protection capability ensures that all routing and protocol exchange are authenticated [3].

G. Enhanced Interior Gateway Routing Protocol (EIGRP)

EIGRP, a distance vector routing protocol, exchanges routing table information with neighboring routers in an autonomous system. Unlike RIP, EIGRP shares routing table information that is not available in the neighboring routers, thereby reducing unwanted traffic transmitted through routers. EIGRP is an enhanced version of IGRP and uses Diffusing Update Algorithm (DUAL), which reduces the time taken for network convergence and improves operational efficiency. Enhanced IGRP stores all its neighbors' routing tables so that it can quickly adapt to alternate routes. If no appropriate route exists, Enhanced IGRP queries its neighbors to discover an alternate route. These queries propagate until an alternate route is found, this feature gives EIGRP the ability to handle the topology changes as fast as possible, and provide much faster convergence. Enhanced IGRP does not make periodic updates. Instead, it sends partial updates only when the metric for a route changes. Propagation of partial updates is automatically bounded so that only those routers that need the information are updated. As a result of these two capabilities, Enhanced IGRP consumes significantly less bandwidth [3].

IV. THE PROPOSED NETWORK

For the design of the network, the university network will be used in the proposed network. It should be taken each router is set for a particular department. There are six engineering departments. These are Information Technology, Electrical Power Engineering, Electronic Engineering, Mechatronic Engineering, Architecture Engineering and Civil Engineering. Each department belong to a separate two Virtual LAN, VLAN. The total number of routers used in the design of the university network is six numbers. The address space on router on R1 refers to Information Technology Department, R2 refers to Electrical Power Engineering Department, R3 refers to Electronic Engineering Department, R4 refers to Mechatronic Engineering Department, R5 refers to Architecture Engineering Department, and R6 refers to Civil Engineering Department. The design of the university network is shown in Figure 1.

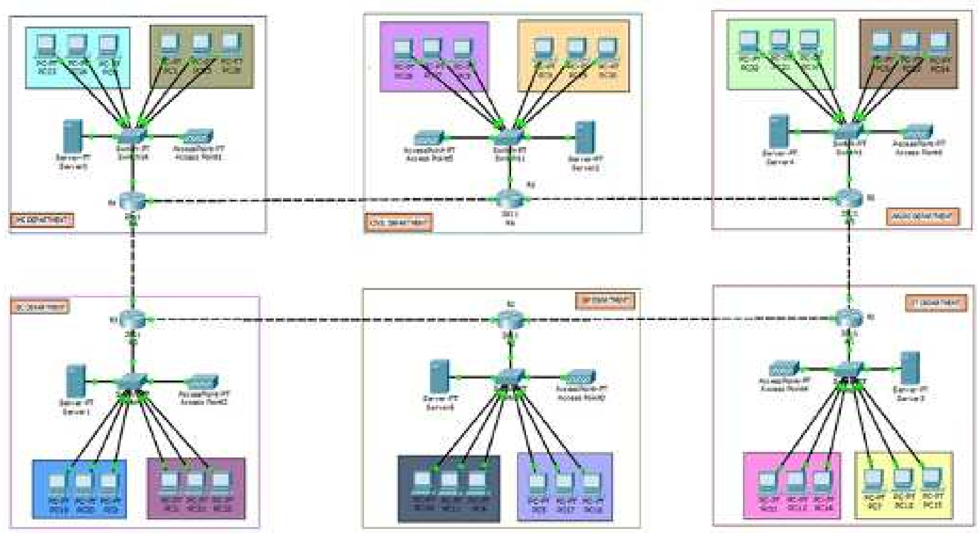


Figure1. Design of the University Network

The university IP network will be using the Variable Length Subnet Masks, VLSM with RIP, OSPF and EIGRP protocols. The principle of using VLSM is dividing an IP address space into a hierarchy of subnets of different sizes, making it possible to create subnets with very different host counts without wasting large numbers of addresses. In this network design, routing table in six routers are analyzed. The routers are connected to each other by fast Ethernet ports that through one router is connected to another router. There are three routing protocols RIP, OSPF and EIGRP has been respectively implemented for each scenario.

