

An Empirical Evaluation of Internal Gateway Protocols (IGP) for Real Applications

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Abstract — A range of IP network routing protocols are being used in transmitting the packets from the source node to the destination node in determining the best route. This paper presents results in the empirical evaluation of internal gateway routing (IGP) protocols for real applications such as database entry, database query, web browsing, E-mail, FTP, HTTP, E-Mail, video conferencing, and voice in three network models. These network models are designed in OPNET IT GURU Academic Edition. Testing is done using efficiency and performance metrics such as response time, traffic sent and traffic received, end-to-end delay, and delay variation. The routing protocols RIP, OSPF, IGRP and EIGRP are used to compare the performance in different networks for different real applications.

Keywords— IGP, EGP, RIP, OSPF, IGRP, EIGRP, OPNET

I. INTRODUCTION

Routing protocols specify how routers communicate with each other by disseminating information and are designed to update the routing rules according to dynamic network environment. In routing each node makes its own routing decision in finding next node along the path towards the destination. This process is repeated until the packet is finally delivered to the destination or in a few cases may result in loss of destination. Information of the next node is stored in the routing table. The packets are forwarded through the optimum path according to the routing algorithm which utilizes a routing table to store the results of metrics used for evaluating the network performance. Routing table is synchronized by two methods: Static routing and Dynamic routing. In static routing each router is manually configured with a list of destinations and the next hop to reach that destination. This process is very cumbersome to handle, when there is a large number of destinations and routers. Similarly, updating routing table becomes very difficult and time consuming, when network topology changes

frequently. Dynamic routing uses a routing protocol that updates routing table continuously to determine the optimized path to the destination nodes in the dynamic network.

II. IP NETWORK PROTOCOLS

Routing protocols are classified as IGP and Exterior Gateway Protocols (EGP) according to the information used within Autonomous System (AS) or between two or more AS. AS is owned and administered by a single commercial entity, and implements some set of routing policies in deciding how to route its packets to the rest of the Internet, and how to export its routes to other AS. Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Interior Gateway Routing Protocol (IGRP), Extended Interior Gateway Routing Protocol (EIGRP) and Intermediate System to Intermediate System (IS-IS) are examples of IGP, while Border Gateway Protocol (BGP) is an example of EGP.

A. Routing Information Protocol

RIP is a distance-vector classful routing protocol, uses number of hops to a destination network as a metric for routing. The maximum hop count is 15 which limits the size of network. RIP prevents routing loops with its limited number of hop counts. RIP uses timers since it is a distance vector protocol for updates, hold-down, flush and timeout with default values 30, 90, 120, and 180 seconds respectively. RIP message contains command entry 1 for request and 2 for reply, version number. RIP message contains maximum 25 route entries including with an address family identifier, IP address reachable hop count metric for the route [4]-[6],[8].

B. Open Shortest Path First

An OSPF is a link-state routing protocol, uses Dijkstra's shortest path algorithm. OSPF routers establish relationships developing with neighbors enabling each to build a consistent view that keeps track of the complete topology of all connections in the local network. An OSPF maintains list

cost database about its adjacent links to all other nodes in the network called as link-state advertisement (LSA). Each router uses similar database to determine the shortest path between any neighboring routers. An autonomous system (AS) area is divided into multiple area in OSPF using either IP address or a number. An OSPF router plays member role in different forms as area-id according to topology such as Area Border Router (ABR), Autonomous System Border Router (ASBR), Designated Router (DR), and Backup Designated Router (BDR). An OSPF area can be normal, stub, or a Not-so-stubby area (NSSA). An OSPF uses neighboring table, topology table and routing table for storing information of all connected OSPF routers, road map of router's topology area and finding shortest route to reach different network in OSPF process [2],[3],[6],[8].

C. Interior Gateway Routing Protocol

IGRP was invented by Cisco is a proprietary distance vector classful routing protocol used in host network or AS. IGRP handles a maximum hop count of up to 255. IGRP sends notification to its neighbors about any new updates every 90 seconds. The parameters delay, bandwidth, reliability, load and maximum transfer unit (MTU) are used to calculate best path to a destination. The disadvantage of IGRP is wastage of IP address space [8].

D. Enhanced Interior Gateway Routing Protocol

EIGRP is a distance vector protocol that uses the Diffusing Update Algorithm (DUAL) convergence algorithm and sometimes referred to as a hybrid routing protocol. EIGRP converge quickly and use little bandwidth because it has separate keepalives and reliable updates. The strength of EIGRP is scalable in terms of hardware resources and network capacity. EIGRP is unique in its support for unequal-cost load sharing. EIGRP builds and maintains a neighbor table: to ensure that all acknowledgements are received, a topology table: to understand paths through the network, and IP routing table: to determine the best paths determine on the metric used [1],[5],[7],[8].

