Performance Evaluation of EIGRP and OSPF Routing Protocols in Real Time Applications

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Abstract: There has been a rapid growth of the routing protocols in the area of communication. A routing protocol is a protocol which is responsible to determine how routers communicate with each other and forward the packets through an optimal path to travel from source node to destination node. The performance of each routing protocol is different from each other. In the context of routing protocol protocol performance, each of them has different architecture, adaptability, route processing delays, convergence capabilities and many more. Among different routing protocols, EIGRP and OSPF have been considered as the pre-eminent routing protocols for the real-time applications.

This paper is a study based on simulation for comparative performance evaluation between EIGRP and OSPF routing protocols for real time applications by using Best-Effort and Quality of service method in OPNET simulator. The evaluation is done based on different aspects such as traffic sent and received, packet delay variation, packet end-to-end delay as well as voice and video traffic sent/received using simulator to evaluate the performance of EIGRP and OSPF, two network models have been studied that are configured with EIGRP and OSPF routing protocols respectively.

Keywords: EIGRP, OSPF, Best-Effort Method, Quality of Service Method, OPNET

1. INTRODUCTION

In modern era of information technology, communication networks are growing rapidly day by day. To provide efficient routing in the network several routers take part in the networks which not only forwards the information in the form of packets but also keeps an eye on the data so that it remains in control manner. Routing protocols specify how routers communicate with each other by disseminating information. The router has prior knowledge about the adjacent networks which can assist in selecting the routes between two nodes. The performance of each routing protocol is different from each other. Among all routing protocols, we have chosen EIGRP and OSPF routing protocols for performance evaluation in real time environment such as video streaming and voice conferencing through simulation. EIGRP is an interior gateway protocol, which is mainly based on DUAL (Diffusing Update Algorithm) to calculate the best route without creating routing table loops based on bandwidth and delay. On the other hand, OSPF is a robust link state interior gateway protocol, which is used to allot routing information within an autonomous system based on cost. These protocols use different algorithm to route the packets and this may vary the route processing delay. As a consequence, the impact of different algorithm can affect the overall network performance.

The simulation of this work is made on OPNET modeler which is a very powerful software tool used for the simulation of the network by using different protocols. It provides complete development of the network environment for supporting the modeling system.

2. OPEN SHORTEST PATH FIRST

Open Shortest Path First (OSPF) is a link-state routing protocol for IP networks and is based on the Shortest Path First (SPF) algorithm. OSPF is perhaps the most widely used interior gateway protocol (IGP) in large enterprise networks. OSPF is used to determine the best route for delivering the packets within an IP network. OSPF routes Internet Protocol (IP) packets within a single routing domain (autonomous system). It gathers link state information from available routers and constructs a topology map of the network. The topology determines the routing table presented to the Internet Layer which makes routing decisions based solely on the destination IP address found in IP packets.

OSPF detects changes in the topology, such as link failures and converges on a new loop-free routing structure within seconds. It computes the shortest path tree for each route using a method based on Dijkstra algorithm, a shortest path first algorithm. OSPF sends link-state advertisements (LSAs) to all other routers within the same area. Information on attached interfaces, metrics used, and other variables are included in OSPF LSAs. Link-state advertisement (LSA) is a packet that contains all relevant information regarding a router's links and the state of those links.

In an OSPF network, routers or systems within the same area maintain an identical link-state database that describes the topology of the area. Each router or system in the area generates its link-state database (LSDB) from the link-state advertisements (LSAs) that it receives from
all the other routers or systems in the same area and the
LSAs that itself generates. Based on the link-state
database, each router or system calculates a shortest-path
spanning tree, with itself as the root, using the SPF
algorithm.

OSPF is a complex link-state routing protocol. Link-
state routing protocols generate routing updates only
when a change occurs in the network topology. When a
link changes state, the device that detected the change
creates a link-state advertisement (LSA) concerning that
link and sends to all neighboring devices using a special
multicast address. Each routing device takes a copy of the
LSA, updates its link-state database (LSDB), and
forwards the LSA to all neighboring devices.

To handle routing efficiently and in a timely manner,
OSPF divides an autonomous system into areas. An area
is a collection of networks, routers and links all contained
within an autonomous system that share the same detailed
LSDB information, but not with routers in other areas, for
better efficiency[8].