V. COMPARISON OF ROUTING PROTOCOLS

The comparative analysis of the features of RIP, OSPF and EIGRP routing protocols are described in the table 1.

Table1. Comparison of RIP, OSPF and EIGRP

Feature	Routing Protocols		
	RIPv2	OSPF	EIGRP
Type	Distance Vector	Link State	Hybrid
Algorithm	Bellman-Ford	Dijkstra	Dual
Class full/ Class less	Class less	Class less	Class less
Metric	Hop Count	Cost	Bandwidth/ Delay
Timers Update	30sec	Network change occurs	Network change occurs
Administrative distance	120	110	Internal 90/ External 170
Authentication	Yes	MD5	MD5
Hop limit	15	No limit	255
Convergence	Slow	Fast	Very fast
Types of Updates	Full table	Only changes	Only changes
Support VLSM	Yes	Yes	Yes
Network Size	Small	Large	Large

VI. SIMULATION RESULTS

This section presents the results that obtained from the simulations of the three scenarios in the proposed university network. Therefore, the simulation results of the proposed scenarios are compared and analyzed to make a decision of the appropriate routing protocol.

A. Result of Convergence Time

The convergence time of a network is very essential to a network. Networks that convergence faster are considered to be very reliable. Users of the network appreciate it when they are always able to access resources. This thesis was carried out to compare the convergence of three routing protocol. The following tables, Table 2, Table 3, Table 4 and Figure 2 are result of convergence time measurement of RIP, OSPF and EIGRP respectively in routers.

Table2. Convergence Time of RIP in Routers

Test	Start Time	R1	R2	R3	R4	R5	R6	Convergence Time
1	04:26	04:40	04:40	04:38	04:39	04:39	04:40	14
2	05:20	05:29	05:29	05:30	05:29	05:30	05:33	13
3	05:40	05:48	05:48	05:50	05:48	05:50	05:53	13
4	07:20	07:34	07:34	07:28	07:30	07:30	07:34	14
5	07:45	07:55	07:58	07:59	07:59	07:58	07:58	14
	Average Time							14

Table3. Convergence Time of OSPF in Routers

Test	Start Time	R1	R2	R3	R4	R5	R6	Convergence Time
1	01:00	01:11	01:11	01:10	01:10	01:11	01:11	11
2	02:00	02:10	02:10	02:10	02:09	02:10	02:10	10
3	02:30	02:40	02:36	02:39	02:40	02:40	02:40	10
4	03:00	03:11	03:10	03:11	03:11	03:11	03:11	11
5	03:20	03:30	03:31	03:31	03:31	03:30	03:31	11
	Average Time							11

Table4. Convergence Time of EIGRP in Routers

Test	Start Time	R1	R2	R3	R4	R5	R6	Convergence Time
1	02:00	02:05	02:04	02:05	02:05	02:04	02:04	5
2	02:20	02:24	02:25	02:25	02:25	02:25	02:25	5
3	02:30	02:36	02:36	02:36	02:36	02:36	02:36	6
4	03:00	03:04	03:05	03:05	03:05	03:04	03:05	5
5	03:10	03:15	03:15	03:15	03:15	03:14	03:15	5
	Average Time							5

