# Performance Analysis of OSPF, RIP, IGRP and EIGRP Routing Protocols using OPNET 14.5 Simulator

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*Abstract— Various protocols are used for forwarding the packets in a network topology. For successful delivery of the packets from the source node to the accurate destination node a routing table is maintained by the routers. The amount of network information stored by a router depends on its algorithm .In this paper the performance of the most popular routing algorithms OSPF, RIP, IGRP and EIGRP are evaluated on the basis of network convergence, throughput, point-to-point queuing delay and utilization by using OPNET 14.5 modeler as a simulating tool. The network convergence graphs are presented and compared for two situations of link status. The EIGRP, OSPF, IGRP and RIP routing protocols are compared on the basis of maximum point-to-point throughput which is measured in bits/seconds. For the point-to-point queuing delay analysis, EIGRP has the least delay followed by OSPF, RIP and IGRP. It is observed that EIGRP Routing Protocol has the maximum link utilization followed by OSPF, IGRP and RIP routing protocols.*

*Keywords— OSPF, RIP, IGRP, EIGRP, routing protocol, traffic, convergence, OPNET.*

## I.    INTRODUCTION

The prime function of routers is to forward the internet protocol packets. Routing protocols are designed to select and determine the best path to each router in the network [1]. The routing protocols used by the routers consists of various algorithms, messages and processes to fastly adapt the changes occurring in a network. Communication between two routing protocols is dependent upon the routing algorithm which is purely dependent upon the metrics to find the path to transfer the data across two networks [2]. The routing protocols are categorized in various groups according to their characteristics. There are two classes of protocols at the network layer: routed and routing protocols. A routed protocols are accountable for the movements of packets across a network and the routing protocols are responsible to aptly direct the packets from source node to the accurate destination node. IP is considered as the routed protocol at the network layer and the various well-liked routing protocols are :

1.  Routing Information Protocol (RIP)
2.  Internet Gateway Routing Protocol (IGRP)
3.  Open Shortest Path First Protocol  (OSPF)
4.  Enhanced Internet Gateway Routing Protocol (EIGRP)

The routing tables are used to promote packets from source to the correct destination. The RIP routing protocols makes use of the basic distance vector which takes hop count as cost. In RIP, the maximum number of hop is 15 because it averts routing loop from source to destination. Mechanism such as route poisoning and split horizon are used to prevent from incorrect routing information. Sally Floyd and Van Jacobson suggests that, without slight randomization of the timer, the timers are synchronized overtime [3]. RIP is poor and small size network when compared with other routing protocols. The main benefit of using RIP is that it uses the User Datagram Protocol and 520 as the reserved port [4]. In multiple path case, RIP protocol uses path which has the lesser hops and the path determined by the RIP is not necessary be the fastest.

The IGRP is based on the distance vector algorithm and it was developed by CISCO system for the small and medium sized protocols. In Interior Gateway Routing Protocol, the fastest path is decided by bandwidth, delay, reliability and load parameters. IGRP maintains multiple metrics for each node which includes delay, bandwidth and load in order to compare the two routes which are combined into single metrics. The IGRP uses port number 9, which is used for communication and by default every 90 seconds it modifies the routing information [5].

OSPF is based on the link-state algorithm and it shares the information between the routers. OSPF was developed by the Internet Engineering Task Force in 1988 to conquer the scalability issues occurred in RIP routing protocol. Using the link state information which is presented in routers, OSPF create the topology in which the topology decides the routing

table for routing decisions [6]. It sustains both classless inter-domain and variable-length subnet masking routing addressing models. OSPF computes the shortest path tree for each route because it uses Dijkstra's algorithm. It was deployed for small as well as large networks. OSPF is a standard protocol in all routers until CISCO has developed additional EIGRP protocol in their router [7]. The chief advantage of the OSPF is that it handles the error detection by itself and it utilizes multicast addressing for routing in a broadcast domain [8].

EIGRP stands for Enhanced Interior Gateway Protocol which permits router to share information to the other routers which are with in the same area. EIGRP is a routing protocol developed by CISCO systems, which uses the characteristics of both distance-vector and link-state algorithm. EIGRP is an advanced version of IGRP that provides superior operating efficiency such as lower overhead bandwidth and faster convergence [9].To reduce the workload and extent of data to be transmitted, only the required information is shared with the neighboring router. Topology table and Neighbor table are maintained by the EIGRP protocol. Comparison of Various Routing Protocols on the Basis of Different Features is presented in Table 1 given at the end of the paper.

