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Performance Evaluation of Common Routing Protocols RIP, OSPF, IGRP

Evaluación de rendimiento de protocolos de enrutamiento comunes RIP, OSPF, IGRP

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ABSTRACT/ In TCP/IP model the network layer is responsible of delivering the packet from source node to destination node by using routers. The router uses the routing table for routing the packet successfully to the intended node. The information stored in the routing table depends on the algorithm/ routing protocol the router follows. In this study an evaluation of the performance of three different protocols (RIP, OSPF, and IGRP) will be conducted.
Index Terms: RIP, IGRP, OSPF, VoIP, HTTP, FTP
RESUMEN/ En el modelo TCP / IP, la capa de red es responsable de entregar el paquete desde el nodo de origen al nodo de destino mediante enrutadores. El enrutador utiliza la tabla de enrutamiento para enrutar el paquete con éxito al nodo deseado. La información almacenada en la tabla de enrutamiento depende del algoritmo / protocolo de enrutamiento que sigue el enrutador. En este estudio, se realizará una evaluación del desempeño de tres protocolos diferentes (RIP, OSPF e IGRP).
Términos del índice: RIP, IGRP, OSPF, VoIP, HTTP, FTP

INTRODUCTION

The router is the primary device in any computer network. Stated simply, a router connects one network to another network .The router is responsible for the routing of traffic between networks; it determines the best path to the destination and forwarding traffic to the next router along that path. [1].A Routing is a basic process for choosing the shortest path from multiple paths in order to forward a packet from source to destination nodes at a minimum cost. Routing protocols can be classified into Interior Gateway Protocol (IGP) and Exterior Gateway Protocols (EGP). IGP is used to distribute routing information between gateways within an Autonomous System (AS). IGP is classified into Distance Vector (DV), Link State (LS), and Advanced Distance Vector (ADV) protocols. DV algorithm constructs a vector that contains costs to all other nodes and advertises a vector to its neighbors. DV routing protocol is a hop count metrics and the next hop presents a direction [2]. DV routing algorithm is also known as distributed routing algorithm Bellman-Ford; named researchers have proposed (Bellman, 1957 Ford and Fulkerson, 1962). The router sends all the essential information to adjacent routers. The receiving router checks for changes from the previous distance vector received from the same neighboring router, if it exists, the routing table will be updated [3]. LS routing works by telling every router on the network about its closest neighbors. The entire routing table is not published from any router, only the part of the table containing its neighbors. Examples of LS routing protocols are the OSPF, and IS-IS [13].

Routing Information Protocol (RIP) is a distance vector routing protocol which use the number of hops between source router and destination router as a metric. RIP sends routing-update messages at periodically. Also there is a feature called trigger update make it send updates if there is a change in the network topology. If router receives an update that includes changes to an entry, it updates its routing table to reflect the change. The hop count increased by one for the path. RIP routers maintain only the best route and also can support load balancing between multi equal cost paths [4]. RIP allows a maximum hop count of 15 hops in a path, in the case of the hop count exceeding 15 hops for reaching a destination network, the network considered unreachable. RIP has Administrative Distance (AD) of 120 and it updates its full routing table with its closest neighbors every 30 seconds [2]. Mechanism like split horizon, route poisoning and hold own are used to prevent from incorrect or wrong routing information, Compared to other routing protocol, RIP is poor and limit size i.e. small network. The main advantage of using RIP is it uses the UDP (User Datagram Protocol) and reserved port is 520 [5].

Interior Gateway Routing Protocol (IGRP) is a distance vector interior gateway protocol (IGP) developed by Cisco. It is used by routers to exchange routing data within an autonomous system. IGRP overcome the limitations of RIP like maximum hop count of only 15, and a single routing metric. IGRP support maximum 255 (default 100). IGRP protocol. Because IGRP protocol has no field for a subnet mask, so it is considered a class-full routing protocol. It assumes that all subnetwork addresses within the same Class A, Class B, or Class C network with the same subnet mask as the subnet mask configured for the interfaces [6]. IGRP sends a full routing table every 90 second, and the hold down timer of IGRP is 280 seconds. The administrative distance of IGRP is 100, and IGRP uses bandwidth, delay, reliability, load, and maximum transmission unit (MTU) in its metric, where bandwidth and delay are default metric in IGRP [2].