III. SIMULATION MODEL

The network models are designed in OPNET IT GURU Academic Edition [9]. The network was designed on two subnets used for server and client division connected over IP cloud. This has been shown in Fig. 1. Two subnets were used for server and client division. Server subnet consists of various similar routers and Ethernet and PPP servers. Routers were connected using a PPPDS3 links. The routers and servers were connected with a 100BaseT links. The four servers were Web server, Database server and File server and PPP server for providing the distinguished services such as database entry, web browsing, E-mail, file transfer,

video conferencing, etc over the client subnet. This has been shown in Fig. 2. Client subnet consists of various routers, PPP workstations, and 100BaseT LANs connected with 100BaseT links. LANs were used with number of workstations for different supported services such as for researchers, engineers, multimedia users etc. These LANs and workstations were connected with any assigned servers from server subnet. This has been shown in Fig. 3.

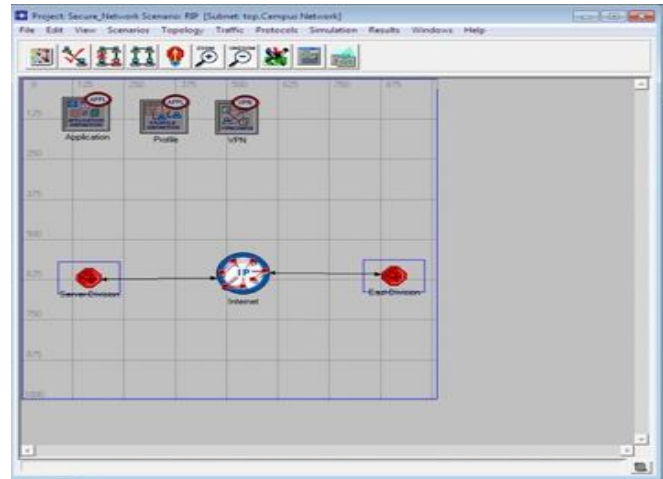


Fig. 1 Two subnet connected over IP Cloud

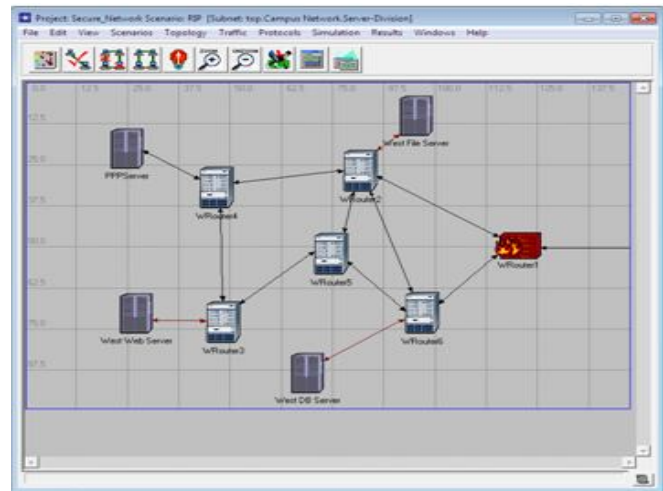


Fig. 2 Server Division Subnet

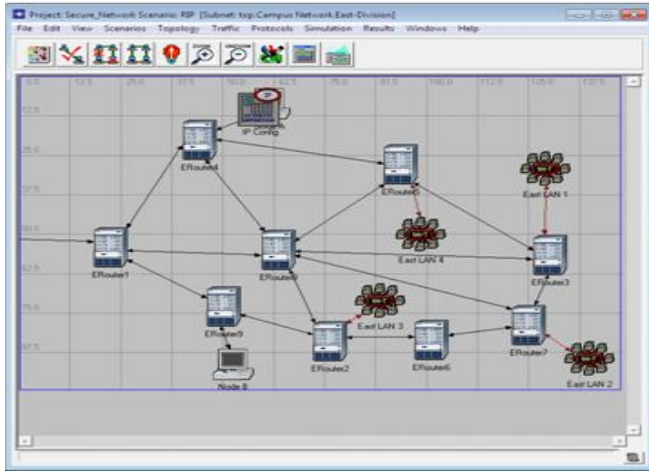


Fig. 3 Client Division Subnet

A range of simulation setups using single and multiple servers were used in the following ways:

- 1) *Simple Network* : for setup containing Subnet, LAN, servers, routers, etc.
- 2) *Fast Network* : was equipped with 10Gbps Ethernet links for increasing higher network bandwidth.
- 3) *Busy Network* : was set for the background utilization varied upto to 99% in client subnet.
- 4) *Secure Network* : was equipped with security aspects using firewall and Virtual Private Network (VPN) to provide security to the information in the servers.