3. ENHANCED INTERIOR GATEWAY
ROUTING PROTOCOL

Enhanced Interior Gateway Routing Protocol
(EIGRP) is a routing protocol which is based on Interior
Gateway Routing Protocol (IGRP). It has the property of
both distance as well as link-state routing protocol due to
which it is also known as a hybrid routing protocol.
EIGRP supports classless inter domain routing (CIDR).

EIGRP allows a router to share information it knows
about the network with neighboring routers within the
same logical area known as an autonomous system.
Contrary to other well known routing protocols, such
as routing information protocol, EIGRP only shares
information that a neighboring router would not have,
rather than sending all of its information. EIGRP is
optimized to help to reduce the workload of the router and
the amount of data that needs to be transmitted between
routers.

The Enhanced Interior Gateway Routing Protocol
(EIGRP), referred to as an advanced Distance Vector
protocol, offers radical improvements over IGRP.
Traditional DV protocols such as RIP and IGRP exchange
periodic routing updates with all their neighbors, saving
the best distance (or metric) and the vector (or next hop)
for each destination. EIGRP differs in that it saves not
only the best (least-cost) route but all routes, allowing
convergence to be much quicker. Further, EIGRP updates
are sent only upon a network topology change; updates
are not periodic.

A router running EIGRP stores copies of all its
neighbor’s routing tables so that it can quickly adapt to
alternate routes. If no appropriate route exists i.e. if it
can’t find a route to a destination in one of these tables,
EIGRP queries its neighbors to discover an alternate
route. These queries propagate until an alternate route is
found. When a routing table entry changes in one of the
routers, it notifies its neighbors of the change only (some
earlier protocols require sending the entire table). To keep
all routers aware of the state of neighbors, each router
sends out a periodic "hello" packet. A router from which
no "hello" packet has been received in a certain period of
time is assumed to be inoperative/dead. Unlike some
earlier routing protocols that would send an entire table to
neighboring routers when one routing table entry
changed, EIGRP notifies the neighbors of only the
specific change in the table.

The fast convergence feature in EIGRP is due to the
Diffusing Update Algorithm (DUAL). The diffusing update algorithm is a routing protocol used
by EIGRP to calculate and create routing tables to
determine whether a path is looped or loop-free and it
determine the most efficient (least cost) route to a
destination. It also allows a router running EIGRP to find
alternate paths without waiting on updates from
other routers.

4. SIMULATION SETUP

OPNET is configured in four phase which include
the design of the network model, appoint the statistics,
implement the simulation and the last phase is the result
phase in which the simulation results are analyzed.
Starting with the first phase in which first a network
model is design which is to be created by using simulator,
once the designing of the network model is done, the next
step is for choosing the statistics that are required for the
network model these statistics are global statistics, node
statistics and the link statistics. The global statistics
include the protocols which are to be simulated on the
network as well as the stats which are to be tested during
simulation which include jitter, traffic send and receive
etc. The node statistics determine the node in the network
which is across the network and at last the link statistics
helps to configure the network on the particular link
which is point-to-point.

Following steps are used to design a network into
consideration-

i. Create Network Model
ii. Choose Statistics
iii. Run Simulation
iv. Analysis Result

4.1 Network Model

Figure 1 Network Topology
In the network model, the given network topology has been composed of following network devices and configurations which includes:

i. Ethernet 4_Slip8_gtwy
ii. Ethernet 16_Switch
iii. PPP_DS1 Duplex link between routers
iv. Ethernet 10 Base T Duplex link
v. Ethernet Workstations
vi. Application Configuration
vii. Profile Configuration
viii. QoS Configuration

The network design is based on video and voice clients and server which are located at different places for sending and receiving the data starting with the Application definition and a Profile definition named as Application Config and Profile Config, both are the two important objects from object palette that are selected. The Application Config is to generate the traffic in the network and also it supports the voice and video data traffic which is used in the network topology. The voice conferencing is set to PCM quality so that a high quality of voice traffic can be generated and easily viewed by the receiver. Another is the video conferencing which is set to low quality video for achieving the better results. Another object known as Quality of Service is also taken in the network which is used to provide the quality service to the routing protocols by using Priority queuing. The QoS is used to determine the guaranteed service as well as to provide better quality of voice and video streaming. Priority Queue technique is implemented which allows scheduling priorities of higher priority traffic over lower priority traffic depend upon the Type of Service (TOS) used. The routers in the network are connected by using PPP_DS1 duplex link whereas the switches and the workstations are connected by using 10 Base T duplex links. After the connection is made all the routing protocols are tested by performing them separately one after another and the simulation duration is set to 100 seconds.