OSPF uses the shortest-path-first (SPF) computation which is based on the Dijkstra’s algorithm, to determine the route to reach each destination [11]. All routers in an area run this algorithm in parallel, storing the results in their individual topological databases [7].OSPF undergoes three processes while it is being configured: finding neighbors, creating adjacency, and sharing routing information [12]. When a router starts, it initializes OSPF and make sure that the router interfaces are functional. The router then sends and receives OSPF hello messages to get their neighbors.

The OSPF hello protocol elects a Designated Router (DR) for the network. This router is responsible for managing Link-State Advertisements (LSA) that describes the network. These procedures reduce the amount of network update traffic and the size of the routers' topological databases.

The router then attempts to form adjacencies with its neighbors. Adjacencies determine the distribution of routing protocol packets. Routing protocol packets are sent and received only on adjacencies, and topological database updates are sent only along adjacencies. The adjacent routers synchronize their topological database. A router sends LSA packets to advertise its state periodically and when the router's state changes. These packets include information about the router's adjacencies. The router sends LSAs throughout the area (called LSA flooding)to make sure that all routers in an area have the same topological database. Each router uses the information in its topological database to calculate a shortest-path tree, with itself as the root tree. The router then uses this tree to route network traffic [7]. OSPF sends updates (LSAs) only the part that has changed and only when a change has taken place. LSAs are additionally refreshed periodically every 30 minutes [2].

The main goal of this study is to analyze and compare the performance of the three routing protocols in terms of, queuing delay, and throughput. Also the performance of different applications will be studied under various routing protocols. The following parameters will be investigated to shows the effect of routing protocols on application performance: voice MOS, voice & video conferencing packet end to end delays, FTP End-to-End delay, FTP throughput, HTTP end-to-End delay.

The paper is organized as follows: In section 2, review briefly the network description involving the proposed networks that have been created by the OPNET 17.5 simulator. In section 3, results and analysis will be performed. We will compare the performance of the scenarios. We present our conclusions in section 4.

Network description

In this study we have two scenarios, small network which consists of 9 routers and large network which have 20 routers as shown in fig. 1 and fig. 2. Our networks deploy the following components to organize the traffic sources:

- **Application Config:** it is a node which is used to set the application through the network and also used for specifications like Ace Tier Information, application specifications eg. Web browsing (heavy http), voice encoder scheme.
- **Profile Config**: it is a node which is used to define applications and manage them. These user profiles created on this node are used on different nodes in network to generate application layer traffic. Profile Config is also used to define the traffic patterns followed by the applications [8]. The networks will deploy RIP, IGRP, and OSPF routing protocols in each scenario. A comparison among our scenarios will be conducted.

In the first scenario, we have 9 routers that are connected together with point to point (PPP) by using Digital Signal 3 (DS3) link model, where DS3 link speed is 44.736 Mbps. We have FTP, HTTP, Video, and Email servers besides their clients. Also we have VoIP session between two PCs. These devices connected to routers through 100BaseT links.