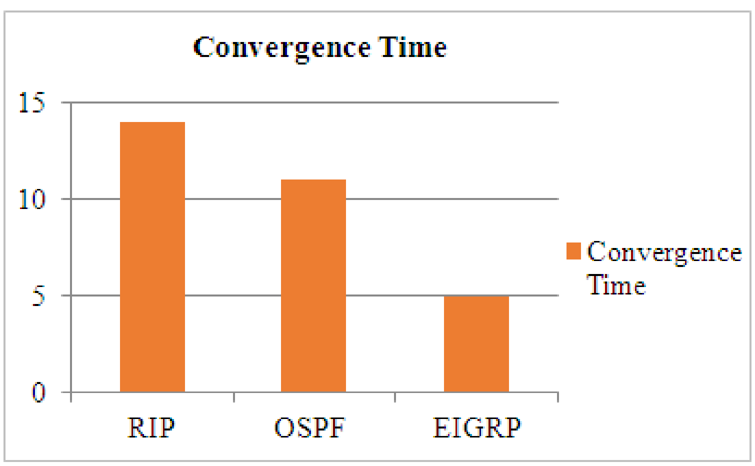


Figure2. Performance Base on Convergence Times

B. Result of Administrative Distance

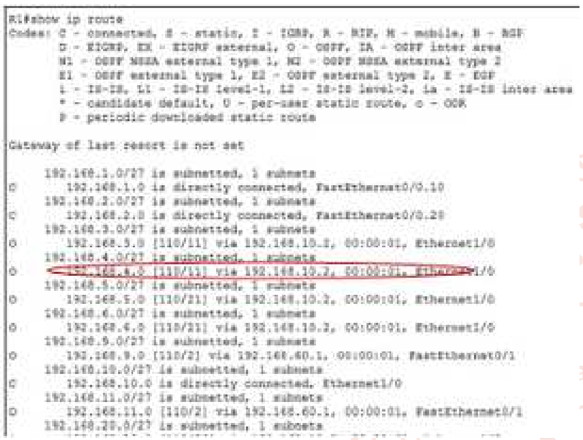
Each routing protocol has its own administrative distance (AD). If a router learns a destination route from two or more routing protocols, it selects the route from the protocol having the smallest administrative distance. The following Figure 3, Figure 4, Figure 5 and Figure 6 are result of administrative distance of RIP, OSPF and EIGRP respectively in routers. As the result, the AD value of RIP is 120, OSPF is 110, and EIGRP is 90.

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     192.168.1.0/27 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, FastEthernet1/0.10
     192.168.2.0/27 is subnetted, 1 subnets
C       192.168.2.0 is directly connected, FastEthernet1/0.20
     192.168.3.0/27 is subnetted, 1 subnets
R       192.168.3.0 [120/1] via 192.168.10.2, 00:00:13, FastEthernet0/0
     192.168.4.0/27 is subnetted, 1 subnets
R       192.168.4.0 [120/1] via 192.168.10.2, 00:00:13, FastEthernet0/0
     192.168.5.0/27 is subnetted, 1 subnets
R       192.168.5.0 [120/2] via 192.168.10.2, 00:00:13, FastEthernet0/0
     192.168.6.0/27 is subnetted, 1 subnets
R       192.168.6.0 [120/2] via 192.168.10.2, 00:00:13, FastEthernet0/0
     192.168.7.0/27 is subnetted, 1 subnets
R       192.168.7.0 [120/3] via 192.168.60.1, 00:00:13, FastEthernet0/1
                    [120/3] via 192.168.10.2, 00:00:13, FastEthernet0/0
     192.168.8.0/27 is subnetted, 1 subnets
R       192.168.8.0 [120/3] via 192.168.10.2, 00:00:13, FastEthernet0/0
                    [120/3] via 192.168.60.1, 00:00:13, FastEthernet0/1
     192.168.9.0/27 is subnetted, 1 subnets
R       192.168.9.0 [120/1] via 192.168.60.1, 00:00:13, FastEthernet0/1
     192.168.10.0/27 is subnetted, 1 subnets
C       192.168.10.0 is directly connected, FastEthernet0/0
     192.168.11.0/27 is subnetted, 1 subnets
```

Figure3. Routing Table of RIP in Router R1



```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
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       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, 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