Network Applications used for providing services by different servers in the experiment are Database entry, database query, web browsing, E-mail, FTP, HTTP, E-Mail, video conferencing, and voice. The routing protocols RIP, OSPF, IGRP and EIGRP were used for testing the experiments.

IV. ANALYSIS

The analysis in empirical study is discussed as follows:

- 1) *Database entry*: Traffic sent and traffic received was observed high and medium spikes throughout the simulation run time after the traffic starts at 1 minute 40 seconds. Average response time was observed at uncertain and sudden change in values at any time of simulation run time.
- 2) *Database query*: Traffic sent and traffic received was in large number of high spikes after traffic starts at 1 minute 40 seconds. Average response time was observed at uncertain level with either sudden change in values shaping in either horizontally straight or like stairs during simulation run time.
- 3) *Electronic Mail*: Download and upload response times were observed at certain time with high rise values then stabilize and drop gently. Traffic sent and traffic received

increased as soon as the traffic started, and then drops at very low values with small spikes.

4) *File Transfer Protocol*: It has been observed that the download response times with high rise values stabilize at the end of the simulation run time. Traffic sent and traffic received has increased then dropped at very low values with small spikes.

5) *Hyper Text Transfer Protocol*: Average page response time increases rapidly and drops smoothly and repeating the same till traffic moves to end of simulation. The traffic sent and traffic received has increased significantly with high values. While the simulation is between 1 minute 40 seconds and 2 minutes, it goes high and continues to form sine waves after it drops at lower values for the rest of the time for simulation run.

6) *Video Conferencing*: It was observed that the traffic sent and traffic received increases up to a certain point when the traffic starts and stabilizes till the traffic is handled adequately. In packet end to end delay, the traffic is generated after 1 minute 40 seconds of the simulation and stabilizes slowly then increases linearly up to 3 minute 20 seconds reaching highest values.

7) *Voice*: The observed value for traffic sent and traffic received increases up to a certain point when the traffic starts, but does not stabilize upto simulation end time. The packet end-to-end delay and packet variation was observed with slight changes in the trends.

V. RESULTS AND FINDINGS

Empirical results and findings obtained are discussed on the efficiency and performance for routing protocols is:

- 1) *Traffic sent and traffic received*: Large traffic sent and traffic received for network traffic is required by video conferencing followed by voice applications. Database entry traffic is maximum for single server simple network using EIGRP while database query traffic is observed highest for single server fast network using RIP, followed by IGRP and then constant for all networks except busy network using RIP. Email traffic is equal for all types of networks used in the experiment while FTP traffic is highest and same for single server secure and fast network using IGRP and EIGRP. HTTP traffic is highest for single server busy network using EIGRP, whereas, for other network it is low. In video conferencing, busy network using OSPF and EIGRP and fast network using EIGRP are high for traffic sent and traffic received respectively. Voice traffic sent is same for all networks while fast network is high for voice traffic received using EIGRP. This has been shown for database entry traffic sent used in simple, fast, busy and secure network for single and multiple servers in Fig. 4, 5, 6 and 7 respectively.