In this paper, the qualitative analysis is performed for RIP, IGRP, OSPF and EIGRP routing protocols. The simulating analysis is done by using OPNET 14.5 modeler as a simulation tool. The paper is organized as follows : Section-I describes the characteristics of various routing protocols, in Section-II, the research methodology is discussed. Section-III is dedicated to the network design and implementation of RIP, IGRP, OSPF and EIGRP routing protocols. Section-IV describes the result of the software simulation and Section-V provides the research conclusion.

## II.    RESEARCH METHODOLOGY

The various steps involved in this research work are described in this section. Mathematical analysis, direct measurement and computer simulation are the three available methods for the performance estimation of routing protocols in a network. After considering all the parameters and constraints, mathematical and computer simulation are appropriate for the qualitative analysis and the performance estimation. The mathematical analysis gives numerous advantages which are time, cost and predictive results. The direct measurement can be an alternative to the computer simulation but it may be expensive in respect of configuration complexity. In the direct measurement technique the analysis is to be carried out on an operational network which can cause to disruptive situation. There are different simulators available like NS-2, NS-3, Qualnet, Omnet++,Telnet and OPNET etc.

To carry out the simulation OPNET 14.5 Modeler is chosen suitably. It is a powerful network simulator which simulates the network graphically and its graphical editors epitomizes the structure of the actual network and network components. OPNET simulator is an object oriented and Discrete Event System based network simulator and was introduced by the OPNET technologies inc. The Discrete Event System is an extensively used efficient simulation tool and known for its efficient performance and reliability. It gives a variety of toolboxes to design, simulate and analyze a network parameters.

## III.    NETWORK MODEL AND SIMULATION TOOL

This section describes various devices and configurations used in building the networks and their functions. To simulate the network model with OPNET 14.5 modeler, following devices are utilized.

CS_7000_6s_a_e6_fe2_fr4_slr4_tr4 : This represents a specific configuration of an IP based router gateway model.

Ethernet_wkstn : It is a node model which shows a workstation with client-server applications running over TCP/IP and UDP/IP. The workstation support one underlying Ethernet connection of 10 mbps and 100 mbps.

PPP_DS3 : It is a full duplex link which join the two IP nodes.

100 BaseT : It is used to represent the Ethernet connections. This links can join any combination of the nodes such as Station, Hub, Switch and the LAN nodes.

Application Configuration : It is a node which is used to set the application through the network and also used for the Ace Tier Information specifications, application specifications like web browsing and voice encoder scheme.

Profile Configuration : It is a node which is used to define applications and manage them. These user profiles created on this node are used on various nodes in a network to generate application layer traffic. It is also used to define the traffic patterns followed by the applications.

Failure Recovery : It is a controller node used to model the failure-recovery scenarios. It give attributes and also provide the time and status of the objects in the model.