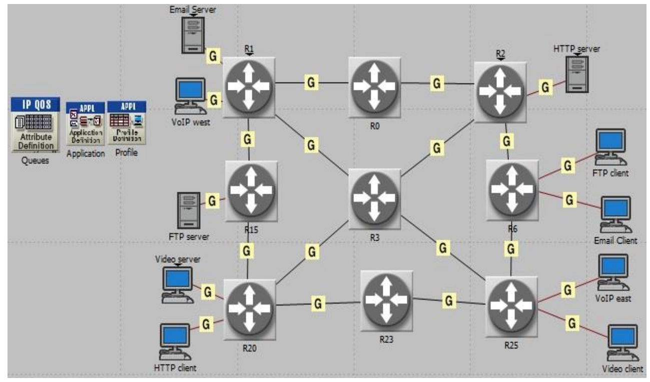

Fig. 1 Small network topology

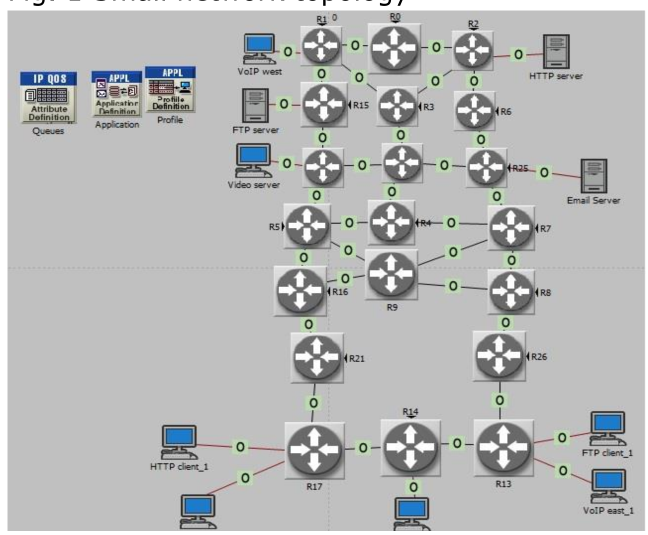

Fig. 2 Large network topology

RESULTS AND ANALYSIS

❖ Routing protocol performance

The performance of routing protocols will be investigated in term of queuing delay of the routers interfaces and the throughput of routing protocols

❖ Queuing Delay

The queuing delay is the packet time to enter the transmitter channel queue until the last bit of the packet is transmitted. It is used to measure a delay of point to point [2] therefore we have measured the queuing delay in the links between R20 which connected to video server and its direct connected routers. We can see from Fig. 3 that the queuing delay for IGRP is the largest during routing table building, this is because the large amount of updates of IGRP protocols and the smallest queuing delay for

OSPF because the small size of SLA messages. After 2 minutes the traffic started to be initiated so the queuing delay starts to increases. Table 1 lists the average queuing delay which again shows that the minimum queuing delay related to OSPF protocol.

Fig. 4 shows queuing delay for large network between R15 which connected to FTP server and its direct connected routers, the graph shows results like fig.3, but with different values due to the nature of FTP traffic.

We conclude that the best routing protocol achieving small queuing delay is OSPF protocol; this is because the small amount of generated updates at routing initialization, but with network stability all protocols generate the same queuing delay.

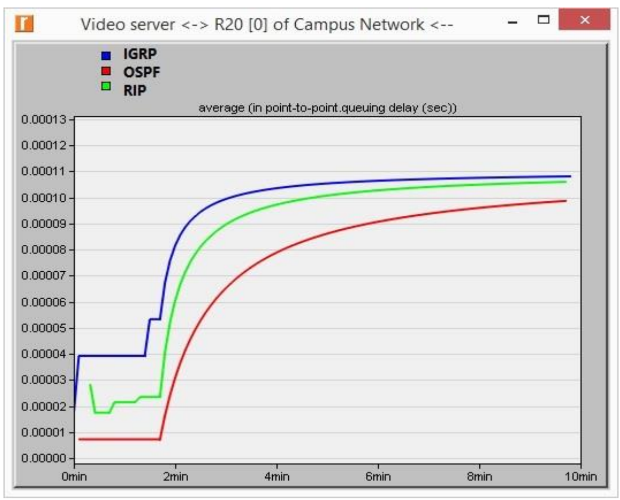

Fig.3 Queuing delay for R20

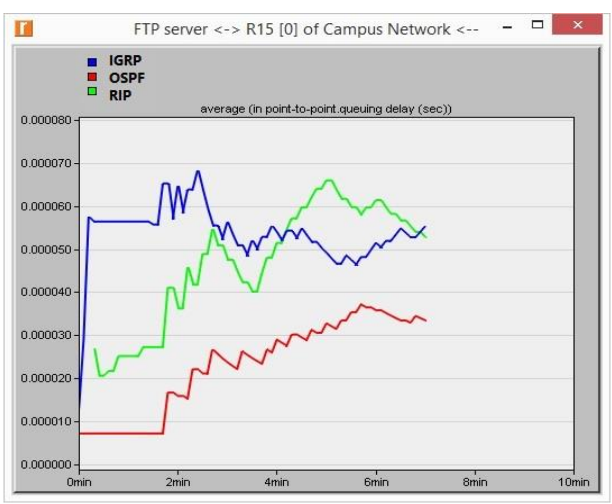

Fig. 4 Queuing delay for R15

Table 1 – average queuing delay

	IGRP	OSPF	RIP
Queuing delay-small net (ms)	0.0888	0.0609	0.0783
Queuing delay-large net (ms)	0.0908	0.0622	0.0793

- **Routing protocol Throughputs**

Fig. 5 shows the total average throughput for the three routing protocols (RIP, IGRP, OSPF) with simulation time. It shows that the largest amount of throughput is generated from RIP, this is because its periodic routing updates. From the figure, we see the increasing of routing traffic related to OSPF and IGRP , this is because the Hello protocol which generate traffic at router initiation. After network stability the update routing traffic for IGRP and OSPF will be nearly similar. Table 2 shows the average values. In the second scenario, due to increasing number of routers the average throughput of the routing protocols increased as shown in table 1.