In this work, two network models are created respectively with EIGRP and OSPF in order to evaluate their performance. The network model which is used for the evaluation of routing protocols and duration to run the simulation is set for 100 seconds in both EIGRP and OSPF scenarios. The network model for EIGRP and OSPF routing protocols is shown in below figures.

4.2 Network model for EIGRP
In EIGRP scenario, EIGRP routing protocol is enabled first for all routers on the network and simulation run time is set to 100 seconds.

4.3 Network model for OSPF
In OSPF scenario, first task is to set routing configuration OSPF as a routing protocol for this network topology and time duration to run the simulation is set for 100 seconds. The network model for OSPF is shown in the figure 3.

5. PERFORMANCE ANALYSIS
To measure and assess the impact of the traffic sent/received in the network, voice and video traffic sent/received, packet delay variation and packet end-to-end delay, the simulator was run under Best effort and QoS method by varying the simulation time with the observed parameters.

5.1 Impact of Traffic Sent in the Network (normal)

a) Best Effort Method
The figure 4(a) & (b) depicts the traffic generated by EIGRP and OSPF routing protocols in the network using best effort method. It is seen that the EIGRP transfers the more packet in best effort method as compared with OSPF routing protocol. After reaching to the peak point (as peak point is seen in the both graphs), it starts dropping and shows fluctuation in the traffic. It is due to non guarantee of delivery of data in best effort method.
b) QoS Method

The figure 5 (a) & (b) illustrates the traffic send by the protocols using QoS method. It is found that the EIGRP sends the more traffic as compared with OSPF routing protocol. EIGRP outperforms than OSPF routing protocol because EIGRP establishes relationship with adjacent router, calculates primary & backup routes and respond to failure in known routes to a particular destination so that it can quickly adapt to alternate routes.

![Figure 5 Protocol Traffic Sent](image)

So after the evaluation we found that EIGRP sends more traffic than OSPF routing protocol in both the methods (i.e. best-effort and QoS method) and it is also seen that QoS method perform better than Best-Effort method because traffic send by both the protocols QoS sends more traffic than best-effort method.

### 5.2 Impact of Voice Traffic Sent in the Network

The figure 6 (a) & (b) shows the comparison of the both best effort and QoS method for the voice traffic sent in the network. The voice quality is set to PCM quality of G.711 codec. It is assume that during the transfer of voice, there is no loss of voice at the client side in both the methods. In QoS method, using priority queue technique voice traffic is serviced reliably. So QoS method sends more traffic than best-effort method. EIGRP routing protocol outperforms than OSPF routing protocol in both the methods because EIGRP has greater control on timing issue such as hold time, hello interval than OSPF, this allows greater flexibility.

![Figure 6 Voice Traffic sent](image)

When we compare both the methods and protocols, it is found that in voice traffic receive, EIGRP routing protocol outperforms than OSPF in both methods because EIGRP receive more traffic/data than OSPF and also found that QoS receives more voice traffic than Best-Effort method because of using priority queue. It can be wrapped up that EIGRP network has better performance than OSPF when there is high congestion in the network.

### 5.4 Impact of Packet Delay Variation in Voice Traffic

The figure 8 (a) & (b) illustrates the difference between the voice packet delay variation in both methods. Delay variation is measured by the difference in the delay of the packets. It is seen from figure 8 that EIGRP has less packet delay variation than OSPF network. So by observing both methods, we have found out that QoS method outperforms than Best-Effort method and figure 8 shown that despite of high congestion in the network, EIGRP is much better than OSPF in terms of packet delay variation.

![Figure 8 Packet delay variation in Voice](image)

### 5.5 Impact of Video Traffic Sent in the Network

The figure 9 (a) & (b) illustrates the video traffic sent in the network. In figure 9 it is seen that EIGRP starts
sending the traffic before OSPF starts. So it is clear that in video traffic EIGRP sends more packets than OSPF routing protocol in both methods and also observed that QoS method sends more video traffic than Best-Effort method. It is also seen from the figure 9 that some packets are being dropped due to high congestion in the network.