### *Simulation Scenarios OPNET Modeler 14.5*

This has been used for the simulation analysis. The architecture of the network and implementation of the four different routing protocols on this network model are discussed in this section of the paper. Four network scenarios have been implemented. In scenarios 1and 2 , OSPF protocol and RIP protocol are modeled as a baseline scenario whereas scenarios 3 and 4 are modeled for IGRP and EIGRP protocols respectively. In the network model, five Cisco 7000 routers and two workstation PCs, Application Config, Profile Config and the Link failure component. In order to obtain the results from the four different scenarios, a baseline network model consisting of five Cisco 7000 routers connected with each other via PPP_3 links and the two PCs. The two PCs are working as Ethernet workstations utilized for the high resolution video conferencing applications. The simulation is done for four different network models designed for the performance analysis of OSPF, RIP, IGRP and EIGRP routing protocols.
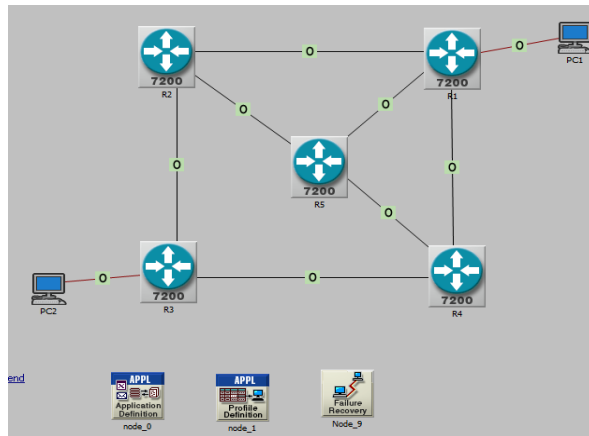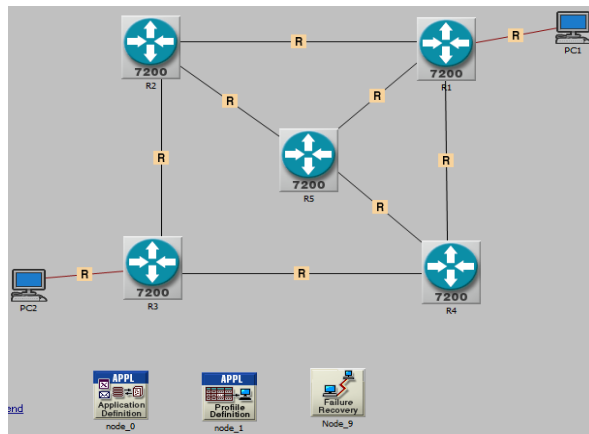
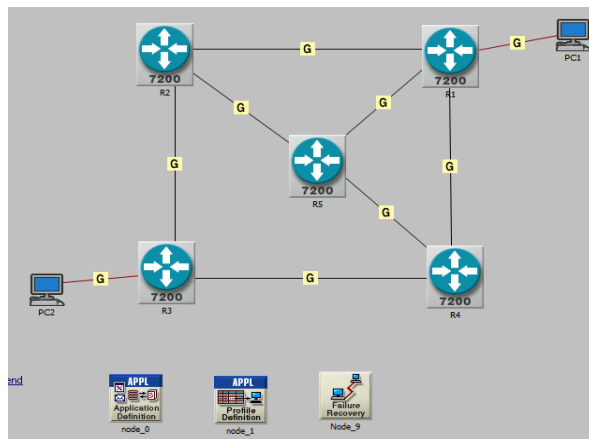Fig. 1 Network model for OSPF



Fig. 2 Network model for RIP



Fig. 3.Network model for IGRP
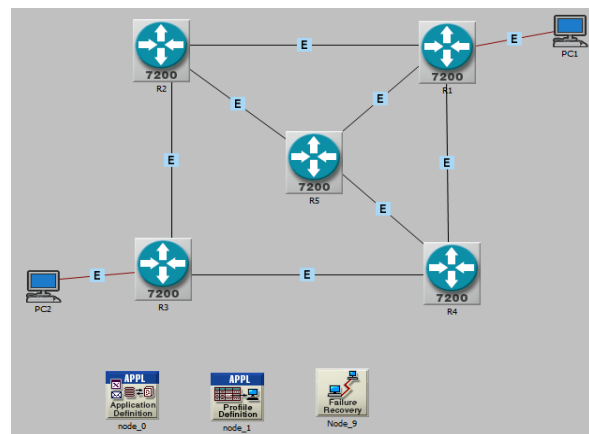


Fig. 4 Network model for EIGRP

Table II Situation-1 for link Failure and RECOVERY

| Status | Time (In Seconds) |
|--------|-------------------|
| Fail | 240 |
| Recover | 410 |
| Fail | 520 |
| Recover | 580 |
| Fail | 610 |
| Recover | 620 |
| Fail | 625 |
| Recover | 626 |
| Fail | 726 |
| Recover | 826 |

Table IIII Situation-2 for link Failure and RECOVERY

| Status | Time (In Seconds) |
|--------|-------------------|
| Fail | 240 |
| Recover | 480 |
| Fail | 720 |
| Recover | 960 |
| Fail | 1200 |
| Recover | 1440 |

## IV.   RESULTS

The performance of routing protocol RIP, OSPF, IGRP  and EIGRP are analyzed for a designed network with typical situations on simulating the network  for 15 minutes in case of situation-1 and for 12 minutes in case of situation-2. The convergence performance is studied for RIP, OSPF, IGRP,  and EIGRP routing protocols. When the network is tested under these two situations, the result for convergence performance in case of RIP, OSPF, IGRP  and EIGRP routing protocols are shown in Figures 5, 6 and 7.
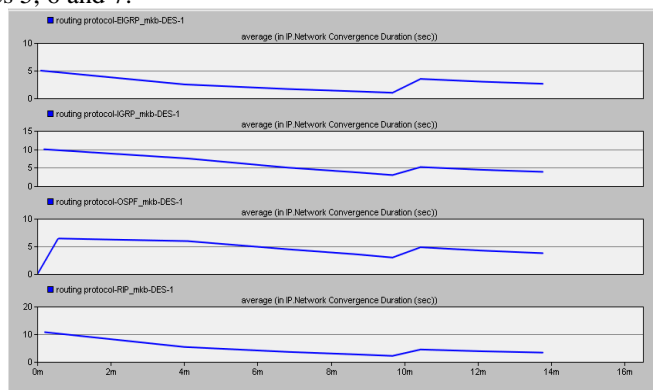