Fig. 6 shows the total number of update bits for the three routing protocols; the figure shows that the largest amount of update traffic in the simulation time belongs to RIP. This is because it sends its updates periodically every 30 sec.

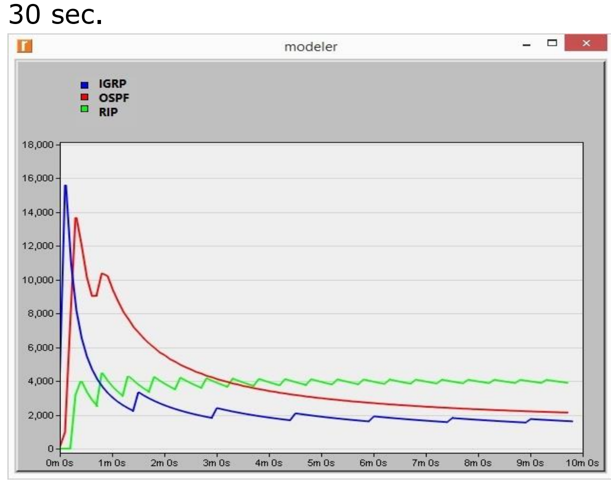

Fig.5 routing protocol throughput (b/s)-small net.

Table 2 – Average throughput for routing protocols

	IGRP	OSPF	RIP
Average (b/s) large net	2431.46	2596.16	3767.82
Average (b/s) small net	16729.1	16962.0	19794.1

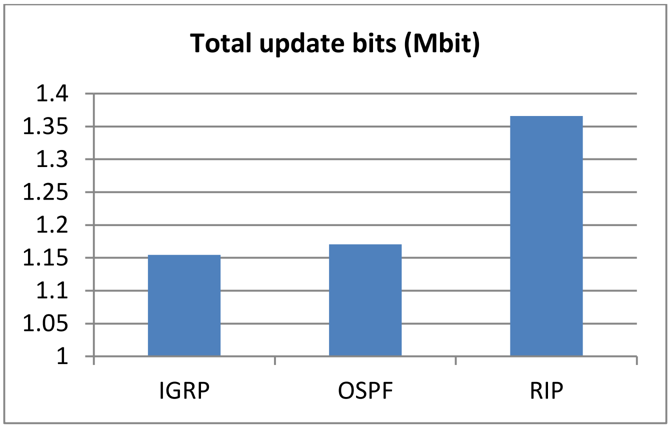

Fig. 6 Total update bits for small network

- **Application performance vs. routing protocol**

- **FTP End-to-End delay**

Table 3 shows FTP End-to-End (E2E) delay which is defined as the average time taken by a data packet to reach from source node to destination node. First we have calculated total delay by subtracting the time when packets was sent from the time when the packet was received. Then find the ratio of total delay to the number of packets received [9].

The results show that small effect of varying the network size and routing protocol on the FTP End-to-End delay. It is concluded that the best protocol which results in decreasing delay is OSPF, there is 28 % less delay compared with IGRP in the small network and 22% decreasing in delay compared with RIP. Also by increasing the network size the delay increased slightly.

Table 3 End-to-End delay for FTP traffic

	IGRP	OSPF	RIP
Average E2E delay small net (sec.)	0.00247	0.001768	0.002283
Average E2E delay large net (sec.)	0.002603	0.002456	0.002382

- **FTP throughput**

Throughput is the ratio of total number of delivered or received data packets at the unit time of simulation [9]. Table 4 shows the average throughput for FTP application (transmitted traffic from FTP server), it shows that with increasing the network size the FTP throughput decreased, this is because with increasing the network size the total amount of routing updates will be increased which reduce the effective throughput for FTP application. Also the best routing protocol which results in increase FTP throughput is OSPF, this is because its small update size during network stability.