     192.168.1.0/27 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, FastEthernet0/0.10
     192.168.2.0/27 is subnetted, 1 subnets
C       192.168.2.0 is directly connected, FastEthernet0/0.20
     192.168.3.0/27 is subnetted, 1 subnets
O       192.168.3.0 [110/11] via 192.168.10.2, 00:00:01, Ethernet1/0
     192.168.4.0/27 is subnetted, 1 subnets
O       192.168.4.0 [110/11] via 192.168.10.2, 00:00:01, Ethernet1/0
     192.168.5.0/27 is subnetted, 1 subnets
O       192.168.5.0 [110/21] via 192.168.10.2, 00:00:01, Ethernet1/0
     192.168.6.0/27 is subnetted, 1 subnets
O       192.168.6.0 [110/21] via 192.168.10.2, 00:00:01, Ethernet1/0
     192.168.9.0/27 is subnetted, 1 subnets
O       192.168.9.0 [110/2] via 192.168.60.1, 00:00:01, FastEthernet0/1
     192.168.10.0/27 is subnetted, 1 subnets
C       192.168.10.0 is directly connected, Ethernet1/0
     192.168.11.0/27 is subnetted, 1 subnets
O       192.168.11.0 [110/2] via 192.168.60.1, 00:00:01, FastEthernet0/1
     192.168.20.0/27 is subnetted, 1 subnets
```

Figure4. Routing Table of OSPF in Router R1

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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

     192.168.1.0/27 is subnetted, 1 subnets
C       192.168.1.0 is directly connected, FastEthernet1/0.10
     192.168.2.0/27 is subnetted, 1 subnets
C       192.168.2.0 is directly connected, FastEthernet1/0.20
     192.168.3.0/27 is subnetted, 1 subnets
D       192.168.3.0 [90/30720] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.4.0/27 is subnetted, 1 subnets
D       192.168.4.0 [90/30720] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.5.0/27 is subnetted, 1 subnets
D       192.168.5.0 [90/33280] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.6.0/27 is subnetted, 1 subnets
D       192.168.6.0 [90/33280] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.7.0/27 is subnetted, 1 subnets
D       192.168.7.0 [90/35840] via 192.168.60.1, 00:00:12, FastEthernet0/1
                    [90/35840] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.8.0/27 is subnetted, 1 subnets
D       192.168.8.0 [90/35840] via 192.168.60.1, 00:00:12, FastEthernet0/1
                    [90/35840] via 192.168.10.2, 00:00:12, FastEthernet0/0
     192.168.9.0/27 is subnetted, 1 subnets
D       192.168.9.0 [90/30720] via 192.168.60.1, 00:00:12, FastEthernet0/1
     192.168.10.0/27 is subnetted, 1 subnets
C       192.168.10.0 is directly connected, FastEthernet0/0
     192.168.11.0/27 is subnetted, 1 subnets
D       192.168.11.0 [90/30720] via 192.168.60.1, 00:00:12, FastEthernet0/1
     192.168.12.0/27 is subnetted, 1 subnets
```

Figure5. Routing Table of EIGRP in Router R1

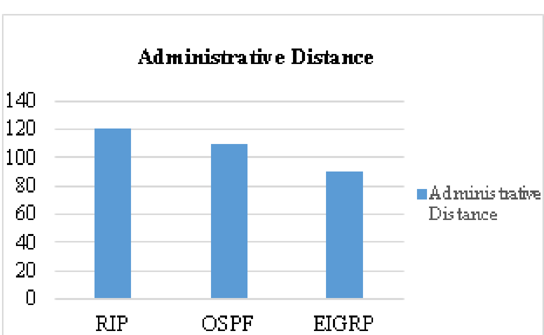

Figure6. Performance Base on Administrative Distance

VII. CONCLUSIONS

The university network is demonstrated using the cisco packet tracer simulator with routing protocols. RIP has many limitations, it generates high traffic that can cause a congestion in slow networks, administrative distance is 120 and it maximum hop count is 15 hop, that limits the use of RIP in a small fast networks. RIP will be really bad choice in slow networks. The performance of RIP can be improved using the triggered extension mode, which decrease the traffic generated by the RIP, enabling the auto summary will also decrease the traffic generated by the RIP. OSPF has a short convergence time, administrative distance is 110 and have no limit maximum hop count; it can be perform efficiently in small and large networks that use routers from other manufacturers other than CISCO systems. From the simulation results, the EIGRP give the best performance when compared with RIP and OSPF. EIGRP generate the least traffic, least administrative distance and thus it will consume the least bandwidth, leaving enough bandwidth for transmission of data. EIGRP also has the best performance in the case of topology changes; it has the least dropped traffic compared to the other distance vector routing protocols. So EIGRP should totally replace IGRP. But EIGRP is a CISCO proprietary protocol, which means that it can only be used on CISCO products.

The main goals of any routing protocol are to achieve fast convergence, while remaining simple, flexible, accurate and robust. In this paper, would compare analyze the convergence times and administrative distance of these three routing protocols.

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