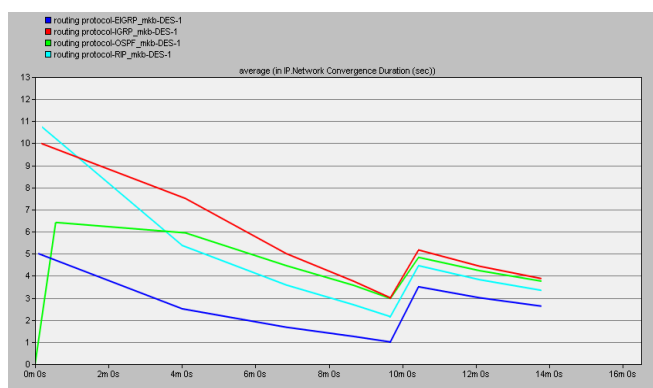Fig. 5 Network Convergence of situation-1 for RIP, OSPF, IGRP and EIGRP



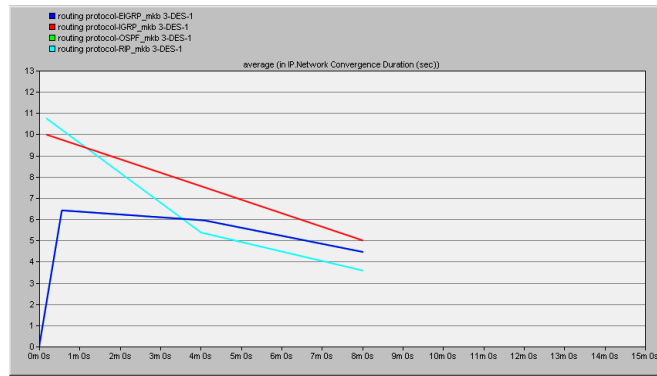Fig. 6 Network Convergence of situation-1

Fig. 7 Network Convergence of situation-2

The distance vector protocols such as IGRP and RIP are disreputably slow to converge. After a change to the network topology, and before the convergence of all the routers, there is the probability of routing errors and lost data. Link-state routing protocols like OSPF and EIGRP are having the faster convergence performance. IGRP routing protocol consumes less bandwidth than RIP but converges much slower. EIGRP routing protocols uses dual-update algorithm which is run in the case when a router recognizes an unavailable specified route and thus its convergence performance is faster. OSPF routing protocol has a copy of topology database and routing table for its specified area, any route changes are determined faster as compared to distance-vector protocol and alternate route are thus detected.
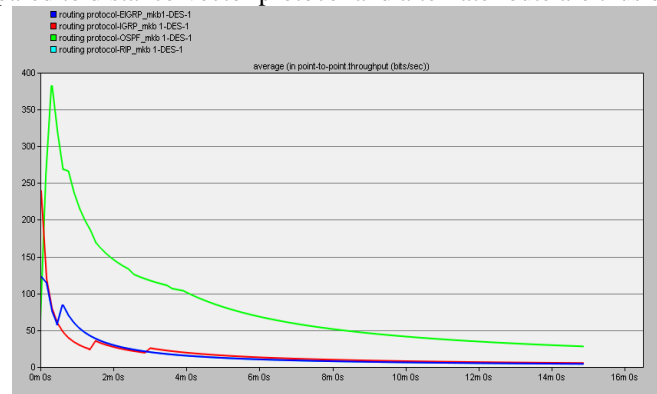