Table 4 FTP throughput

	IGRP	OSPF	RIP
Average (byte/s) small net	3203.23	3640.83	2644.3
Average (byte/s) large net	2731.96	3150.29	2549.04

- **VoIP performance**

MOS (Mean Opinion Score) will be used as a measure of VoIP performance. MOS is now the “de-facto” metric used to quantify perceived media quality. The 5-point MOS scale (5-excellent, 4-good, 3-fair, 2-poor, and 1-bad) in particular is extremely popular [10]. Fig. 7 shows MOS for VoIP using the different routing protocols. The figure shows that the best MOS value is a result of using OSPF because the smallest queuing delay results with using

OSPF. Also, by increasing the network size the MOS value decreased. This is logical results as with increasing the network size, the amount of delay increased which decrease the voice quality.

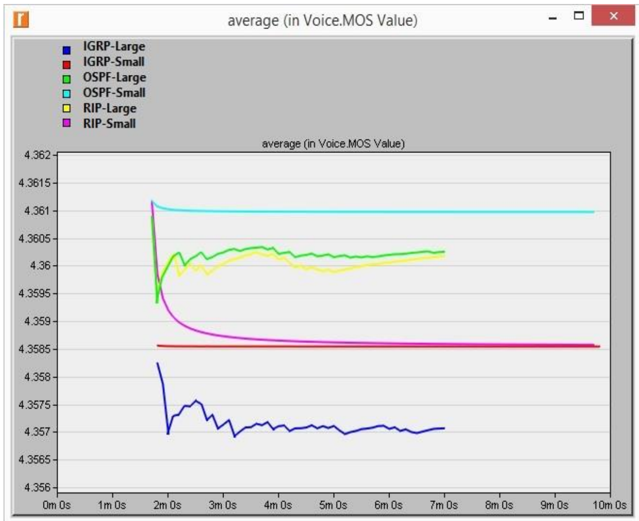

Fig. 7 MOS values with different Routing protocols

- **Video performance**

Fig. 8 shows video End-to-End delay. It shows that there is very small effect for varying the routing protocol on E2E video delay, again OSPF gives the minimum video delay. There is small effect for increasing the network size (large network). From the figure the average end-to-end delay for video conference application is 0.01 ms for large network and 0.009 ms for small network.

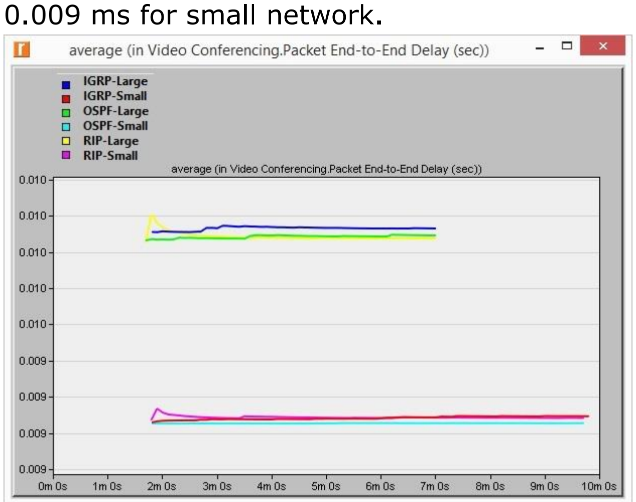

Fig. 8 Video End-to-End delay

- **HTTP performance**

Table 5 shows the average End-to-End delay for video traffic. The results show that the best routing protocol which gives the minimum delay is OSPF; again this is because the small throughput compared with RIP and IGRP.

Table 5 Average End-to-End video delay

	IGRP	OSPF	RIP
Average E2E delay small net (msec.)	0.375	0.285	0.5
Average E2E delay large net (msec.)	0. 866	0. 795	1.1

IV Conclusion

Two network scenarios have been investigated, and both scenarios deployed the three routing protocol in each simulation. From the above results it is concluded that OSPF gives best performance in terms of Queuing delay in router interfaces and routing protocol throughput. Also by applying higher layer traffic like VoIP, Video, FTP, and HTTP in both scenarios, OSPF gives the best performance for these applications in terms of many parameters which is related to the application nature like MOS in VoIP, and throughput in FTP.

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