![Figure 9 Video Traffic Sent](image)

5.6 Impact of Packet End-to-End Delay for Voice
The figure 10 (a) & (b) shows the packet end-to-end delay for voice in EIGRP and OSPF routing protocol using both methods. End-to-End Delay is defined as the time that is taken to transmit the packet through the network from source to destination. It is seen from figure 10 that in QoS Method the voice packet end to end delay is much less than Best-Effort method. It also depicts that end-to-end delay of EIGRP is relatively less than OSPF. End-to-end delay of OSPF is higher than EIGRP network due to network congestion. This measurement deals with the speed of the network and the existing congestion.

![Figure 10 Voice Packet End-to-End Delay](image)

5.7 Impact of Video Traffic Received in the Network
The figure 11 (a) & (b) depicts the Video traffic received in best-effort as well as QoS method. It is clear from both the graphs that QoS method receives more video traffic than best-effort method and if we compare both the routing protocols than we also evaluate that EIGRP receives more traffic than OSPF routing protocol. Some packets are being dropped due to high congestion in the network and high bottleneck.

![Figure 11 Video Traffic Received](image)

5.8 Impact of Packet End-to-End Delay for Video
The figure 12 (a) & (b) shows the video packet end-to-end delay in EIGRP and OSPF using Best-Effort and QoS methods. When we evaluate both the methods then we realize that in QoS Method the video packet end to end delay is relatively less than Best-Effort method. End-to-end delay of OSPF is higher due to lower link speed of the network and high congestion in the link that causes packet loss. It shows that end-to-end delay of EIGRP has better performance compared to OSPF and QoS method is much better than Best-Effort method.

![Figure 12 Video Packet end-to-end delay](image)

5.9 Impact of Packet delay Variation for Video
The figure 13 (a) & (b) depicts the difference between the packet delay variation in both methods. As we know that Delay variation is measured by the difference in the delay of the packets. In figure 13(a) the video packet delay variation of OSPF is less than EIGRP whereas in figure 13(b) packet delay variation of EIGRP is less than OSPF routing protocol. It is clear that QoS method generates less packet delay variation and EIGRP has low video packet delay variation than OSPF routing protocol. It is because when a change occurs through the network, it detects the topology change and sends query to the immediate neighbours to have a successor and propagated this update to all routers. In the case of OSPF, when change occurs in the network, all routers within an area update the topology database by flooding LSA to the neighbours and routing table is recalculated so OSPF takes much time that’s why EIGRP has less packet delay variation than OSPF.
CONCLUSION

The performance of the Best effort and Quality of Service methods were used to evaluate the performance of EIGRP and OSPF routing protocols under various parameter (i.e. traffic in network, voice and video traffic send/receive, packet delay variation and packet end-to-end delay) to judge the impact under both methods (i.e. Best-effort and QoS method).

Following inferences have been extracted-
1. By evaluating EIGRP and OSPF protocol performance, we have come across that in most of the cases EIGRP routing protocol performs better compared to OSPF routing protocol in quality-of-service method than best-effort method.
2. The performance of packet delay variation for EIGRP is better than OSPF routing protocol. It evaluates that the packet delay variation of EIGRP network is low while OSPF network is high because EIGRP network learns the topology information & updates faster than OSPF routing protocol.
3. The simulation results have shown that end-to-end delay of EIGRP network is relatively less than OSPF network. As a result, data packets in EIGRP network reach faster to the destination.
4. EIGRP routing protocol has a feature of link-state as well as distance vector routing protocol and also it is a DUAL. So it is found that EIGRP send and receives more traffic than OSPF routing protocol.
5. The voice and video traffic sends/receives more in QoS method than best effort method because by using QoS method technique which include priority queue; during congestion periods, traffic is queued as high, normal, medium or low. Using priority queuing, all high priority traffic is serviced first, then normal and so on.

Further, it is also inferred that among both methods, QoS method is good as compared to best effort method as it gives the guarantee for delivery of packets in the network than best effort method which does not provide any guarantee for delivery of packet in the network.

References


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