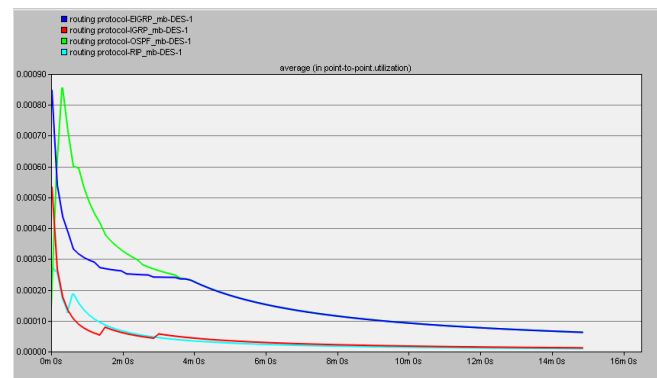Fig. 8 Point-to-Point throughput in bits/second
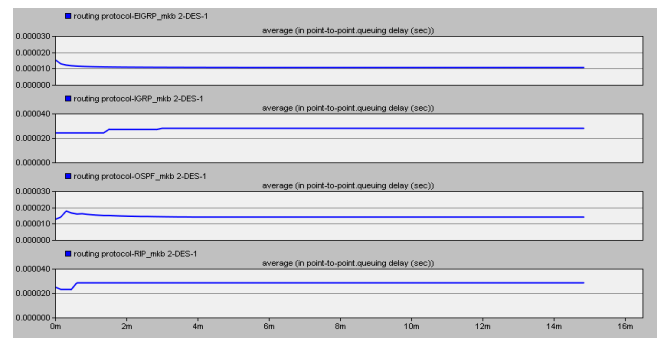

Fig. 9 Point-to-Point Utilization


Fig. 10  Point-to-Point queuing delay (in seconds)  for different routing protocols
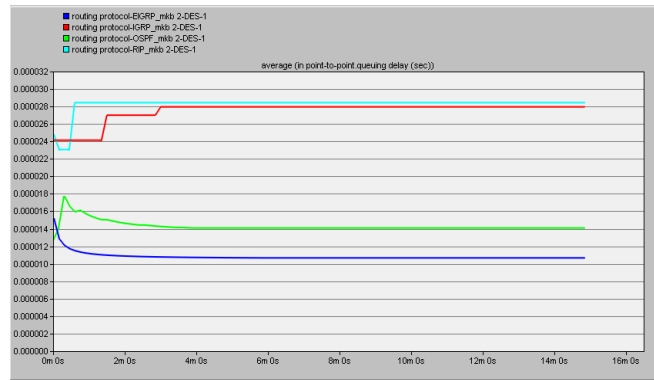
Fig. 11 Point-to-Point queuing delay in seconds

On comparing the performance parameters such as throughput, utilization and queuing delay as per the graphs obtained, EIGRP has the maximum throughput followed by the OSPF, IGRP and RIP routing protocols. For the queuing delay analysis, EIGRP has the least delay followed by OSPF, RIP and IGRP. EIGRP has the maximum link utilization followed by OSPF, IGRP and RIP routing protocols.

## V.  CONCLUSIONS

The size of the today's network has been growing fastly and support complicatd applications. Quality transmission is requirement of time. This requires some good results producing routing protocols at the routers. In this paper, comparison results of the simulation of the various protocols namely OSPF, RIP, IGRP and EIGRP on the basis of  the convergence, throughput, queuing delay and link utilization performance parameters depicts that the performance of EIGRP comes out the best among other routing protocols. OSPF has the second highest throughput and link utilization after EIGRP. EIGRP executes better but OSPF can be second choice when the other decisive factor like least cost of transmission and lower router overhead are taken into consideration.

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Table III  Comparison of Various Routing Protocols on the Basis of Different Features

| Features | RIP | OSPF | IGRP | EIGRP |
|---|---|---|---|---|
| Algorithm | Distance Vector | Link State | Distance Vector | Both Distance Vector and Link State |
| Maximum no. of hops | 15,16 hops considered to be infinity | Depends on the size of the routing tables | 255 Maximum | 255 Maximum |
| Metric | Hop Count | Depends on bandwidth delay, Throughput and RTT | Depends on delay, bandwidth, channel occupancy and Reliability of path | Bandwidth, load, delay, hop count and reliability |
| Integrity | No authentication in RIP-1. Authentication is added in RIP-2. | Supports aunthentication | No authentication | Supports aunthentication |
| Subsystem Segmentation | Autonomus System is treated as single Subsystem | Breaks the Autonomus System in areas | No segmentation of Autonomus System | System is not divided in areas |
| Protocol/Port | UDP 520 | IP 89 | IP 9 | IP 88 |
| Complexity | Simple | Relatively complex | More complex than RIP | Highly complex |