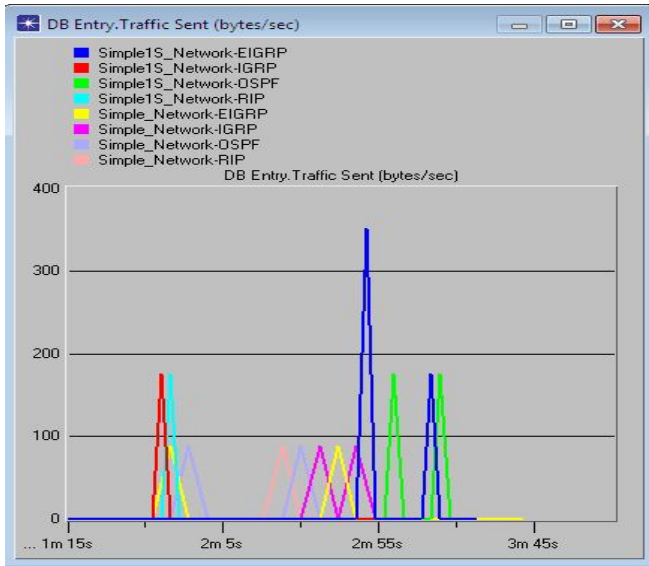


Fig. 4 Traffic sent for database entry in simple network model

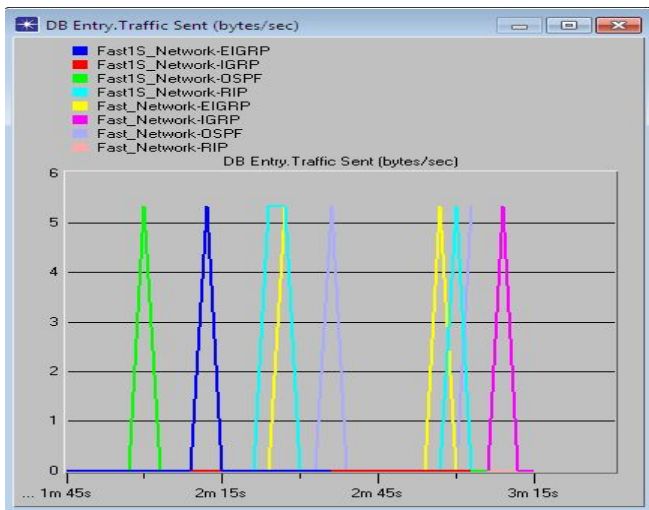


Fig. 5 Traffic sent for database entry in fast network model

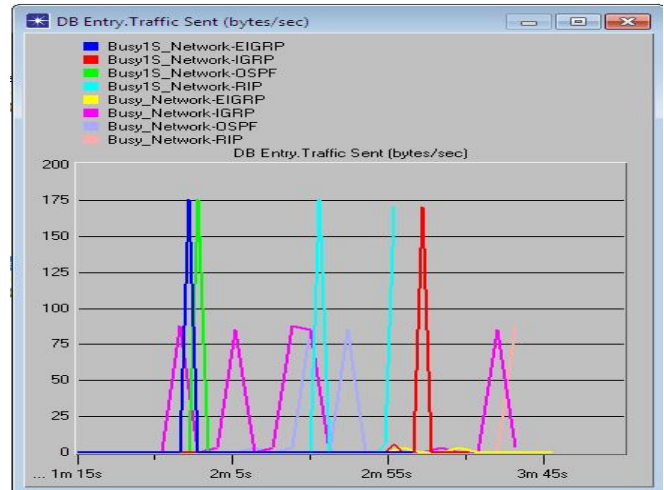


Fig. 6 Traffic sent for database entry in busy network model

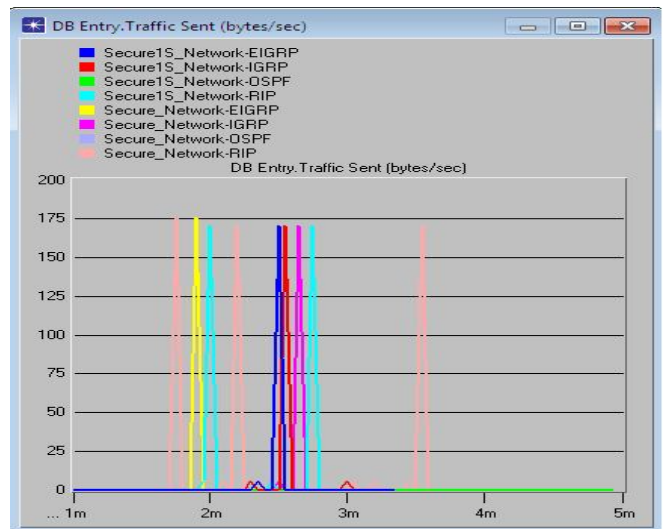


Fig. 7 Traffic sent for database entry in secure network model

2) *Response Time*: For database entry, average response time is high for multi-server secure network using RIP, whereas the fast network is observed for low response. In fast network RIP outperforms in average database query response time. In busy network a moderate response to database entry is observed except RIP. In email average download response time, single server secure network performs best using RIP and IGRP followed by busy network using EIGRP, while average upload response time is maximum for simple network using EIGRP, followed by busy network except IGRP. In FTP application, simple network performs using best RIP followed by secure network using EIGRP. Average page response time in HTTP is highest for secure network using EIGRP.

3) *End-to-end delay*: In video conferencing, low packet end-to-end delay is observed for fast network using OSPF followed by simple network using OSPF and worst for secure network and busy network using OSPF. A negligible voice packet end-to-end delay was recorded for fast network using any protocol. Secure network was recorded with high packet end-to-end delay using any used protocol.

4) *Delay variation*: In video conferencing, less packet delay variation was observed in busy network using RIP and EIGRP whereas, less performance for secure network using OSPF. Voice packet delay variation was recorded with fast network for any used protocol in this experiment. Secure network is high in voice packet delay variation irrespective of any protocol.

VI. CONCLUSION

RIP outperforms for database entry and database enquiry with respect to response time. Download response time in busy network and upload response time in simple network for email is high for EIGRP. FTP download response time is low for RIP in simple network. Network traffic sent and received in FTP, HTTP, and email, and traffic sent in voice is same for all protocols. High HTTP response time was observed for EIGRP in secure network.

In fast network setup for all applications, the traffic received parameter increases to 95 % than other network setup for all protocols. Network works fast with negligible end-to-end delay and delay variation in video and voice applications using all networks, but less end-to-end delay requires in voice applications for fast network by all protocols.

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